Stop Annoying Me! An Empirical Investigation of the Usability of App Privacy Notifications

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ABSTRACT

Privacy nudges are a "soft-paternalistic" method to nudge (instead of force) users to make more informed privacy decisions. While previous work has shown that privacy nudges are effective in encouraging users to adjust their privacy settings, current privacy nudges are considered to be annoying. Previous research found that modalities influence the effectiveness of responses to system messages. Hence, with the aim of improving the usability of privacy nudges, we conducted both a lab and a 3-day field study to empirically investigate how users perceive receiving privacy nudges using different modalities (combinations of visual, vibration, audio and speech). Our results suggest that app designers should implement privacy nudges which cede the decision of their delivery time to the users themselves. Most importantly, our findings reveal that to minimize annoyance, intrusiveness and interruption, while still being read, low priority notifications should not be delivered using salient modalities (i.e., audio or speech).[1]

CCS CONCEPTS

• **Security and privacy** → **Human and societal aspects of security and privacy**; Usability in security and privacy

KEYWORDS

Privacy Nudges; Notifications; Multimodalities

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1 INTRODUCTION

Mobile apps can access, collect or even share users' information for undesirable purposes (e.g., advertising [18]). For instance, research suggests that from ~500k apps on Google Play, 46% collected and shared at least one type of personal information [9]. On the Android platform, users are presented a list of permission requests at installation to raise their awareness of the sensitive data that apps can access, and to help them make an informed decision. However, research shows that users do not read permission requests, nor understand them [4, 6, 7]. This leads to a lack of awareness about app data access [3].

Hence, researchers studied the use of privacy nudges, which are notifications that use a "soft-paternalistic" method to nudge (instead of force) users to make more informed privacy decisions [1, 3, 22]. Previous work showed that privacy nudges are effective in raising users' awareness of data accessed by apps [5, 10, 24]. However, current privacy nudges are considered to be annoying [5]. Also, previous work has not studied how different combinations of modalities affect participants' perception of annoyance, intrusiveness and interruption of privacy nudges, though previous research [19] has found that modalities influence the effectiveness of responses to system messages. Hence, investigating how users perceive receiving privacy nudges using different modalities could improve the usability of privacy nudges. This could lead to an improved behavior when making privacy decisions.

Since we wanted to obtain a more realistic understanding of experiencing privacy nudges in a real life context, we conducted both a lab and a field study. These studies helped us understand how users perceive the use of different combinations of salient (i.e., speech and audio) and non-salient (i.e., visual and vibration) modalities (7 combinations in total, following the same setup as [13]) to notify them of an access of personal information from their most frequently used apps. After a short lab study, we conducted a 3-day field study. Since we were evaluating 7 combinations of modalities we limited the number of received nudges by users to 7 per day (2-3 times for 3 of the users' most actively used apps – similar to [21]). The nudge message showed that the apps were accessing personal data, drawing on previous results showing that 46% of the tested apps on Google Play collected and shared at least one type of personal information [9]. Hence, our research questions were:

RQ1: Which modalities are most preferred to notify users of privacy nudges and why?
RQ2: Does a users' perception of modalities change after experiencing them for 3 days?
RQ3: Is there a specific time point(s) in which most users prefer to receive privacy nudges?

In the following sections we describe the privacy nudges design, the procedure used to conduct the lab and field studies and discuss how our findings contribute to notifying users of privacy concerns about their apps.

2 PRIVACY NUDGES DESIGN

Privacy nudges were presented on the screen (see Fig. 1a) and available in the notification bar (see Fig. 1b), as with typical phone app notifications. Based on [1, 10], the nudges were prompted as a full-screen and users could only dismiss the nudge by clicking either: (1) I want to change my privacy settings, or (2) keep the same privacy settings. Next we describe the modalities and message content used in our studies.

