Too Tense for Candy Crush: Affect Influences User Engagement With Proactively Suggested Content

Kostadin Kushlev
University of Virginia
Charlottesville, USA
kpk3m@virginia.edu

Bruno Cardoso
KU Leuven
Leuven, Belgium
b.m.pinto.cardoso@gmail.com

Martin Pielot
Telefonica Research
Barcelona, Spain
martin.pielot@telefonica.com

ABSTRACT

Push notifications are increasingly being used to engage users with app content. In the present research, we propose that users' current affect (i.e., how they are feeling) should be a critical—yet underexplored—factor in user engagement. Participants (N = 337) downloaded a custom-developed app that delivered notifications. After attending to a notification (N = 32,704), participants reported how they felt and chose whether to engage with further content; they could choose between mentally demanding or simple/diverting tasks. When feeling good, people were less likely to engage with mentally demanding tasks. When feeling calm, people were more likely to engage with diverting tasks. When feeling energetic, people were less likely to respond to distractions altogether. These findings provide a tantalizing first glimpse into how affect predicts the kind of content users choose to engage with, paving the way for the use of affect in the design of notification systems.

Author Keywords

Push Notifications; User Engagement; Mobile Computing; Affect; Attention Management; Pervasive Computing; Proactive Recommendations

ACM Classification Keywords

H.1.2. [Information Systems]: User/Machine Systems—Human Factors; H.1.2. [Information Systems]: User/Machine Systems—Human Information Processing; H.1.2. [Information Systems]: User/Machine Systems—Software psychology

INTRODUCTION

Smartphones have become a constant presence in our daily lives [4], providing useful tools for work, sources of entertainment, and ways to connect with others. In this context, mobile notifications now serve as a primary way of pro-actively delivering information to users. But as ever more apps are competing for user attention, what factors determine whether users decide to engage with the content suggested by notifications?

A large body of literature has explored the factors that determine users' receptivity to mobile notifications. Past research, for example, has documented the role of notification source [12], notification content [6], current mental load [2], social context [9, 22], and location and time of day [14]. Most of this past research has focused on predictors that can be directly inferred from mobile phone sensors. In contrast, relatively few studies have explored the role of psychological factors, which are more difficult to infer automatically. In one study, researchers found that personality traits predict how quickly users respond to notifications [12]. In another study, participants were more open to interruptions when they scored above average on the Boredom Proneness Scale (BPS), which measures an individual's tendency to experience boredom [11]. Beyond such dispositional *traits*, researchers have also begun to explore the role of current psychological *states*. In one study, for example, participants were more likely to engage with suggested content when they felt bored [16].

Despite this growing interest in how current psychological states influence interaction with technology, almost no research has explored the role of affect in responding and engaging with notifications. Affect refers to people's current feelings and emotions along several generalized dimensions (e.g., pleasant–unpleasant; tense–calm; tired–awake). Along with cognition and conation (i.e., motivation), affect has historically been considered a major area of study in the behavioral sciences (for a review, see [8]). Yet, only one study that we are aware of directly examined how affect influences notification-related behavior: Participants were more likely to respond to notifications delivering health interventions when they were happy or energetic than when they were stressed [18]. In the present research, we contribute to this incipient area by examining whether current affect influences user engagement with suggested content after people have decided to respond to a notification.

