Does Facebook Use Sensitive Data for Advertising Purposes?
Worldwide Analysis and GDPR Impact

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ABSTRACT
The recent European General Data Protection Regulation (GDPR) and other data protection regulations restrict the processing of some categories of personal data (health, political orientation, sexual preferences, religious beliefs, ethnic origin, etc.) due to the privacy risks associated to such information. The GDPR refers to these categories as sensitive personal data. This paper quantifies the portion of Facebook (FB) users, across 197 countries, who are labeled with advertising interests linked to potentially sensitive personal data. Our study reveals that Facebook labels 67% of users with potential sensitive interests. This corresponds to 22% of the population in the referred 197 countries. Moreover, our work shows that the GDPR enforcement had a negligible impact in this context since the portion of FB users labeled with sensitive interests in the European Union remains almost the same 5 months before and 9 months after the GDPR was enacted. The paper also illustrates potential risks associated to the use of sensitive interests. For instance, we quantify the portion of FB users labelled with the interest "Homosexuality" in countries where being gay may be punished with the death penalty. The last contribution is the implementation of a web browser extension that allows FB users removing in a simple way the potentially sensitive interests FB has assigned them.

1 INTRODUCTION
Worldwide citizens have demonstrated serious concerns regarding the management of personal information by online services. For instance, the 2015 Eurobarometer about data protection [12] reveals that: 63% of EU citizens do not trust online businesses, more than half do not like providing personal information in return for free services, and 53% do not like that Internet companies use their personal information in tailored advertising. Similarly, a recent survey carried out among US users [9] reveals that 53% of respondents were against receiving tailored ads from the information websites they visit. It is also urgent to get the attention of policymakers in their country on data protection matters.

Policymakers have reacted to this situation by passing or proposing new regulations in the area of privacy and/or data protection. For instance, in May 2018 the EU enforced the General Data Protection Regulation (GDPR) [6] across all 28 member states. Similarly, in June 2018 California passed the California Consumer Privacy Act [10], claimed to be the nation’s toughest data privacy law. In countries like Argentina or Chile governments proposed in 2017 new bills updating their existing data protection regulation [13]. For the purpose of this paper we will take as reference the GDPR since it is the one affecting more countries, citizens and companies.

The GDPR (but also most data protection regulations) defines some categories of personal data as sensitive and prohibits processing them with limited exceptions (e.g., the user provides explicit consent to process that sensitive data for a specific purpose). In particular, the GDPR defines as sensitive personal data: “data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, bio-metric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”.

Due to the legal, ethical and privacy implications of processing sensitive personal data, it is important to verify whether online services may be commercially exploiting such sensitive information. If that is the case, it is also essential to measure the portion of users/citizens who may be affected by the exploitation of their sensitive personal data. In this paper, we address these crucial questions focusing on online advertising, which represents the most important source of revenue for most online services. In particular, we consider the case of Facebook (FB), whose online advertising platform is second only to Google in terms of revenue [5].

FB labels users with the so-called ad preferences, which represent potential interests of users. FB assigns users different ad preferences based on their online activity within this social network. Advertisers running ad campaigns can target groups of users that have been assigned a particular ad preference (e.g., target FB users interested in "Starbucks"). Some of these ad preferences suggest political opinions, sexual orientation, personal health, and other potentially sensitive attributes. In fact, an author of this paper received the ad shown in Figure 1 (left side). The text in the ad clearly reflects that the ad was

Figure 1: Snapshot of an ad received by one of the authors of this paper & ad preference list showing that FB inferred this person was interested in Homosexuality.
targeting homosexual people. The author had not explicitly defined his sexual orientation, but he discovered that FB had assigned him the "Homosexuality" ad preference (see Figure 1 right side). The dataset collected for this research suggests that similar assignment of potentially sensitive ad preferences occurs much more broadly. For example, some landing pages associated with ads stored in our dataset include: iboesterreich.at (political), gaydominante.com (sexuality), elpartoestuyo.com (health).