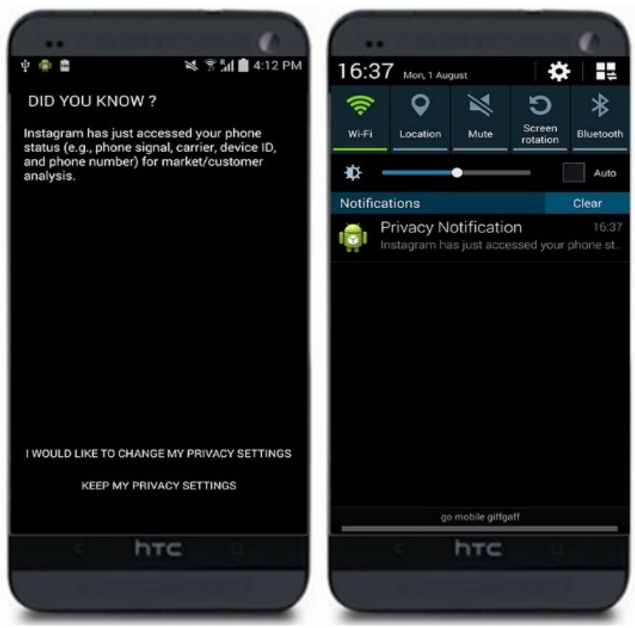

Figure 1: a) Privacy nudge and b) notification for nudge.

2.1 Modalities

We used the following 7 combinations of notification modalities in our studies: "No Modality", "Visual only", "Visual+Vibrate", "Visual+Audio", "Visual+Speech", "Visual+Vibrate+Audio" and "Visual+Vibrate+Speech". These combinations were selected since [13] found that visual, audio and speech modalities were significantly preferred to other modality combinations for rehabilitation reminders. Also, "No Modality", "Visual only" and "Visual+Vibrate" were selected as [5] found that some users wanted non-silent privacy notification modalities, though this was not thoroughly evaluated. Following setup advice from [13], we used the following configuration settings: (1) same volume (high) and duration (2s); (2) for audio we used the Android default 'Journey' tone; (3) for Speech we used a synthesized female voice that said: "Privacy notification"; (4) for Visual we switched on the phone's screen for the configured duration. We now describe the content of the privacy notifications.

2.2 Message Content

Similar to [21] we used popular Android apps[2] to show privacy nudges during our studies. These apps were selected based on two criteria: (1) popularity (number of downloads and users' rating)[3] and (2) undesirable data access of users' personal information [20]. Before starting the study participants were asked to choose 5 apps that they actively used from a list. From these 5 apps we arbitrarily selected 3 apps [21] for which our app showed privacy nudges (see Fig. 1a). The messages were based on observed app behaviour from a reputable source [20]. Based on content extracted from [20] the messages had one of the following data access types: (1) Read phone status and identity; (2) Access user's location; (3) Access Internet; and (4) Connect to Wi-Fi (e.g., "Kakao Talk has just connected to Wi-Fi for advertising purposes.").

3 EVALUATION

The evaluation spanned over 5 days (day 1: lab study, day 2–4: field study and day 5: uninstall app and post-evaluation questionnaire). The 7 modality combinations were initially evaluated in the lab (with same setup as [13]). Then, the modalities were experienced in a 3-day field setup because we wanted to obtain a more realistic understanding of experiencing them in real life. So in each day of the field study the participants experienced the 7 combinations of modalities and at the end of the field study they reselected their preferred modalities. All participants undertook the 3-day field study during weekdays and by using our app on their personal phones, in order to experience the nudges during their normal daily routine [14, 15]. Prior to starting the evaluation we obtained ethical approval from our University's Ethics Committee.

3.1 Procedure

We started the evaluation by explaining the studies and collecting demographic information, and information about participants' use of modalities in their standard apps (i.e., text messages, emails, Facebook, alarms). Then, we conducted a lab study in which participants evaluated the 7 combinations of notification modalities explained in the Modalities section. After each privacy nudge participants rated (5-point Likert scale) the perceived likeability, helpfulness, intrusiveness, interruption, salience (noticeability), and annoyance of the modality combination (similar to [1, 10]). To investigate the suitability of these modalities in different situations, participants were also asked whether they would use them in two different situations:

[2] Skype, Netflix, Snapchat, LinkedIn, Amazon Kindle, Temple Run 2, Kakao Talk, 8 Ball Pool, Talking Tom Cat 2 free, Angry Birds Rio, Super-Bright LED Flashlight, Telegram Talk, Yahoo Mail, SoundCloud, Chrome, FireFoxm Gmail, Facebook, Instagram, LiveScore, Pokemon Go, Twitter, WhatsApp, Wikipedia, IMDB, 2048 Puzzle, 4 Pics 1 Word, Dropbox, MyFitnessPal, YouTube.
[3] https://play.google.com/store

(a) when they are alone and (b) when other people are present (as per [11]). At the end of the lab study participants were asked to select their preferred combination of modalities to notify them of an undesirable app access, and to explain their choice. The experimenter configured the settings and the participants were handed the phones to experience the privacy nudges in the 7 combinations of modalities while using the phone.