Basic research in psychology has shown that affect matters for how people process information. Positive affect, for example, has been associated with a tendency for shallower
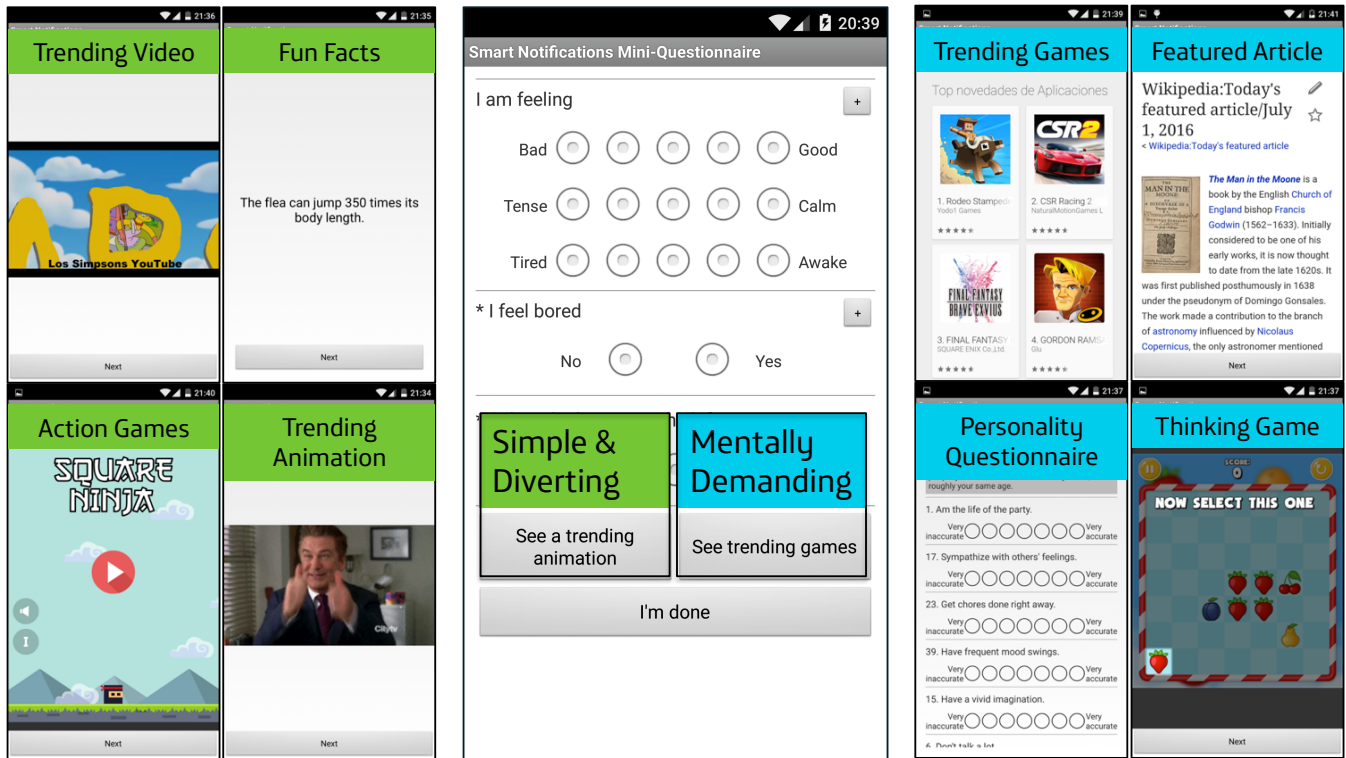
Figure 1. The experience sampling questionnaire (middle) and some examples of the two classes of content offered: simple and diverting (left) and mentally demanding (right).

cognitive processing than negative affect [21]. Accordingly, we explore the relationship between affect and engagement with two different kinds of content: mentally demanding versus simple and diverting content. Based on basic psychological research [21], we propose that when people feel better (i.e., report higher affect valence), they will be less likely to engage with mentally demanding content.

Although the most well-known model of affect is two-dimensional—breaking affect into a valence and an arousal dimension [17]—recent research has suggested that a three-dimensional structure, further breaking down arousal into energetic and tense arousal, is a better fit to data [19, 20]. Indeed, this distinction makes intuitive sense: Tense arousal captures arousal due to stressors, whereas energetic arousal captures wakefulness. Given the lack of past research on how affect influences user engagement, however, we have no strong *a piori* predictions about the role of tense arousal and energetic arousal on user engagement, aiming instead to provide an initial exploratory study of these affect dimensions on user behavior.

Methodology

We conducted an in-the-wild user study to explore the role of affect in user engagement with mobile content. We recruited participants through a specialized agency in order to ensure a representative sample that matches the gender and age distribution of the country in Western Europe where the study was conducted. People interested in participating could only do so after reading the informed consent and agreeing to participate in the study. Participants were first taken to an installation guide that explained how to install a dedicated study application on their Android mobile phones. In total, 337 participants took part in the study for a median duration of 27 days.
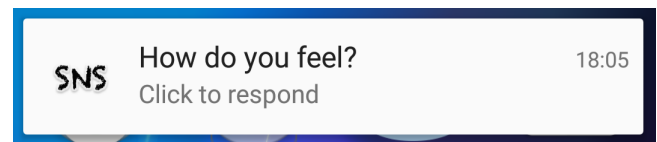

Figure 2. Notification presented to participants.

