

# Public Perception of the German COVID-19 Contact-Tracing App *Corona-Warn-App*

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**Abstract**—Several governments introduced or promoted the use of contact-tracing apps during the ongoing COVID-19 pandemic. In Germany, the related app is called *Corona-Warn-App*, and by end of 2020, it had 22.8 million downloads. Contact tracing is a promising approach for containing the spread of the novel coronavirus. It is only effective if there is a large user base, which brings new challenges like app users unfamiliar with using smartphones or apps. As *Corona-Warn-App* is voluntary to use, reaching many users and gaining a positive public perception is crucial for its effectiveness. Based on app reviews and tweets, we are analyzing the public perception of *Corona-Warn-App*. We collected and analyzed all 78,963 app reviews for the Android and iOS versions from release (June 2020) to beginning of February 2021, as well as all original tweets until February 2021 containing #CoronaWarnApp (43,082). For the reviews, the most common words and n-grams point towards technical issues, but it remains unclear, to what extent this is due to the app itself, the used *Exposure Notification Framework*, system settings on the user’s phone, or the user’s misinterpretations of app content. For Twitter data, overall, based on tweet content, frequent hashtags, and interactions with tweets, we conclude that the German Twitter-sphere widely reports adopting the app and promotes its use.

**Index Terms**—corona, SARS-CoV-2, COVID-19, contact-tracing, app reviews, Twitter

## I. INTRODUCTION

The worldwide ubiquitous use of smartphones allows for technical support in tackling the spread of the novel coronavirus SARS-CoV-2 and the related ongoing COVID-19 pandemic [1]. Different countries with different cultures and different traditions regarding privacy and data protection implemented different solutions for contact-tracing apps. Such apps mostly make sense when a significant part of the population uses them. In order to achieve public acceptability of such apps, there is the question of public perception and sentiment, i.e., what do the users of such an app and the general population think about it? In this paper, we investigate the public perception of the contact-tracing app used in Germany, *Corona-Warn-App*. As an extension to existing survey-based studies [2], [3], we analyze app review data from the Apple

App Store and from Google Play, as well as public tweets with the corresponding hashtag #CoronaWarnApp. Our analysis can help to achieve a better understanding of the users’ sentiment toward the app. Our main contribution in this paper is the collection and analysis of more than 75,000 app reviews and 40,000 tweets about the German COVID-19 contact-tracing app *Corona-Warn-App*.

The rest of the paper is structured as follows. Section II introduces the background and details related work. Section III describes the methodology and how we collected and analyzed app reviews and tweets. In Section IV, we give the results, which we discuss in Section V, before concluding in Section VI.

## II. BACKGROUND AND RELATED WORK

*Corona-Warn-App* is an open source COVID-19 contact tracing app. Figure II shows the main screen of the app. It was developed by Deutsche Telekom (one of the largest telecommunications companies in Europe) and SAP (one of the largest software companies in the world) and released by RKI (Robert Koch Institute), the German federal agency for public health responsible for disease control and prevention. The app was released on June 16, 2020, its use is voluntary, and by the end of November 2020, 22.8 million users downloaded the app, with Germany having a population of 83 million<sup>1</sup>. The core functionality of *Corona-Warn-App* utilizes Bluetooth via the *Exposure Notification Framework* from Apple/Google to trace which other devices have been in proximity. The IDs that are exchanged are generated continually and are valid for 10-20 minutes. They are derived from device-specific keys that are locally created every 24 hours. The IDs that are marked as positive for a coronavirus test, are regularly downloaded from a server and are locally compared to the list of devices met before<sup>2</sup>. When tested, the user can use the app to scan a QR-code at the doctor’s office or testing station and can get the result of the test via the app. At the end of 2020, *Corona-Warn-App* introduced a new contact journal feature, allowing users to manually log who they met.