The field study began the first weekday after a participant conducted the lab study (e.g., if the lab study completed on Friday, the field study started on Monday). Every day for 3 consecutive days, participants were exposed to the same 7 combinations of privacy notification modalities they evaluated in the lab study. Patil et al. [16, 17] found that immediate privacy notifications should be reserved for truly important and privacy-sensitive cases because these notifications seemed to have an overly alarming nature. Hence, to not overly alarm users, we delivered privacy nudges at specific time points and within reasonable intervals from each other. The 7 privacy notifications (using the 7 different combinations of modalities) were presented in a different random order every day and with a 2 hour interval (similar to [17]) from each other at the following time points: 9:00, 11:00, 13:00, 15:00, 17:00, 19:00 & 21:00. The motivation for using the intervals was to cover the full day [12, 15, 16, 21] in which participants use their smartphones, to understand whether there is a particular time point in which most participants would prefer to receive privacy nudges (**RQ3**). To understand participants' perception of different combinations of modalities over the field study, the experimenter met the participants at the end of the study to collect log data, uninstall the app and complete a post-evaluation questionnaire.

3.2 Participants

We recruited 16 participants (8 females, 8 males) through social media and word of mouth. All participants received a A$15 gift card after the evaluation. One participant dropped out in the middle of the study and another participant experienced a problem with their phone. Hence, we subsequently analyze the results of 14 participants (7 females, 7 males). The mean age was 33 (18-64), med=31. Half the participants (7) were students and the rest (7) were employed full-time. All participants (14/14) said that they were experienced and confident using smartphone apps.

4 RESULTS AND DISCUSSION

All results were analysed using the non-parametric Friedman's test. This test was used since we had 3 or more samples (i.e., for modalities 7 samples), the data was not normally distributed and the samples were paired. Wilcoxon paired signed tests were used to test which combination of samples were significantly different. Significance levels were adjusted with the Bonferroni correction for multiple testing. In this section we also discuss how these results address our research questions and how they may be applicable to the field of privacy notifications related to the apps used on smartphones.

4.1 Preferred modalities

Participants were exposed to different combinations of modalities with the purpose of understanding their preferred modalities for privacy nudges (**RQ1**). After the lab and field studies participants rated (on a 5-point Likert scale) how they perceived the modality combinations according to likeability, helpfulness, annoyance, intrusiveness, interruption, if they would use the modality alone, and if they would use it with other people. Friedman statistical analysis of the perception ratings of the 7 combinations of modalities after the lab study found significant differences for interruption (x^2 (6) = 39.460, p < 0.001) and when used with other people (x^2 (6)=48.484, p< 0.001). Column 2 in Table 1. lists the number of Wilcoxon pair-wise comparisons across the 7 different combinations of modalities (adjusted Bonferroni p value = 0.00238) which returned significant differences when comparing non-salient (all combinations which did not have speech or sound, e.g., "Visual+Vibration") vs salient modalities (all combinations which had speech or sound, e.g., "Visual+Audio") during the lab study. There were no significant differences when comparing salient modalities amongst themselves and non-salient modalities amongst themselves. Hence, after the lab study there was a slight indication that participants found salient modalities to be undesirable.

Table 1: No. of instances with significant differences when conducting Wilcoxon pair-wise comparisons of non-salient vs salient modalities (Column 2 & 3). No. of instances in which salient modalities were significantly different when comparing lab vs field (Column 4).

Perceptions	Lab	Field	Lab vs Field
Likeability	0/11	5/11	4/4
Helpfulness	0/11	1/11	4/4
Annoyance	0/11	8/11	4/4
Intrusiveness	0/11	5/11	3/4
Interruption	4/11	4/11	2/4
When used alone	0/11	2/11	4/4
When used with others	2/11	9/11	2/4

Table 2: Individual modalities compared to self-reported pre-evaluation questionnaire preferences.