Once installed, the mobile app delivered notifications (Figure 2), which were triggered semi-randomly throughout the day. Prompts took place around the clock, but between 22:00 and 8:00 in participants' local time, the notifications were silent and without vibration. In order to reduce the burden of the study, notifications were suspended after participants responded to 6 notifications per day. If the participants did not respond within 10 minutes, the notification was removed from the notifications tray; this time threshold was chosen because past work used the same threshold to label notifications as *unattended* [5].

Experience Sampling

We used the experience sampling method (ESM; [7]) in order to capture how participants felt at the time of each notification. When participants attended to a notification, they were asked to respond to three items assessing affect (Figure 1, middle panel). Accordingly, we measured the

three basic aspects of affect: valence (feeling good vs. bad), tense arousal (feeling tense vs. calm), and energetic arousal (feeling awake vs. tired; Figure 1, middle panel).[1] Past research shows that single items provide an acceptable alternative to multi-item assessment when the latter is not possible, such as in experience sampling [1]. The three affect items correlated in a way consistent with past research using multi-item assessment [19]: valence and tense arousal ($r = -.65$); valence and energetic arousal ($r = .45$); tense and energetic arousal ($r = -.44$).

Engagement with Distractors

After indicating how they felt, participants were offered two types of additional content (*distractors*), or a third option: no distractors ("I am done"; Figure 1, middle panel). Participants believed that the responses to the questionnaire were the primary purpose of the evaluation, and that the distractors had only been added for diversion. The informed consent stressed that the use of the distractors was completely voluntary.

To combat content habituation, we took special care to provide a variety of distractors, randomly presented to participants. One button always featured a *simple & diverting* distractor, that is content that did not require much mental effort to be consumed (e.g., simple action videogames, trending video, trending gifs, and fun facts; Figure 1, left panel). In contrast, the other button always featured a *mentally demanding* distractor, that is content that required mental effort to be consumed (e.g., Wikipedia articles, personality questionnaires, videogames with more evolved gameplay; Figure 1, right panel).

We validated our theoretical distinction between diverting and demanding distractors in a separate sample (N = 40). Participants rated each activity on 1 to 7 scales, indicating how much mental effort they thought the activities required. In addition, we assessed whether participants perceived differences on other dimensions, namely how fun and how time-consuming the activities were. As theorized, people perceived the activities in the mentally demanding category to require more mental effort ($M = 4.48$) than the activities in the simple and diverting category ($M = 3.27$), $t(39) = 7.97$, $p < .001$. People also rated the mentally demanding activities as less fun, $t(39) = -4.08$, $p < .001$ and more time consuming, $t(39) = 4.56$, $p < .001$. Controlling for how much mental effort the activities required, however, explained those differences in fun and time, p's > .170. In contrast, controlling for how fun and time-consuming participants perceived the activities did not explain the

differences in mental effort, p's < .04. These findings support our assumption that the overarching theoretical distinction between the two groups of activities is indeed the mental effort they require.

Although there was compensation offered to participants of our study, we carefully emphasized that the use of the distractors was completely voluntary and not required to receive the compensation. Rather, the compensation was solely tied to questionnaire responses: participants had to accumulate 21 days with at least two responses during the study period of 5 weeks.

Participants

In total, 337 participants (52.8% female) took part in the study; age ranged from 18 to 66 years ($M = 37.85$, $SD = 11.01$). The mean number of active participation days was 27.43 ($Mdn = 27$, $SD = 11.49$).

RESULTS

Out of the 114,522 notifications, 32,704 (28.6%) were clicked, that is, the participants opened the questionnaire and responded to the items (see Fig. 1). These 32,704 cases were used in the analyses described below. This conversation rate of 28.6% is on par or higher than the conversation rate for other nonsocial notifications, especially considering that participants only had 10 minutes before the notification disappeared (e.g., [15]). Participants opened one of the recommended contents in 3,729 of those 32,704 cases (11.4%). The affect variables—valence, tense arousal, and energetic arousal—were standardized (M's = 0, SD's = 1.00).