This episode illustrates that FB may be actually processing sensitive personal information, which is now prohibited under the EU GDPR without explicit consent, but it was neither allowed under some EU national data protection regulations prior to the GDPR. In May 2017, the French Data Protection Agency (DPA) fined Facebook with €150K arguing (among other things) that FB "collects sensitive data of the users without obtaining their explicit consent".1 Similarly, In September 2017, the Spanish DPA fined FB €1.2M arguing (among other things) that FB "collects, stores and uses data, including specially protected data, for advertising purposes without obtaining consent".2

Motivated by all these events, this paper examines Facebook’s use of potentially sensitive data across 197 different countries in February 2019. The main goal of this paper is quantifying the portion of FB users that may have been assigned ad preferences linked to potentially sensitive personal data. In addition, for the particular case of the 28 countries forming the EU, we analyze whether there has been some relevant reduction in the portion of users labelled with potentially sensitive ad preferences comparing three datasets collected in January 2018, October 2018 and February 2019 (5 months before, 5 months after and 9 months after the GDPR was enacted, respectively). We also illustrate privacy and ethics risks that may be derived from the exploitation of sensitive FB ad preferences. Finally, we present a technical solution that allows users to remove in a simple way the potentially sensitive interests FB has assigned them.

2 BACKGROUND

Advertisers configure their ads campaigns through the FB Ads Manager.3 It allows advertisers to define the audience (i.e., user profile) they want to target with their advertising campaigns. It can be accessed through either a dashboard or an API. The FB Ads Manager offers advertisers a wide range of configuration parameters such as (but not limited to): location (country, region, etc.), demographic parameters (gender, age, etc.), behaviors (mobile device, OS and/or web browser used, etc.), and interests (sports, food, etc.). The interest parameter is the most relevant for our work. It includes hundreds of thousands of possibilities capturing users’ interest of any type.

The FB Ads Manager provides detailed information about the configured audience. The most relevant element for our paper is the Potential Reach that reports the number of monthly active users in FB matching the defined audience.

In parallel, FB assigns to each user a set of ad preferences, i.e., a set of interests, derived from the data and activity of the user on FB. These ad preferences are indeed the interests offered to advertisers in the FB Ads Manager.4 Therefore, if a user is assigned " Watches" within her list of ad preferences, she will be a potential target of any FB advertising campaign configured to reach users interested in watches.

The dataset used in this work is obtained from the data collected with our FDVT web browser extension [1]. The FDVT main functionality is to inform FB users of the revenue they generate out of the ads they receive in FB. The FDVT collects (among other data) the ad preferences FB assigns to the user. It is important to note that FDVT users granted us explicit permission to use the collected information (in an anonymous manner) for research purposes.

Finally, for any ad preference, we are able to query the FB Ads Manager API to retrieve the Potential Reach (i.e., FB active users) associated to any FB audience. Hence, we are able to obtain the number of FB users in any country (or group of countries) that have been assigned a particular interest (or group of interests).

3 DATA AND METHODOLOGY

We seek to quantify the number of FB users that have been assigned potentially sensitive ad preferences across 197 countries in February 2019. To this end we follow a two step process.

First, we identify likely sensitive ad preferences within five of the relevant categories listed as Sensitive Personal Data by the GDPR: racial or ethnic origin, political opinions, religious or philosophical beliefs, health, and sexual orientation. This paper reuses the list of 2092 potentially sensitive ad preferences we obtained in [2] out of analyzing more than 126K unique ad preferences assigned 5.5M times to more than 4.5K FDVT users.

To extract that list we first implemented an automatic process to reduce the list of 126K ad preferences to 4452 likely sensitive ad preferences. Next, a group of 12 panelists manually classified the 4452 ad preferences into sensitive, in case they could be assigned to some of the five sensitive categories referred above, or non-sensitive. Each ad preference received 5 votes, and we used majority voting [11] to classify each ad preference either as sensitive or non-sensitive. Overall, 2092 out of the 4452 ad preferences were labeled as sensitive. The complete list of the ad preferences classified as sensitive can be accessed via the FDVT site 5. We referred to this subset of 2092 ad preferences as the suspected sensitive subset. We collected this list in January 2018, and checked that 2067 out of these 2092 potentially sensitive ad preferences were still available within the FB Ads Manager in February 2019.