	No Sound	Visual	Vibrate	Audio
Text Msg	5	7	14	6
Email	4	8	8	6
Facebook	7	6	7	4
Alarms	1	0	11	13
After Lab	11	14	7	1
After Field	11	12	9	3

Friedman statistical analysis of the perception ratings of the 7 combinations of modalities after the field study found significant differences for likability (x^2 (6)=50.373, p <0.001), helpfulness (x^2 (6)=30.930, p<0.001), annoyance (x^2 (6)=51.358,p<0.001), intrusiveness (x^2 (6)= 56.031, p<0.001), interruption (x^2 (6)= 48.062, p<0.001); when used alone (x^2 (6)=40.538, p<0.001) and when used with other people (x^2 (6)=65.777, p<0.001). Column 3 in Table 1. lists the number of Wilcoxon pair-wise comparisons across the 7 different combinations of modalities (adjusted Bonferroni p value= 0.00238) which returned significant differences when comparing non-salient vs salient modalities during the field study. There were no significant differences when comparing salient combinations amongst themselves and non-salient combinations amongst themselves. These results indicate that participants found (significantly) the '*no sound*' combinations to be likeable, helpful, not annoying, not intrusive, not interruptive and could be used with other people. However, they found (significantly) the combinations of modalities that contained audio and speech to be annoying, intrusive, interruptive and should not be used with other people. Thus, a main finding from this work is that participants preferred '*no sound*' modalities (i.e., notifications which were delivered with combinations of modalities which did not include speech and sound) because they found them to be likeable, helpful, not annoying, not intrusive, not interruptive and could be used with other people.

In Table 2. we compare the individual modality preferences obtained in the lab and field study to the participants self-reported notification modality preferences for standard smartphone apps (which we collected in the pre-evaluation questionnaire). Although almost half of the participants (6/14) reported that they used audio to notify them of text messages/emails and almost all participants (13/14) used audio to notify them of alarms, they still did not prefer to use audio and speech (1/14) for privacy nudges. Also, participants preferred the visual modality considerably more when using notifications for their standard apps. Hence, a major contribution of this work is that participants appear to have different modality requirements for privacy nudges than for their standard apps. These opposing choices might be related to the fact that our participants regarded privacy nudges as low priority notifications, and did not require immediate attention. For example P4 said: *"It's not a priority and I would only use it secondary to the main functions of my phone (texts or calls)"*. Hence, they felt it was not appropriate to use the most salient modalities such as audio and speech.

An interesting finding from the log data was that participants viewed 89% of the privacy nudges, while they only ignored 11%, by swiping the notifications away without looking at them. Thus, the main recommendation from this work is that app designers should evaluate the notification's importance before choosing the modalities to deliver them. We found that using less salient modalities for low priority notifications can reduce levels of annoyance, intrusiveness and interruption while still being read (89% were read by our participants).

4.2 Change in perception of modalities after 3 days

To compare the ratings given to the combinations of modalities between the lab and field studies (**RQ2**), we performed Wilcoxon pair-wise comparisons. Column 4 in Table 1. lists the number of times in which we obtained significant differences when comparing the perception of combinations which included salient modalities (e.g., "Visual+Speech") in between studies. There were no significant differences when comparing combinations which included only non-salient modalities in between studies. Hence, these results indicate that after the 3-day field study participants' perception of combinations of modalities which contained audio and speech (i.e., salient) got stronger, while the perception of the other combinations (i.e., non-salient) were unchanged.

Thus, this finding indicates that exposing participants to undesired modalities in a field study could exacerbate their negative perception. This is an interesting finding since previous HCI research [8] argued that field studies are not necessary when evaluating mobile systems and lab studies are sufficient. However, [2] contradicted this argument and found that both lab and field studies are important when conducting mobile evaluations. Thus, our work strengthens their findings by recommending that evaluations of modalities should not only be conducted in the lab but should also be conducted in the field.

4.3 Best time to deliver privacy nudges

During the field study participants were notified of privacy nudges during different time points of the day with the aim of understanding whether there is a particular time point(s) in which participants would prefer to receive privacy nudges (**RQ3**). At the end of the evaluation participants were asked to rank time points from 1 (most desired) to 7 (least desired) in order of preference. Results show that participant choices averaged from 3.1 to 5.3, with 4/7 time points having large (>2) standard deviations. There were no significant differences across time points. Hence, there was no specific time point, which we used, for which users would prefer to receive privacy nudges, but rather that it is influenced by context (which we plan to investigate in more detail in our next studies), e.g., whether anyone is with the user at the time of the notification. This might be related to users having different needs based on their unique routines [14, 23]. Hence, we recommend that smartphone designers should implement privacy notifications which cede the decision of privacy nudges delivery time to the users themselves.