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<sup>1</sup>[https://www.rki.de/DE/Content/InfAZ/N/Neuartiges\\_Coronavirus/WarnApp/Archiv\\_Kennzahlen/Kennzahlen\\_20112020.pdf](https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/WarnApp/Archiv_Kennzahlen/Kennzahlen_20112020.pdf)

<sup>2</sup><https://www.coronawarn.app/en/>

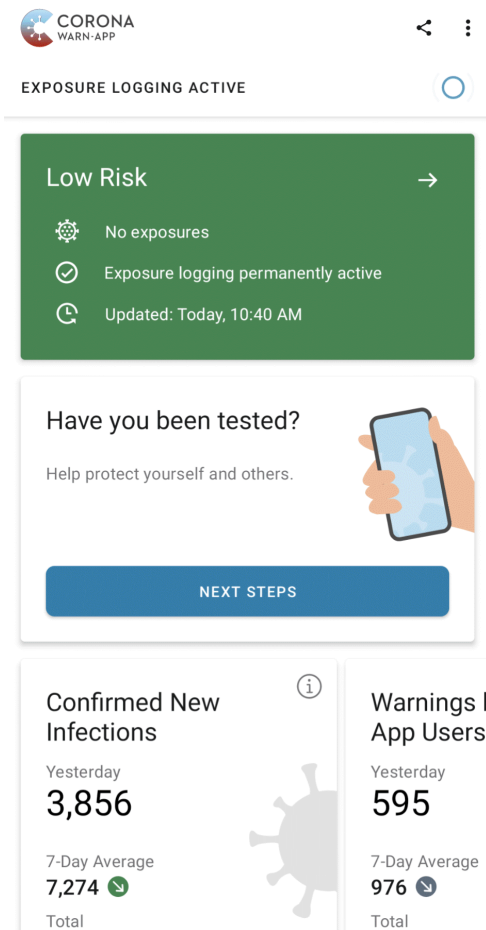


Fig. 1. Main screen of Corona-Warn-App.

Our previous research has shown that in general, users are quite willing to share data with researchers when using apps voluntarily [4]. Additionally, apps focusing on entertainment or social networking, like Facebook or TikTok, have lots of users in Germany, without concerns about privacy being a deal-breaking point for the general population. The case of a governmental contact-tracing app is different in some key respects:

**Target audience and user base:** The target audience or scope of the app is much higher compared to traditional apps because of the ubiquity of the novel coronavirus and its effect on daily life. Contact-tracing apps are not aimed at any specific age group or market segment, but are aimed at anyone using a smartphone. From the wider scope follows a more diverse user base than any other app. This includes users that might be unfamiliar with app usage, smartphone usage, or technology in general, and poses challenges to the design of the app.

Because of the big scope of the app, Corona-Warn-App probably was under special scrutiny from its inception. Users might be more prone to be critical of the government, combined with the large scope and user base, this might lead to a large, critical user base with parts of it not having

the background to understand how the app works. How the tracing technically works, what changing identifiers mean, how data is exchanged, what data is actually exchanged, etc., is information that is hard to convey to non-tech-savvy users. All this can create potential misunderstandings about technical limitations in terms of functionality of the app.

Altmann et al. published a paper about a survey asking participants about contact-tracing apps [2] (published end of August 2020). They found very high willingness to install and use COVID-19 contact-tracing apps. Horstmann et al. conducted a survey about the usage of Corona-Warn-App [3] (published mid-December 2020). A survey among 1,972 German adult reveals that non-users had low trust in other people and often cited privacy concerns or doubts regarding the app's effectiveness as reasons. Now that a about a year of the pandemic has passed and such apps are deployed and in use for some time, publicly available data can help understand how users perceive them, rate them, and what aspects they discuss about.

### III. METHODOLOGY

We used appbot<sup>3</sup> for exporting publicly available app review data from the Apple App Store and Google Play. We exported 78,963 reviews for the time until 4 February 2021. Appbot detects the language; 75,891 of the reviews are in German (96%). Out of those, 77% are for the Android app and 23% for the iPhone app. In contrast to only a *rating*, a *review* contains manual text input from the reviewing user. For the same time window, appbot reports 166,439 ratings, 109,539 on Google Play (66%), and 56,900 on Apple App Store (34%). This means that 47% of users that rated the app also wrote a review. We analyzed the ratings of the reviews, the reviews' distribution and ratings over time as well as the review content. We pre-processed the review texts, this includes stop word removal and stemming, before we analyzed the review content in terms of frequency of used words and n-grams.