Second, we leveraged the FB Ads Manager API to retrieve the portion of FB users in each country that had been assigned at least one of the Top N (with N ranging between 1 and 2067) potentially sensitive ad preferences from the suspected sensitive subset. In particular, we retrieve how many users in a given country are interested in ad preference 1 OR ad preference 2 OR ad preference 3... OR ad preference N. An example of this for N = 3 could be "how many people in France are interested in Pregnancy OR Homosexuality OR Veganism". We have defined the following metric that we use in the rest of the paper.

1https://www.cnil.fr/en/facebook-sanctioned-several-breaches-french-data-protection-act
2https://techcrunch.com/2017/09/11/facebook-fined-et-2m-for-privacy-violations-in-spain/
3https://www.facebook.com/ads/manager
4https://fdvt.org/usenix2018/panelists.html
5Given that interests and ad preferences refer to the same thing, we use these two terms interchangeably in the rest of the paper.
Figure 2: Choropleth map of the number of FB users assigned potentially sensitive ad preferences (FFB(C,1000)) for the 197 countries analyzed in the paper.

- FFB(C,N): Percentage of FB users in country C that have been assigned at least one of the top N potentially sensitive ad preferences from the suspected sensitive subset. We note C may also refer to all the countries forming a particular region (e.g., EU, Asia-Pacific, America, etc.). FFB(C,N) is computed as the ratio between the number of FB users that have been assigned at least one of the top N potentially sensitive ad preferences and the total number of FB users in country C. Finally, it is important to note that the FB Ads Manager API only allows creating audiences with at most N = 1000 interests. Therefore, in practice, the maximum value of N we can use to compute FFB is 1000.

4 EXPOSURE OF FB USERS TO POTENTIALLY SENSITIVE AD PREFERENCES

We have computed the portion of FB users that have been assigned some of the 2067 potentially sensitive ad preferences within 197 different countries. Figure 2 shows a choropleth map of FFB(C,1000) for those countries in February 2019.

If we consider the 197 all together, 67% of FB users are tagged with some potentially sensitive ad preference. This portion of users actually corresponds to 22% of citizens across the 197 analyzed countries according to the population data reported by the World Bank\(^6\). However, FFB shows an important variation across countries.

We find that the most impacted country is Malta where 82% of FB users are assigned some potentially sensitive ad preference. Contrary, the least impacted country is Equatorial Guinea where 37% of FB users are assigned potentially sensitive ad preferences.

More interesting, an overview of the map seems to suggest that western countries have a higher exposure to potentially sensitive ad preferences compared to Asian and African countries. To quantify these effects we have computed the Pearson correlation of the FFB metric with the following socio-economic indicators: (i) FB penetration, (ii) expected years of school; (iii) access to a mobile phone or internet at home; (iv) GDP per capita; (v) voice and accountability; and (vi) birth rate. Note that Western developed countries shows higher values in all the indicators but birth rate. Hence our hypothesis is that we will find positive correlation between FFB and all the indicators but birth rate. Table 1 shows the results of the referred correlations. Note that in all the cases the results are statistically significant since the highest p-value is 1.478e-06.

| indicator                                                      | correlation FFB | p_value   |
|----------------------------------------------------------------|-----------------|-----------|
| FB penetration                                                 | 0.544           | 2.2e-16   |
| Expected Years of School                                       | 0.444           | 7.249e-09 |
| Access to a mobile phone or internet at home (% age 15+)       | 0.395           | 1.478e-06 |
| GDP per capita (current USD)                                   | 0.381           | 5.733e-08 |
| Voice and Accountability                                      | 0.372           | 1.142e-07 |
| Birth rate, crude (per 1,000 people)                          | -0.455          | 4.922e-11 |

Table 1: Pearson correlation and p_value between FFB and six socioeconomic development indicators of the country.

