Edinburgh Research Explorer

Does the Presence of Privacy Relevant Information Affect App Market Choice?

Does the Presence of Privacy Relevant Information Affect App Market Choice?

Maria K Wolters
Centre for Design Informatics,
University of Edinburgh, UK
Alan Turing Institute, London, UK
maria.wolters@ed.ac.uk

Xinyu Yang
School of Cyberspace Security
Beijing University of Posts and
Telecommunications, Beijing,
China
yangxycl@bupt.edu.cn

Shuobing Li
School of Informatics, University
of Edinburgh

Haoyu Wang
School of Computer Science
Beijing University of Posts and
Telecommunications, Beijing,
China
haoyuwang@bupt.edu.cn

Yao Guo
MOE Key Lab of HCST,
Dept of Computer Science,
Peking University, Beijing, China
yaoguo@pku.edu.cn

Abstract

While in most countries, Google Play and Apple App Store
dominate, Chinese mobile phone users can choose among
dozens of different app markets, which differ greatly in the
information presented. This makes the Chinese mobile
ecosystem a unique case study for investigating whether
users actively choose app markets that conform to their
preferences. We investigated this question in a survey of
200 Chinese users aged 18-49. Scenarios covered apps
that require disclosure of different types of sensitive infor-
mation (shopping, dating, health), with gaming as a base-
line. Users preferred markets that were easy to use and
had a wide choice of apps. Only nine users highlighted se-
curity as a feature. Despite this, they primarily used only
one app market—the pre-installed one. App-market specific
features were important for the game scenario, but less im-
portant for all others. We suggest that download decisions
for most apps are made before users enter an app market,
and discuss implications for presenting privacy and security
information.

Author Keywords
app markets; privacy; security; understanding users.

CCS Concepts
•**Human-centered computing → Empirical studies in
ubiquitous and mobile computing; •Social and profes-**

sional topics → *Cultural characteristics;* •**Security and privacy** → Usability in security and privacy;

Introduction

In many countries, there are only two dominant app markets: Google Play for Android phones, and Apple App Store for iPhones. China is different. Since Google Play is not routinely installed on Chinese Android phones, dozens of alternative app markets have emerged. The biggest markets are typically maintained by established Internet companies, such as Baidu or Tencent, or by mobile phone manufacturers, such as Huawei and Xiaomi [13, 12]. These app markets differ greatly in the information they present to users, the security and quality checks they conduct on the apps in their store, and the number of apps provided [12].

There is a wealth of work on dashboards and interfaces to support users in making app download decisions that take into account their privacy preferences [2, 3, 8, 11]. Relevant information includes whether an app has ads, what the app's privacy policy is, or what access permissions it needs. While no Chinese app market explicitly implements these results, some app markets are better at providing relevant information than others. In this study, we examine to what extent users actively choose markets that have more security relevant information.

Method

App Markets Used in the Study
For the purpose of our study, we selected 15 representative app markets, including 2 official app markets (Apple App Store and Google Play), the top 3 app markets maintained by large Chinese Internet companies (Tencent, Baidu and 360), the top 5 app markets provided by smartphone vendors (OPPO, Xiaomi, Meizu, Huawei and Lenovo), and 5 specialized third-party app markets (25PP, Wandoujia, Hi-

APK, Anzhi, and LIQU). Only Apple App Store and Google Play provided information about app quality, options for in-app purchases, and two features relevant to privacy and security, namely the existence of a privacy policy and the presence of ads. App quality ratings are based on downloads, user comments, developer level and other metrics. Of the third-party app markets, Tencent and 360 have quality ratings, Baidu and 360 highlight in-app purchases, and Tencent, Baidu, 360, OPPO, Huawei, and 25PP alert users to ads.

Survey
Data were collected as part of a survey on the effect of personality [6, 4] and privacy preferences [14] on app selection priorities. Scores on the privacy scale range between 0 and 63, where 63 reflects the highest level of privacy concerns.

Participants were asked about the model of phone used, the types of apps that they used and their frequency of use, and their knowledge and use of these 15 app markets. For each app market, there were five choices: *used frequently*; *used sometimes*; *used rarely*; *known, but not used*; and *unknown*. Participants were asked to provide comments on why they chose certain app markets, what they liked and disliked about app markets, and what they used app markets for. We also asked participants about the frequency of use of different app categories, using a scale that was similar to the one used for app markets.

Participants were asked to imagine that they were going to search an app store for an app that allows them to complete a relevant task. The scenarios were shopping, dating, gaming, obtaining medication from online pharmacy, and obtaining medical advice from online doctors. Both health use cases are common in China [5]).