5 CONCLUSIONS AND FUTURE WORK

In this research we try to improve the usability of privacy nudges by empirically investigating how users perceive receiving privacy nudges using different modalities. Our results reveal that our participants significantly preferred receiving privacy nudges with '*no sound*' modalities (i.e., visual and vibration) rather than '*sound*' modalities (i.e., audio and speech) because they found the combinations of '*no sound*' modalities to be likeable, helpful, not annoying, not intrusive, not interruptive and could be used when with other people. Also, participants' selection of modalities for privacy nudges were almost completely opposite (except for vibration) from the modalities that they use in their standard smartphone apps (i.e., text messages, emails, Facebook, alarms) because they considered privacy nudges to be of lower priority than standard app notifications. Thus, using less salient modalities for low priority notifications can significantly reduce their level of annoyance, intrusiveness and interruption, whilst crucially still being read (89% of privacy nudges were read by our participants). Therefore, our work significantly contributes to the broader field of modalities and notifications on mobile devices by recommending that designers should evaluate the importance of their notifications before deciding which modalities to use to deliver them.

In our future work we aim to investigate the impact of delivering privacy nudges in different contexts (e.g., when at work) and using different screen configurations (e.g., full vs partial screen). Also, we want to investigate other mobile devices (i.e., tablets and smartwatches). The aim is to understand whether our findings would hold with other types of mobile devices which are increasingly becoming more popular since they provide opportunities for novel interactions with respect to modalities and also have apps which exhibit similar privacy concerns.

REFERENCES

[1] Hazim Almuhimedi, Florian Schaub, Norman Sadeh, Idris Adjerid, Alessandro Acquisti, Joshua Gluck, and Lorrie Faith Cranor. 2015. Your Location has been Shared 5,398 Times!: A Field Study on Mobile App Privacy Nudging. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* - CHI '15, ACM, New York, NY, USA, 787–796. DOI: http://doi.org/10.1145/2702123.2702210

[2] Lynne Baillie, and Raimund Schatz. 2005. Exploring multimodality in the laboratory and the field. In *Proceedings of the 7th international conference on Multimodal interfaces,* 100–107.

[3] Rebecca Balebako, Jaeyeon Jung, Wei Lu, Lorrie Faith Cranor, and Carolyn Nguyen. 2013. "Little brothers watching you": raising awareness of data leaks on smartphones. In *Proceedings of the Ninth Symposium on Usable Privacy and Security* - SOUPS '13, ACM, New York, NY, USA, 1. DOI: http://doi.org/10.1145/2501604.2501616

[4] Adrienne Porter Felt, Elizabeth Ha, Serge Egelman, Ariel Haney, Erika Chin, and David Wagner. 2012. Android permissions: user attention, comprehension, and behavior. In *Proceedings of the Eighth Symposium on Usable Privacy and Security* - SOUPS '12, ACM, New York, NY, USA, 1. DOI:http://doi.org/10.1145/2335356.2335360

[5] Huiqing Fu, Yulong Yang, Nileema Shingte, Janne Lindqvist, and Marco Gruteser. 2014. A field study of run-time location access disclosures on android smartphones. In *Proceedings of USEC 2014*.

[6] Marian Harbach, Markus Hettig, Susanne Weber, and Matthew Smith. 2014. Using personal examples to improve risk communication for security & privacy decisions. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems* - CHI '14, ACM, New York, NY, USA, 2647–2656. DOI: http://doi.org/10.1145/2556288.2556978

[7] Patrick Gage Kelley, Lorrie Faith Cranor, and Norman Sadeh. 2013. Privacy as part of the app decision-making process. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* - CHI '13, ACM, New York, NY, USA, 3393. DOI: http://doi.org/10.1145/2470654.2466466

[8] Jesper Kjeldskov, Mikael B. Skov, Benedikte S. Als, and Rune T. Høegh. 2004. Is It Worth the Hassle? Exploring the Added Value of Evaluating the Usability of Context-Aware Mobile Systems in the Field. In *Proceedings of Mobile Human-Computer Interaction* - MobileHCI 2004, Springer Berlin Heidelberg, 61–73. DOI: http://doi.org/10.1007/978-3-540-28637-0_6

[9] Ilaria Liccardi, Joseph Pato, and Daniel Weitzner. 2014. Improving User Choice Through Better Mobile Apps Transparency and Permissions Analysis. *Journal of Privacy and Confidentiality*, 5(2), pp.1-55.

[10] Bin Liu, Mads Schaarup Andersen, Florian Schaub, Hazim Almuhimedi, S. A. Zhang, Norman Sadeh, Alessandro Acquisti, and Yuvraj Agarwal. 2016. Follow My Recommendations: A Personalized Privacy Assistant for Mobile App Permissions. In *Proceedings of Twelfth Symposium on Usable Privacy and Security* (SOUPS 2016), USENIX Association, 27–41.