The results Table 1 corroborate our hypothesis since all the indicators but birth rate are positively correlated with FFB. In summary, the results validate our initial observation that FB users in western developed countries are more exposed to be labelled with sensitive ad preferences than users in Africa and Asia. It is interesting to observe that in the case of South-America we observe a similar pattern in which the most powerful economies and developed countries such as Brazil, Chile and Argentina shows higher exposure to sensitive ad preferences than other countries in South-America.

5 EXPOSURE OF FB USERS TO VERY SENSITIVE AD PREFERENCES

Although legislation tries to define what sensitive data is, some people might think that not all different sensitive data items are equally sensitive. For instance, data revealing sexual orientation from somebody could be considered more sensitive than, for example, data showing that one user may be affected by a flu. Therefore,
the level of sensitivity of our list of interests could vary depending on the importance given by someone.

In this section, we zoom in on our analysis in a narrowed list of interests that match undoubtedly with the definition of the GDPR for the case of sensitive personal data. We examined a subset of 15 ad preferences that have been verified by an expert from the Spanish DPA as initially not compliant with the GDPR definition of sensitive personal data.

We retrieve the portion of users in FB for each of the 15 expert-verified ad preferences and the aggregation of them. Since it is unsafe to show the results for each of the countries within the paper, we have grouped them into five continents: Africa, America, Asia, Europe and Oceania. To obtain the desegregated results for each of the 197 countries we refer the reader to the following external link.\(^7\)

Table 2 shows FFB for each of the expert-verified sensitive ad preferences within the five continents. In addition, the last row referred to as Union shows the aggregated results considering all the 15 interests within a group, while the last column World depicts the overall results considering all 197 countries. The results show that when considering all the 197 countries 33% of FB users, which corresponds to almost 11% of citizens within those countries, have been labeled with some of the 15 sensitive interests in the table. As it was expected from the correlation results depicted in the previous section, Asia and Africa are showing the lowest values of FFB (27.62% and 30.43%, respectively). The exposition of FB users grows up to 38.25%, 40.66% and 46.92% for Europe, America and Oceania, respectively.

If we look in detail some of the ad preferences in the table, we observe that the portion of users across the 197 countries labeled with the ad preference homosexuality is almost 5%. This number doubles for the ad preference bible (intimate related to one particular religious belief), and grows up to almost 15% for pregnancy.

![Figure 3: Variation of FFB in percentage points for each EU country between: (i) the data obtained in January 2018 and October 2018 (5 months before and 5 months after the GDPR was enacted) represented by the grey bar; (ii) the data obtained in January 2018 and February 2019 (5 months before and 9 months after the GDPR was enacted) represented by the black bar. The last label (EU28) represents the results for all EU countries together.](https://fdvt.org/world_sensitivities_2019/display_sensitivities.html)

### 6 COMPARISON OF EU FB USERS EXPOSURE TO POTENTIALLY SENSITIVE AD PREFERENCES BEFORE AND AFTER GDPR ENFORCEMENT

This section aims to analyze whether the GDPR enforcement had some effect on the utilization of potentially sensitive ad preferences to label FB users in the EU. To that end we compare the exposure of EU users to potentially sensitive ad preferences in January 2018 [2] (5 months before the GDPR was enforced) to the exposure measured in October 2018 and February 2019 (5 and 9 months after the GDPR was enforced, respectively).

The first relevant change is that Facebook had removed 19 ad preferences in October 2018 and 25 in February 2019 from the set of 2092 potentially sensitive ad preferences we retrieved in January 2018. Although this is a negligible amount, it is worth noting that five of the removed ad preferences are: Communism, Islam, Quran, Socialism and Christianity. These five ad preferences were included in an initial set of 20 ad preferences verified by the DPA expert as very sensitive. Hence, it seems FB is starting to consider some very sensitive interests as too invasive and has decided to remove them from its advertising platform.

Figure 3 shows the FFB difference in percentage points between the results obtained in January 2018 and October 2018 (grey bar); and between January 2018 and February 2019 (black bar) across the 28 EU countries, and the EU aggregated labeled as EU28.