Our main goal was to explore whether user engagement depends on affect. Thus, we examined whether each of the three dimensions of affect predicted whether people decided to engage in either mentally demanding or diverting content at the time of each ESM probe. Because the data contain multiple notification instances per person (i.e., the data are nested within person), we employed multilevel modeling (MLM) to account for the nonindependence between observations. For all of the models reported next, we employed generalized linear mixed modeling (GLMM, *i.e.*, the GenlinMixed command in SPSS 21)[2]. Because our target variable is binary, we specified a binomial probability distribution using the *logit* function, $f(x) = ln(x/(1-x))$. We treated predictors as fixed effects, allowing only the intercept to vary as a random effect at the person level. The models were estimated using a variance components type of covariance structure and the Satterthwaite method of estimation with model-based estimates. We used the conventional p < .05 to indicate

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[1] Participants were randomly assigned to respond to the affect questionnaires on a 5-point scale (shown in Figure 1) or 3-point scale (not shown in Figure 1). This was done in order to test a separate hypothesis that people would be more likely to respond to shorter scales. We found no difference in response rates to the 3- and 5-point scales, and we analyzed the data together standardizing the scores and then combining them.

[2] Consistent with prior research (e.g., [19]), the affect variables were not normally distributed: People generally tend to feel good, and thus, valence and energetic arousal were negatively skewed, and tense arousal were positively skewed. Multilevel modeling is not affected by non-normally distributed variables, so no transformations of the variables were performed.

statistically significant effects and p < .10 to indicate marginally significant effects. Although we report all findings below, we conservatively interpret and further discuss only conventionally significant findings. We also report effect sizes in terms of odds ratios.[3]

Combining across types of content (i.e., disregarding the mentally demanding and simple & diverting dichotomy), affect mattered surprisingly little for predicting distraction seeking. Valence, $b = -.02$, p = .625, $e^b = .98$, 95%CI [.93; 1.05], did not predict whether people chose to distract themselves, and neither did tense arousal, $b = -.05$, p = .090, $e^b = .95$, 95%CI [.89; 1.01]. Only energetic arousal predicted significantly lower likelihood to seek distraction overall, $b = -.09$, $p = .004$, $e^b = .92$, 95%CI [.86; .97].

Valence and tense arousal did, however, predict engagement with type of content. When feeling good, people were significantly less likely to seek mentally demanding distractors, $b = -.08$, $p = .014$, $e^b = .92$, 95%CI [.86; .98], but somewhat more likely to seek simple diversions, $b = .06$, $p = .093$, $e^b = 1.07$, 95%CI [.99; 1.15]—although the latter effect was only marginally significant. When feeling tense, people were less likely to seek diverting distraction, $b = -.10$, $p = .005$, $e^b = .90$, 95%CI [.84; .97], but no less or more likely to seek mentally demanding content, $b = .04$, $p = .255$, $e^b = 1.04$, 95%CI [.97; 1.11]. Finally, consistent with the significant effect on energetic arousal on overall distraction seeking, when people felt more energetic, they tended to be less likely to seek either diverting distractions, $b = -.06$, $p = .079$, $e^b = .94$, 95%CI [.88; 1.01], or mentally demanding distractions, $b = -.06$, $p = .065$, $e^b = .94$, 95%CI [.89; 1.00].

DISCUSSION

Consistent with basic research in psychology [21], we found that when people felt good, they were less likely to seek mentally demanding content. These results suggest that service providers who want to engage their users with cognitively demanding content might benefit from inferring how good their users are feeling, and avoid suggesting mentally demanding content when users are feeling good (c.f., [16]). When people felt tense, however, they sought diverting distractions less. We speculate that engaging with

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[3] In GLMM, the b's can be interpreted as regular unstandardized regression coefficients (i.e., every one unit change in the predictor results in b units change in the outcome). The e^b can be interpreted as an indicator of likelihood of selecting the predicted distractor; $e^b = 1$ means both outcomes are equally likely; $e^b > 1$ means that higher values of the predictor (i.e., affect) are associated with higher likelihood of selecting the predicted distractor; $e^b < 1$ means that higher values of the predictor are associated with lower likelihood of selecting the predicted distractor. Thus, for example, $e^b = 2$ would indicate people were twice as likely to select the distractor for each one-standard-deviation-unit change in affect, and $e^b = .5$ would indicate that people were half as likely to do so.

diverting content requires a relatively relaxed psychological state (e.g., when relaxing at home vs. when trying to make it on time for a work meeting). Finally, when people felt awake and energetic, they were less likely to seek further content, regardless of its type. Thus, when people are already in an energized state, they may feel less inclined to seek further stimulation altogether.