Age		
	18–24	83 (41.5%)
	25–29	82 (41%)
	30+	35 (17.5%)
Gender		
	male	127 (63.5%)
	female	64 (32%)
	not discl.	9 (4.5%)
Occupation		
	student	63 (31%)
	employed	127 (63%)
	other	14 (7%)
OS		
	iOS	95 (47%)
	Android	104 (52%)
	both	2 (1%)
Phone Use		
	every hour	155 (77%)
	every day	44 (22%)
	less	2 (1%)

Table 1: Participant Demographics. Participants were able to choose multiple occupations, and some listed two personal phones.

The scenarios were designed to vary by the need to disclose sensitive personal information (health, dating), and by the need to disclose payment information (online shopping, health). Gaming served as a baseline. The two health scenarios were presented in two different versions, *non-stigmatising* (generic cold symptom: very bad cough) and *stigmatising* (symptom occurring near the genital area: painful urination). For half of the participants, the doctor scenario was assigned to the stigmatising condition, and the medication scenario to the non-stigmatising condition; for the other half, this was reversed.

Participants then indicated how likely they were to download an app given seven different criteria, which were chosen to reflect key differences between Chinese app markets as identified in [12]. Three of the seven criteria reflect *curation* (passed manual inspection, high quality rating, app is up to date), two provide relevant *user data from the app market* (high number of downloads, high average user rating), and the final two are *properties of the app* (contains in-app purchases, contains ads). Participants answered on a four-point Likert scale, where 1 corresponds to very likely, 2 to somewhat likely, 3 to somewhat unlikely, and 4 to very unlikely to download app with the criterion).

From the security and privacy point of view, users should ideally avoid apps that contain ads, which is of concern in particular for health apps [9]. They should also ensure that they have the latest version, which is likely to contain patches for known security issues.

The survey was designed in English, implemented on Qualtrics, and translated into Chinese. Since Chinese survey websites that provide access to balanced samples require use of their own survey tools, which have fewer functions, we recruited participants through personal networks and posts on the platform WeChat. They were reimbursed with

RMB30 through WeChat Pay. This sum was established as a fair incentive by consulting with people who had previously taken and distributed surveys in China. We sampled both Android and Apple iPhone users. The study was certified with the Ethics Panel of the School of Informatics, University of Edinburgh, reference number 2019/60328.

Analysis

Differences in demographics between groups were assessed using Fisher tests and Kruskal-Wallis tests. Differences in judgements across scenarios were assessed using the Friedman test. The Nemenyi method, which is conservative in its calculation of significance, was used for assessing pairwise differences. The threshold for statistical significance was set conservatively at 0.01. We used the implementation provided in the R Package PMCMR.

Free comments on markets (use, why, likes, dislikes) were analysed using content analysis. One of the authors extracted key issues and designed the initial code book. A second author then checked and revised the code book, and final annotations were completed based on the revised code book.

Results

Participants
We received 217 responses, of which 17 were excluded due to invalid responses on the personality and privacy scales. This leaves a total of 200 participants. Two thirds were female, most were aged below 30, and two thirds were employed. A third were students. Most of the employed participants had completed a university degree, which means that our participants were overall highly educated. While there were no gender differences by age, students were less likely to be female.

Store	Known	Used	
		At All	Frequently
Apple App Store	196	127	92
Google Play	170	58	11
Tencent	190	71	7
Baidu	190	69	2
360	190	71	6
Huawei	191	68	41
Xiaomi	189	52	13
Meizu	182	25	3
Lenovo	169	20	0
OPPO	183	36	5
X25PP	128	10	1
Wandoujia	176	42	2
HiApk	146	27	5
AnZhi	119	8	0
LIQU	117	7	0
Other	154	32	10

Table 2: Percentage of respondents who know, use, or frequently use an app store.

Four in five respondents check their mobile phone every hour (c.f. Table 1); there are no differences in age, gender, or occupation between those who do and those who do not. The average score on the privacy scale was 52 (SD: 8, range: 33–63). Participants felt quite strongly about their privacy, and most were fully aware of their personal data being tracked and collected.

All users had social and communication apps installed on their phone, and 92% reported using them frequently. Two thirds often use shopping apps, but only a quarter reports frequent mobile gaming. 68% do not have any health apps installed on their private phone, and if they do, they use them rarely.

Brand	Users	Brand Store
Apple	97	87 (90%)
Huawei	58	41 (71%)
Redmi	20	11 (50%)
OPPO	9	3 (33%)
Smartisan	2	2 (100%)
Other	15	0 (0%)

Table 3: Percentage of respondents who often use the app store associated with the brand of their own phone.

Information Preferences
Users are very likely to download an app (median rating: 1) if it has high user ratings, somewhat likely (median: 2) if it is up to date, has passed manual inspection, is of high quality, or has a high number of downloads, and somewhat unlikely (median: 3) if it contains ads.