If we consider the results of October 2018, we observe that the portion of users labelled with potentially sensitive ad preferences was lower in all EU countries but Spain after the GDPR enforcement (i.e., compared to the data obtained in January 2018). However, the aggregated EU reduction is rather small, only 3 percentage points. The largest reduction is 7.33 percentage points in the case of Finland.
Table 3: Percentage of FB users (FFB) tagged with the interest Homosexuality in countries where being homosexual may lead to death penalty. Note we do not include Iran and Sudan since FB is not providing information for those countries.

| Code | Country       | Homosexuality |
|------|---------------|---------------|
| AF   | Afghanistan   | 12.31         |
| MR   | Mauritania    | 0.99          |
| QA   | Qatar         | 2.35          |
| SO   | Somalia       | 1.44          |
| PK   | Pakistan      | 1.54          |
| AE   | United Arab Emirates | 3.00 |
| NG   | Nigeria       | 2.35          |
| SA   | Saudi Arabia  | 2.08          |
| YE   | Yemen         | 1.68          |
| IQ   | Iraq          | 3.20          |

The slight GDPR effect observed in the results obtained in October 2018 seems to disappear when we observe the results from February 2019. There are 13 countries where the portion of users labelled with potentially sensitive data is higher in February 2019 as compared to January 2018. Overall, the aggregated results shows that the portion of users labeled with potentially sensitive ad preferences in February 2019 is only 1% less than in January 2018.

In summary, FB seems to have adopted some steps to eliminate few very invasive ad preferences, but the overall impact of the GDPR to prevent FB of using potentially sensitive ad preferences for advertising purposes is negligible.

7 ETHICS AND PRIVACY RISKS ASSOCIATED WITH SENSITIVE PERSONAL DATA EXPLOITATION

The possibility of reaching users labeled with potentially sensitive personal data enables the use of FB ads campaigns to attack (e.g., hate speech) specific groups of people based on sensitive personal data (ethnicity, sexual orientation, religious beliefs, etc.). Even worse, in [2], we performed a ball-park estimation showing that in average an attacker could retrieve personal identifiable information (PII) of users tagged with some sensitive ad preference through a phishing-like attack [7] at a cheap cost ranging between €0.015 and €1.5 per user, depending on the success ratio of the attack. Following, we describe other potential risks associated to sensitive ad preferences.

Recently, a journalist of the Washington Post wrote an article to denounce her own experience after she become pregnant. It seems FB algorithms inferred that situation out of some actions she performed while browsing in Facebook. Probably FB labelled her with the ad preference “pregnancy” or some other similar and she started to receive pregnancy-related ads. Unfortunately, the journalist had a stillbirth but she kept receiving ads related to pregnancy, which exposed here to a very uncomfortable experience.

Another serious risk, which in our opinion is extremely worrying, is linked to the fact that many FB users are tagged with the interest “Homosexuality” in countries where being homosexual is illegal and may even be punished with the death penalty. There are still 78 countries in the world where the homosexuality is penalized and few of them such where Death Penalty is the maximum punishment. Table 3 shows the FFB metric results only considering the interest “Homosexuality” in countries that penalize homosexuality with the death penalty. For instance, in the case of Saudi Arabia we found that FB assigns the ad preference “Homosexuality” to 540K people (2.08% of FB users in that country). In the case of Nigeria 620K (2.35% of FB users in that country).

We acknowledge the debate regarding what is sensitive and what is not is a complex one. However, we believe FB should take immediate actions to avoid worrying and painful situations like the one exposed in this section, in which FB may unintentionally expose users to serious risks. For instance, a straightforward action should be stop using the ad preference “Homosexuality” (or similar ones) in countries where being homosexual is illegal.

8 FDVT EXTENSION TO ALLOW USERS REMOVING POTENTIALLY SENSITIVE AD PREFERENCES

The results reported in previous sections motivate a need for solutions that make users aware of the use of sensitive personal data for advertising purposes. In addition, it is also important to empower them to remove in a very simple manner those sensitive ad preferences they do not fill comfortable with. Unfortunately, the existing process FB offers is unknown and complex for most users.