Our research has several notable strengths. First, we used the experience sampling method (ESM), which is the most reliable way of measuring current psychological states in vivo [7]. Second, we relied on a large sample of over 300 participants, who are representative of the population in terms of age and gender. Finally, we showed that the relationship between affect and engagement with content depends on the cognitive demands associated with the suggested content.

Our findings showed that when people felt more positive affect, they were less likely to engage in mentally demanding tasks. Past research has shown, however, that people completing cognitively demanding tasks (e.g., solving Sudoku puzzles) are more likely to switch between tasks for negative compared to positive reasons [3]. Thus, while positive affect might motivate individuals away from engaging in demanding tasks in the first place, negative affect might promote disengagement from ongoing tasks. This possibility is consistent with flow theory [4], which proposes that when people's skills do not match task difficulty, people experience more negative affect, promoting disengagement.

In a typology of self-interruptions in HCI, Jin and Dabbish [10] proposed that one of the reasons that people seek distractions is to take a break from primary tasks. They observed that a positive consequence of such breaks is alleviating stress arising from the primary task. We found, however, that when people felt tense, they were less likely to seek diverting distractions. This suggests that, ironically, when people feel stressed, they might be less interested in the kind of distractions that—because of their simple and diverting nature—can help them deal with stress. Our findings thus suggest that when people seek to reduce task-induced stress (e.g., at work), they might want to rely on externally scheduled (e.g., the Pomodoro method) rather than on self-initiated breaks.

We found that when people felt more energetic and alert, they were less likely to engage in further distractions—regardless of its type. This finding jibes with recent research showing that when people feel more alert they are less likely to use entertainment apps, but more likely to use productivity apps [13]. These findings suggest that participants in our study perceived both types of distractions—diverting or demanding—as entertainment (rather than as a productive time spent on developing cognitive skills, for example). Thus, future research needs to explore how alertness would function with regards to

engagement in the context of productivity applications (e.g., email).

As an initial investigation of the role of affect in notification-related user engagement, the present research provides a fertile ground for future research. As mentioned, researchers could explore how affect influences engagement with notifications from different categories of apps (e.g., work email vs. Facebook). Future research should also take into account the context in which notifications are delivered (e.g., during a focused task at work versus during down-time, such as watching TV). Given the large number of instances in which people choose not to engage in further distraction, future qualitative research should try to illuminate when and why people do decide to engage with notification-suggested content. Relatedly, future quantitative research should explore the role of individual differences (e.g., stimulation seeking, chronic multitasking) in determining the rate at which people respond to notifications and engage with different kinds of content.[4]

CONCLUSIONS
Given the increasing competition for user attention through push notifications, a critical question for developers is when users are more likely to engage with suggested content. In the first study of its kind with more than 300 participants, we have shown preliminary evidence that the answer depends on the interaction between how users feel and what content is offered. In sum:

- When feeling good, people tend to avoid mentally demanding tasks. Hence, proactive recommendations for content that requires mental effort should target moments of neutral or even negative valence.
- When tense, people tend to avoid diverting tasks. Thus, people who want to reduce task-induced stress might want to rely on external timers to schedule regular breaks with fun activities.
- When energetic, people tend to avoid suggestions for further distraction altogether. Hence, proactive

recommendations should target moments of low energetic arousal.

These findings suggest that future "smart" devices should not only be technologically smart, but also *psychologically smart*—that is, strive to understand how users feel in order to engage them with the most appropriate content at the most opportune of times.

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[4] In addition to affect, we also captured boredom. However, due to the lack of novelty (see [15]), we decided not to focus on boredom in the present report. When people felt bored (vs. not bored), they were almost twice as likely to choose to engage with the suggested content, $b = .67$, $p < .001$, $e^b = 1.95$, 95%CI [1.63; 2.33]. When bored, participants were more likely to seek both diverting, $b = .24$, $p = .024$, $e^b = 1.27$, 95%CI [1.03; 1.56], and mentally demanding distraction, $b = .52$, $p < .001$, $e^b = 1.68$, 95%CI [1.40; 2.02]. Notably, as indicated by the effect sizes, boredom seemed to be more predictive of seeking mentally demanding distractions than diverting distractions. Note that the effect sizes for boredom should not, however, be directly compared to those of affect because boredom and affect were measured on different scales (i.e., dichotomous vs. continuous).

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