Modelling the Impact of Push Notifications on Mobile Session Duration: A Regression and Mixed-Effects Study

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Abstract

Mobile app engagement increasingly relies on purposeful, context-sensitive interventions, with push notifications aimed to encourage users to re-engage with and experience apps as the most common example. The majority of past work and commercial analytics focus on if users respond (using some measure of getting users to respond such as open rate and click rate); the nuanced quality and depth of engagement, following user interaction with a push notification, is rarely explored. For example, product teams and researchers want to know: does a push notification stimulate meaningful, longer session time, and under what conditions does it lead to its most potent influence?

In this study, we test these questions using a large-scale log data set of approximately 100,000 mobile app sessions, with rich device, behavioural, and contextual features encoded. Following a careful cleaning and feature engineering process, we are left with a clean analytic data set of 93,235 sessions. We develop and estimate two complementary models: (i) a robust linear regression of session duration, robust to outliers and distributional skew; and (ii) a mixed-effects regression model with user-level random intercepts to account for a significant amount of user-level heterogeneity.

Feature engineering generates interpretable factors such as low battery warning, high memory use, age categories, and binary flags for subscribing and push notification settings. Regression results show that (1) sessions from subscribed users are longer, (2) low battery context shows stronger prediction of shorter session length, and (3) high memory use, which is taken as equivalent to in-app engagement, predicts you will spend longer in-app. Allowing for user level random effects in the models improved fit by a substantial amount and emphasizes the necessity to allow for individual, baseline differences. The implications of these findings for notification scheduling, user targeting, fairness in engagement algorithms, and avenues for causal identification from micro-randomized trials and experimental designs are strong.

Keywords

Push notifications, session duration, mobile engagement, robust regression, mixed-effects, user modelling.