To this end, we have extended the FDVT browser extension to: (i) inform users about the potentially sensitive ad preferences that FB has assigned them, both the active ones but also those ones assigned in the past that are not currently active; (ii) allow users to remove with a single click either all the active sensitive ad preferences or those individual ones users do not fill comfortable with.

We have introduced a new button in the FDVT extension interface with the label “Sensitive FB Preferences”. When a user clicks on that button, we display a page listing at the top the potentially sensitive ad preferences included in the user’s ad preference set (both the active ones and inactive ones). Figure 4 shows an example of this page. We provide the following information for each ad preference: (i) Ad preference name, (ii) Topic and, (iii) Sensitive, whether the ad preference is potentially sensitive (highlighted in yellow) or not.

In addition, next to each ad preference there is a button Delete Ad Preference to individually remove those ad preferences. Moreover,
we provide another button More Info to individually display the historical information for the ad preference, which includes the period(s) when the ad preference has been active and the reason why FB has assigned that ad preference to the user. Finally, at the top of the page we include a search bar to look for specific preferences and two buttons: Delete All Sensitive Ad Preferences and Delete All Ad Preferences to remove all currently active potentially sensitive ad preferences and all currently active, respectively.

9 RELATED WORK

We published a prior paper [2] in which we already analyzed the use of sensitive information on Facebook. That paper just focuses on the European Union few months before the GDPR was enacted. The research community asked us in various forums that it would be interesting to further extend our analysis to: (i) cover the use of sensitive information in Facebook worldwide and not just in the EU, and (ii) understand the potential impact that the GDPR could have on reducing the exposure of users to sensitive ad preferences. This paper covers both requests and, in addition, it adds two more contributions: (i) we present two clear scenarios in which the use of sensitive ad preferences could have serious consequences for the users; and (ii) we introduce an improvement of the FDVT that allows users to remove in a simple way potentially sensitive ad preferences they do not like. Hence, this paper notably extends our previous work.

There are also few previous works in the literature that address issues associated with sensitive personal data in online advertising, as well as some recent works that analyze privacy and discrimination issues related to FB advertising and ad preferences.

Carrascosa et al. [3] propose a new methodology to quantify the portion of targeted ads received by Internet users while they browse the web. They create bots, referred to as personas, with very specific interest profiles (e.g., persona interested in cars) and measure how many of the received ads actually match the specific interest of the analyzed persona. They create personas based on sensitive personal data (e.g., health) and demonstrate that they are also targeted with ads related to the sensitive information used to create the persona’s profile.

Castelluccia et al. [4] show that an attacker that gets access (e.g., through a public WiFi network) to the Google ads received by a user could create an interest profile that could reveal up to 58% of the actual interests of the user. The authors state that if some of the unveiled interests are sensitive, it could imply serious privacy risks for users.

Venkatadri et al. [15] and Speicher et al. [14] exposed privacy and discrimination vulnerabilities related to FB advertising. In [15], the authors demonstrate how an attacker can use Facebook third-party tracking JavaScript to retrieve personal data (e.g., mobile phone numbers) associated with users visiting the attacker’s website. Moreover, in [14] they demonstrate that sensitive FB ad preferences can be used to apply negative discrimination in advertising campaigns (e.g., excluding people based on their race). The authors also show that some ad preferences that initially may not seem sensitive could be actually used to discriminate in advertising campaigns (e.g., excluding people interested in Blacknews.com that are potentially black people).

10 CONCLUSION

Facebook offers advertisers the option to commercially exploit potentially sensitive information to perform tailored ad campaigns. This practice lays, in the best case, within a gray legal area according to the recently enforced GDPR. Our results reveal that 67% of FB users (22% of citizens) worldwide are labeled with some potentially sensitive ad preference. Interestingly, users in rich developed countries present a significantly higher exposure to be assigned sensitive ad preferences. Our work also reveals that the enforcement of the GDPR had a negligible impact on FB regarding the use of sensitive ad preferences within the EU. We believe it is urgent that stakeholders within the online advertising ecosystem (i.e., advertisers, ad networks, publishers, policy makers, etc.) define an unambiguous list of personal data items that should not be used anymore to protect users from potential privacy risks as those ones described in this paper.