The app features that matter to users do not vary much across scenarios. The main difference is between gaming and dating: Users are more likely to value a larger number of downloads ($p < 0.005$), higher quality ratings ($p < 0.005$), higher user ratings ($p < 0.0005$), and being up to date ($p < 0.0005$) when choosing a new game. Users also tend to prefer apps that allow them to make in-app purchases when looking for medical advice ($p < 0.0005$) or purchasing medication ($p < 0.00001$) as opposed to gaming. We found no effect of potential stigma on users' preferences for health apps. Ads always affect download decisions negatively, and human inspection always affects decisions positively.

Market Choice Inertia
Participants are aware of almost all markets mentioned in the questionnaire (median: 14, inter-quartile range: 10–15), but rely on a single app market for most downloads

(median: 1, inter-quartile range 1–1), even though they have a median of two markets installed on their phone (inter-quartile range: 1–5). Those with a phone from Apple, Huawei, Redmi, and Smartisan tend to use the app market that is associated with their mobile phone; users of OPPO and other Android phones tend to use other app markets (c.f. Table 3). 32 participants mentioned other ways of obtaining apps, including the market associated with their own phone that was not mentioned in the survey (Smartisan), independent markets such as TapTap, downloading apps from the browser, and copying installation files (APKs) directly onto their phone. One user stated that there was no need for app markets, since all apps already came with their phone.

The Apple App Store and the Huawei App Store are the only stores with more than 20 frequent users in our sample. All other stores, including well-known third party stores such as TenCent, are used far less often (c.f. Table 2). Note users answered the question about app market use for all of their phones, which explains the higher numbers in Table 2 compared to Table 3.

193 participants gave reasons for their choice of main app market. Two of them reflected system constraints: the app market came with the phone operating system (n=136 mentions, 70%), and the phone could not be jailbroken (n=14, 4%) to allow for the installation of other app markets, which was primarily a concern for iPhone users. The next most important aspect was ease of use (n=60, 31%), followed by privacy related reasons, including the absence of ads (n=27, 14%), and the number of apps available (n=20, 10%). The final set of reasons (no other markets known, popularity, less download traffic) were only mentioned rarely.

190 participants told us what they liked or disliked about app markets. Problematic issues included unavailability of

apps (n=41, 22%), ads (n=27, 14%), bad user experiences (n=21, 11%), slow speed (n=14, 7%), cost (n=11, 6%), and app recommendations (n=11, 6%). Nine users (5%) complained about security issues. A third of the respondents (n=57, 30%) were neutral about app markets; they used them because they had been provided with the phone. Positive aspects included ease of use (n=29, 15%) and range of apps available (n=23, 12%).

Discussion and Conclusion

We found strong user preferences for the app market installed on their phone, even though the most common Android App market, Huawei's, does not provide information about privacy policies, quality ratings, and in-app purchases, which are provided by vendor-independent alternatives. This accurately reflects the main reason users gave for choosing their main app market, and might be another instance of the well-known gap between users' privacy preferences and their privacy behaviour (see e.g. [10] for the disclosure of sensitive information). We obtained these results even though participants had been primed to think about privacy by administering the privacy questionnaire before the scenarios, and even though participants were well educated, of relatively high socioeconomic status, and valued online privacy. If there is one group of users that we would expect to actively choose app markets, it is this one.

The pattern of responses we have seen, which is backed up by our qualitative findings, suggests that the main app selection decisions are made outside of the app markets. This is in line with the findings of Kelley *et al.* [8] that the information in their privacy dashboard had a significant, but small effect on app choice. We suspect that participants are unlikely to switch to an app market with strong app security checks and transparent privacy dash boards, unless those features are easy to use, and there is a broad range

of apps available. Indeed, HiAPK is the only market represented that does not check copyright, check apps, or perform security checks [12]. Yet, it is the second most used among the five specialised app markets (c.f. Table 2).

There are two important confounding factors that we did not assess in this questionnaire: the role of privacy and mobile computing self-efficacy (e.g. [7, 1]), and the role of pre-app market research in app selection. The effect of additional information in the app market might be the strongest for games, because there are so many games in the market, such that users face a real choice, while the choice of apps for shopping, dating, ordering medication and consulting with doctors is a lot more narrow, and users might prioritise the ability to download their app of choice over other attributes.

In future work, we aim to conduct user interviews in order to better understand the dynamics of app and app market selection, and the stage of app selection at which privacy and security are considered. We also intend to contextualise our findings with a narrative review of what is known about Chinese users' privacy preferences, privacy strategies, and privacy self-efficacy. Last, but not least, this pilot survey only covered 200 relatively well-educated participants. We plan to test the working hypotheses discussed above in a larger study with a more socio-demographically balanced sample.