[11] Marilyn R McGee-Lennon, Maria Wolters, and Tony McBryan. 2007. Audio Reminders in the Home Environment. International Community on Auditory Display, Retrieved August 23, 2015 from https://smartech.gatech.edu/handle/1853/49977

[12] Nicholas Micallef. 2015. *Evaluating the usability of ambient profiles for context-sensitive authentication on smartphones.* Ph.D. Dissertation. Glasgow Caledonian University

[13] Nicholas Micallef, Lynne Baillie, and Stephen Uzor. 2016. Time to exercise!: an aide-memoire stroke app for post-stroke arm rehabilitation. In *Proceedings of the 18th international conference on Human-computer interaction with mobile devices and services* - MobileHCI '16, ACM, New York, NY, USA, 112–123. DOI: http://doi.org/10.1145/2935334.2935338

[14] Nicholas Micallef, Mike Just, Lynne Baillie, Martin Halvey, and Hilmi Gunes Kayacik. 2015. Why aren't users using protection? Investigating the usability of smartphone locking. In *Proceedings of the 17th international conference on Human-computer interaction with mobile devices and services* - MobileHCI '15, ACM Press. DOI: http://doi.org/10.1145/2785830.2785835

[15] Nicholas Micallef, Hilmi Güneş Kayacık, Mike Just, Lynne Baillie, and David Aspinall. 2015. Sensor use and usefulness: Trade-offs for data-driven authentication on mobile devices. In *Proceedings of 2015 IEEE International Conference on Pervasive Computing and Communications* (PerCom), St. Louis, MO, pp. 189-197. DOI: http://10.1109/PERCOM.2015.7146528

[16] Sameer Patil, Roberto Hoyle, Roman Schlegel, Apu Kapadia, and Adam J. Lee. 2015. Interrupt Now or Inform Later?: Comparing Immediate and Delayed Privacy Feedback. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, New York, NY, USA, 1415-1418. DOI: https://doi.org/10.1145/2702123.2702165

[17] Sameer Patil, Roman Schlegel, Apu Kapadia, and Adam J. Lee. 2014. Reflection or action?: how feedback and control affect location sharing decisions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 101-110. DOI: https://doi.org/10.1145/2556288.2557121

[18] Paul Pearce, Adrienne Porter Felt, Gabriel Nunez, and David Wagner. 2012. AdDroid: privilege separation for applications and advertisers in Android. In *Proceedings of the 7th ACM Symposium on Information, Computer and Communications Security* - ASIACCS '12, ACM, New York, NY, USA, 71. DOI: http://doi.org/10.1145/2414456.2414498

[19] Hans-Rüdiger Pfister, Sabine Wollstädter, and Christian Peter. 2011. Affective responses to system messages in human–computer-interaction: Effects of modality and message type. *Interacting with Computers,* 23, 4 (Jul. 2011), 372-383, DOI: https://doi.org/10.1016/j.intcom.2011.05.006

[20] PrivacyGrade. PrivacyGrade. Retrieved August 5, 2017 from http://www.privacygrade.org/apps

[21] Fuming Shih, Ilaria Liccardi, and Daniel Weitzner. 2015. Privacy Tipping Points in Smartphones Privacy Preferences. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, New York, NY, USA, 807-816. DOI: https://doi.org/10.1145/2702123.2702404

[22] Yang Wang, Pedro Giovanni Leon, Alessandro Acquisti, Lorrie Faith Cranor, Alain Forget, and Norman Sadeh. 2014. A field trial of privacy nudges for facebook. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '14). ACM, New York, NY, USA, 2367-2376. DOI: https://doi.org/10.1145/2556288.2557413

[23] Fengpeng Yuan, Xianyi Gao, and Janne Lindqvist. 2017. How Busy Are You?: Predicting the Interruptibility Intensity of Mobile Users. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (CHI '17). ACM, New York, NY, USA, 5346-5360. DOI: https://doi.org/10.1145/3025453.3025946

[24] Bo Zhang and Heng Xu. 2016. Privacy Nudges for Mobile Applications: Effects on the Creepiness Emotion and Privacy Attitudes. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing* - CSCW '16, ACM, New York, NY, USA, 1674–1688. DOI: http://doi.org/10.1145/2818048.2820073