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REFERENCES

[1] José González Cañabas, Ángel Cuevas, and Rubén Cuevas. 2017. FDVT: Data Valuation Tool for Facebook Users. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI ’17). ACM, New York, NY, USA, 3799–3809. https://doi.org/10.1145/3025453.3025903

[2] José González Cañabas, Ángel Cuevas, and Rubén Cuevas. 2018. Unveiling and Quantifying Facebook Exploitation of Sensitive Personal Data for Advertising Purposes. In 47th USENIX Security Symposium (USENIX Security 18). USENIX Association, Baltimore, MD, 479–495. https://www.usenix.org/conference/usenixsecurity18/presentation/cabanbas

[3] Juan Miguel Carrascosa, Jakub Máklans, Rubén Cuevas, Vijay Erramilli, and Nikolay Sauturs. 2015. I Always Feel Like Somebody’s Watching Me: Measuring Online Behavioural Advertising. In Proceedings of the 11th ACM Conference on Emerging Networking Experiments and Technologies (CoNEXT ’15). ACM, New York, NY, USA, Article 13, 13 pages. https://doi.org/10.1145/2716281.2836098

[4] Claude Castelluccia, Mohamed-Ab Raafar, and Minh-Dang Tran. 2012. Betrayed by your ads? In International Symposium on Privacy Enhancing Technologies Symposium. Springer, Springer Berlin Heidelberg, Berlin, Heidelberg, 1–17.

[5] Emarketer.com. 2017. Google and Facebook tighten grip on US digital ad market. https://www.emarketer.com/Article/Google-Facebook-Tighten-Grip-on-US-Digital-Ad-Market/1016494.

[6] EU. 27 April 2016. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). http://eur-lex.europa.eu/eli/reg/2016/679/oj.

[7] Jason Hong. 2012. The State of Phishing Attacks. Commun. ACM 55, 1 (Jan. 2012), 74–81. https://doi.org/10.1145/2063176.2063197

[8] InternetSociety.org. 2016. The Internet Society Survey on Policy Issues in Asia-Pacific 2016. https://www.internetsociety.org/wp-content/uploads/2017/08/ APAC_Regional_Policy_Survey_Report_2016_final_copy.compressed.pdf.

[9] Janrain.com. 2018. Consumer Attitudes Toward Data Privacy Survey 2018. https://www.janrain.com/resources/industry-research/consumer-attitudes-toward-data-privacy-survey-2018.

[10] California State Legislature. 2018. California Consumer Privacy Act. https://www.capivory.org/.

[11] Anand Narasimhamurthy. 2005. Theoretical bounds of majority voting performance for a binary classification problem. IEEE Transactions on Pattern Analysis and Machine Intelligence 27, 12 (2005), 1988–1995.
[12] TNS Opinion and Social. 2015. Special Eurobarometer 431 Data Protection. http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_431_en.pdf.
[13] PWC.in. 2018. Privacy in the Data Economy. https://www.pwc.in/assets/pdfs/publications/2018/privacy-in-the-data-economy.pdf.
[14] Till Speicher, Muhammad Ali, Giridhari Venkatadri, Filipe Nunes Ribeiro, George Arvanitakis, Fabrício Benevenuto, Krishna P Gummadi, Patrick Loiseau, and Alan Mislove. 2018. Potential for Discrimination in Online Targeted Advertising. In Proceedings of the 1st Conference on Fairness, Accountability and Transparency (Proceedings of Machine Learning Research), Sorelle A. Friedler and Christo Wilson (Eds.), Vol. 81. PMLR, New York, NY, USA, 5–19.
[15] Giridhari Venkatadri, Yabing Liu, Athanasios Andreou, Oana Goga, Patrick Loiseau, Alan Mislove, and Krishna P Gummadi. 2018. Privacy risks with Facebook’s PII-based targeting: Auditing a data broker’s advertising interface. In S&P 2018, IEEE Symposium on Security and Privacy. IEEE, San Francisco, CA, USA, 89–107.