Acknowledgements

REFERENCES

[1] Hsuan-Ting Chen and Wenhong Chen. 2015. Couldn't or Wouldn't? The Influence of Privacy Concerns and Self-Efficacy in Privacy Management on Privacy Protection. *Cyberpsychology, Behavior, and Social Networking* 18, 1 (Jan. 2015), 13–19. DOI: http://dx.doi.org/10.1089/cyber.2014.0456

[2] Jing Chen, Christopher S. Gates, Ninghui Li, and Robert W. Proctor. 2015. Influence of Risk/Safety Information Framing on Android App-Installation Decisions:. *Journal of Cognitive Engineering and Decision Making* 9, 2 (2015), 149–168. DOI: http://dx.doi.org/10.1177/1555343415570055

[3] Isis Chong, Huangyi Ge, Robert W. Proctor, and Ninghui Li. 2018. Safety Priming and Subsequent App Selection Behaviors:. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 62, 1 (Sept. 2018), 302–306. DOI: http://dx.doi.org/10.1177/1541931218621069

[4] Lewis R Goldberg, John A Johnson, Herbert W Eber, Robert Hogan, Michael C Ashton, C Robert Cloninger, and Harrison G Gough. 2006. The international personality item pool and the future of public-domain personality measures. *Journal of Research in personality* 40, 1 (2006), 84–96.

[5] Jeffrey Hsu, Di Liu, Ya Min Yu, Hui Tong Zhao, Zhi Rou Chen, Jiao Li, and Wei Chen. 2016. The Top Chinese Mobile Health Apps: A Systematic Investigation. *J Med Internet Res* 18, 8 (Aug. 2016), e222. DOI: http://dx.doi.org/10.2196/jmir.5955

[6] Sih-Ci Jhu. 1992. Chinese Translation of the IPIP 50-item Big-Five markers. (1992). https://ipip.ori.org/ChineseAB5CFactorMarkers.htm

[7] Mark J. Keith, Jeffry S. Babb, Paul Benjamin Lowry, Christopher P. Furner, and Amjad Abdullat. 2015. The role of mobile-computing self-efficacy in consumer information disclosure. *Information Systems Journal* 25, 6 (Nov. 2015), 637–667. DOI: http://dx.doi.org/10.1111/isj.12082

[8] 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)*. Association for Computing Machinery, New York, NY, USA, 3393–3402. DOI: http://dx.doi.org/10.1145/2470654.2466466

[9] Konstantin Knorr, David Aspinall, and Maria Wolters. 2015. On the Privacy, Security and Safety of Blood Pressure and Diabetes Apps. In *ICT Systems Security and Privacy Protection*, Hannes Federrath and Dieter Gollmann (Eds.). Springer International Publishing, 571–584. DOI: http://dx.doi.org/10.1007/978-3-319-18467-8_38

[10] Monika Taddicken. 2014. The 'Privacy Paradox' in the Social Web: The Impact of Privacy Concerns, Individual Characteristics, and the Perceived Social Relevance on Different Forms of Self-Disclosure. *J. Comp.-Med. Commun.* 19, 2 (Jan. 2014), 248–273. DOI:http://dx.doi.org/10.1111/jcc4.12052

[11] Max Van Kleek, Ilaria Liccardi, Reuben Binns, Jun Zhao, Daniel J. Weitzner, and Nigel Shadbolt. 2017. Better the Devil You Know: Exposing the Data Sharing Practices of Smartphone Apps. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. Association for Computing Machinery, New York, NY, USA, 5208–5220. DOI: http://dx.doi.org/10.1145/3025453.3025556

[12] Haoyu Wang, Zhe Liu, Jingyue Liang, Narseo Vallina-Rodriguez, Yao Guo, Li Li, Juan Tapiador, Jingcun Cao, and Guoai Xu. 2018. Beyond Google Play: A Large-Scale Comparative Study of Chinese Android App Markets. In *Proceedings of the Internet Measurement Conference 2018 (IMC '18)*. ACM, New York, NY, USA, 293–307. DOI: http://dx.doi.org/10.1145/3278532.3278558

[13] T. Wang, D. Wu, J. Zhang, M. Chen, and Y. Zhou. 2016. Measuring and Analyzing Third-Party Mobile Game App Stores in China. *IEEE Transactions on Network and Service Management* 13, 4 (Dec. 2016), 793–805. DOI: http://dx.doi.org/10.1109/TNSM.2016.2601329

[14] Heng Xu, Sumeet Gupta, Mary Beth Rosson, and John M Carroll. 2012. Measuring mobile users' concerns for information privacy. In *Proceedings of the 33rd International Conference on Information Systems*.