Additionally, we collected all original tweets (i.e., no retweets) containing #CoronaWarnApp until February 4, 2021 via the Twitter API v2. Twitter has 5.45 million users in Germany as of end of 2020<sup>4</sup>. We collected 43,082 tweets and analyzed the distribution and context of the tweets. As with the reviews, we pre-processed the tweets before looking into frequent words, n-grams, and hashtags.

### IV. RESULTS

First of all, we note that if the reported number of 22.8 million app downloads is correct, only about 0.7% of app downloaders rated the app, and about half of those left a review. Still, the number of users reflected in our analysis is much higher than it is feasible in, e.g., a typical survey. Furthermore, we assume that app reviews and tweets often have a signaling effect because they can be posted by almost anyone and are publicly visible. Users that do not see their

<sup>3</sup><https://appbot.co>

<sup>4</sup><https://www.statista.com/statistics/242606/number-of-active-twitter-users-in-selected-countries/>

opinion expressed in the reviews or on Twitter can just write their own review or tweet.

### A. App Reviews

The distribution between Android and iOS in the reviews (77% Android) roughly matches that of the distribution of Android and iOS market shares in Germany (64% Android)<sup>5</sup>. Looking at all ratings, including those without a review, for Android, 36% of the ratings were 5-star ratings, and 35% were 1-star ratings. The average was 3.0 stars. For iOS, 75% of the ratings were 5-star ratings, the average was 4.3 stars. Just looking at the ratings that contain a manually written review, we get the results shown in Figures 2 and 3. The averages for Android and iOS both were 2.9 stars. Overall, the average rating of those with a review was lower, especially for iOS. For the ratings with reviews, 1-star ratings made up the largest proportion of the reviews, for both Android and iOS. We consider this evidence that negative perceptions drive users more to write a review than positive perceptions. Figures 2 and 3 show that almost 70% of the reviewers either gave a 1-star rating or a 5-star rating. At the time of writing, other often downloaded apps like *Jitsi Meet* or *Zoom* show a similar pattern of mostly 1-star or 5-star reviews.

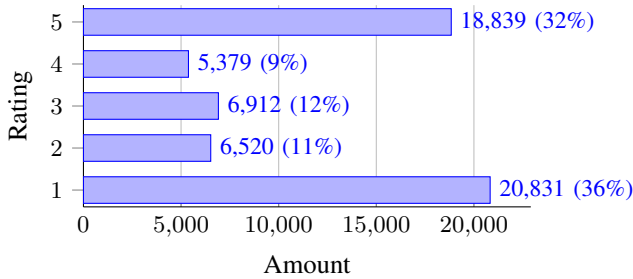


Fig. 2. Distribution of ratings from Android reviews.

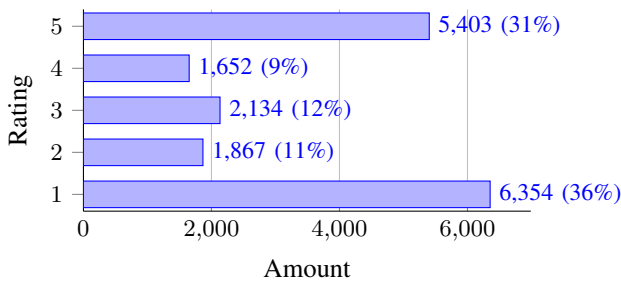


Fig. 3. Distribution of ratings from iOS reviews.

Ratings of the reviews over time are shown in Figure 4. The blue line with circles shows the amount of downloads and the red line with stars shows the average number of ratings. We observe that 36% of all reviews (as of end of January 2020) were from June 2020. The amount of reviews was in steady decline, except for a slight increase in October 2020. The average rating in the reviews started out at 3.6 in June

<sup>5</sup><https://gs.statcounter.com/os-market-share/mobile/germany>

2020, declined rapidly after that, and stayed at around 2.4 since August 2020.

For Google Play, appbot exports the public reply rates of the app developer. The provider of the app can directly answer to reviews. This was done to a large extent for Corona-Warn-App. The reply rate was 50%-60% for all reviews with 1 to 4 stars, and 31% for the reviews with 5 stars. There were 26,138 manual replies to reviews, indicating a large effort taken.

In order to get a better understanding of what users are writing about in their reviews, we looked into the most frequent words and n-grams. Taking into account the 75,891 German reviews, for pre-processing, we removed stop words. Then, we used the CISTEM stemmer for getting the stem of each word [5].

Table I shows the English translation of the most frequent word stems in the German reviews. Some of the words can be used in both positive as well as negative contexts, for example, a review could contain "The app is not *good*" or "The app is *good*." The word *good* alone does not suffice to interpret the sentiment of the review. There are some words, however, that we regard as relevant for understanding the public perception of the app. We assume that (*to*) *function*, *update*, *test*, and *error* all refer to the functionality of the app. While *update* and *error* likely refer to the technical side, *test* likely refers to coronavirus tests, for which the result can be received via the app.

TABLE I  
MOST FREQUENT WORDS IN APP REVIEWS (ANDROID AND IOS).

Word	Occurrences
day	20,137 (27%)
to function	15,552 (20%)
more	13,116 (17%)
since	12,873 (17%)
good	12,237 (16%)
always	9,241 (12%)
update	8,707 (11%)
test	8,705 (11%)
error	8,462 (11%)

Table II shows the most frequent bigrams, and Table III shows the most frequent trigrams. We observe that *day* was the most frequent word and that there were two frequent bigrams containing "*day*": *since, day* and *day, active*. When Corona-Warn-App is started for the first time, it indicates that because of the incubation period, the app should be used for 14 days to track encounters for long enough before meaningful results can be displayed. For this time period, the number of days the app is already in use is shown on the main screen. *Day, active* probably refers to this. *Since, day* might refer to the same aspect, or to some other time period in which the user is waiting for something, for example, change in app functionality, or waiting for a test result. All other bigrams and all listed trigrams refer to the functionality of the app. There seems to be a focus on technical aspects: Google, API, QR Code, communication.

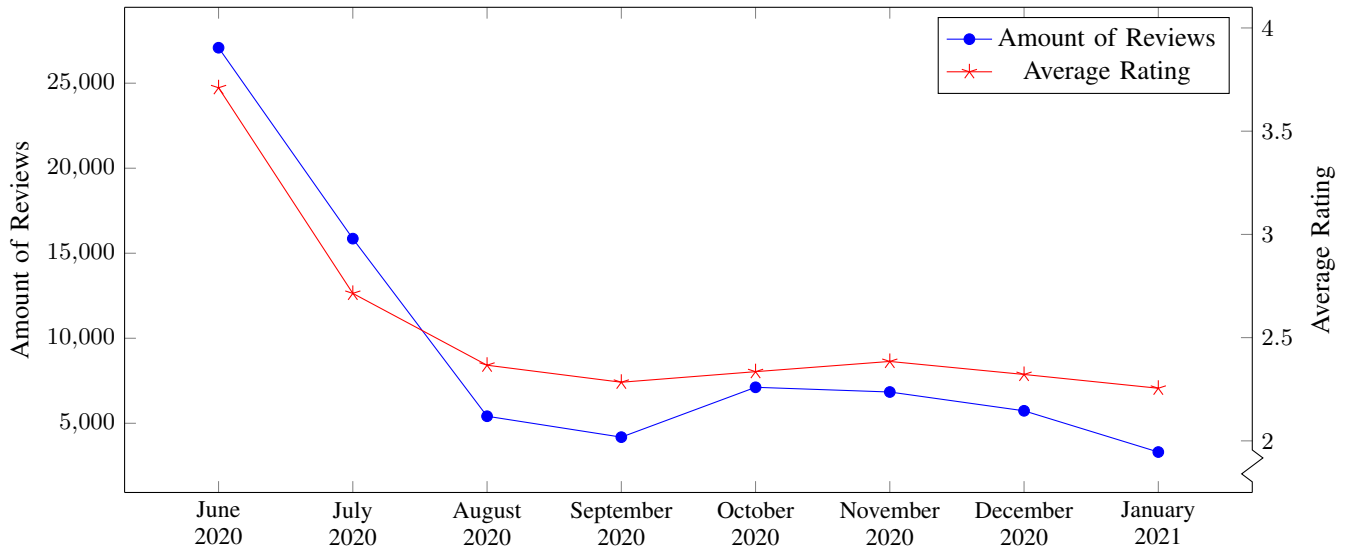


Fig. 4. Reviews over time and their average rating (Android and iOS combined).

TABLE II  
MOST FREQUENT BIGRAMS IN APP REVIEWS (ANDROID AND IOS).

Bigram	Occurrences
since, day	3,191 (4%)
positive, test	1,675 (2%)
Google, API	1,572 (2%)
new, to install	1,451 (2%)
QR, code	1,333 (2%)
communication, Google	1,276 (2%)
error, communication	1,240 (2%)
day, active	1,216 (2%)
last, update	1,185 (2%)

TABLE III  
MOST FREQUENT TRIGRAMS IN APP REVIEWS (ANDROID AND IOS).

Trigram	Occurrences
error, communication, Google	1,125 (1%)
communication, Google, API	1,003 (1%)
since, last, update	629 (1%)
cause, gone, wrong	423 (1%)

## B. Twitter

The first tweet with *#CoronaWarnApp* appeared on April 2, 2020. We collected all original tweets containing this hashtag until February 4, 2021. There were 43,082 tweets overall. In Figure 5, we show the number of tweets per day. Between June 15, 2020 and June 19, 2020, there were 18,901 tweets (42% of all tweets), with a maximum of 12,058 tweets (28% of all tweets) on June 16, 2020. Even more than for the reviews, the peak in terms of number of tweets immediately followed after the initial release.

After that, the plot in Figure 5 shows peaks on July 24, August 4, and September 23. For July 24, the most common words and hashtags did not show any specific topic besides

those covered at other times. For August 4, one single, unverified user tweeted 222 original tweets, containing spam. On September 23, among the frequent words and hashtags was "Illner," the name of a talk show on German TV. Likely, the COVID-19 pandemic and Corona-Warn-App were topics in the show and sparked some statements or discussions on Twitter. At the end of October 2020, Germany saw new record numbers of new infections several times. In November, new restrictions to public life were introduced. We assume that the increase in tweets at the end of October can be related to that.

Looking at the top 10 tweet groups *most retweets*, *most likes*, and *most replies* of German tweets, we observe that 9 out of 10 tweets were from verified accounts. The average follower count in each group was  $>400,000$ . There was some overlap of the users in each group. Overall, the users were mostly publicly funded television programs, journalists, politicians, and scientists.

For the 36,304 German tweets (84% of all tweets), we did the same pre-processing of stop word removal and stemming with CISTEM as for the reviews. Some of the most frequent words from the reviews (see Table I) were also most frequent words in the tweets: *to function*, *more*, *good*, *day*, *always*, *since*, *test*. They occurred in 3% to 10% of the tweets. *To install* was the most frequent word in tweets and was present in 10% of the German tweets. We note that neither *update*, nor *error* was among the most frequent words in the tweets. *Data protection*, not among the frequent words in the reviews, appeared in 1,708 (5%) of the tweets<sup>6</sup>. In their work, Xue et al. analyzed 4 million tweets related to COVID-19 and found *virus* to be the most frequent word with a frequency of 1.18% [6]. We assume that the narrower topic of Corona-Warn-App leads to a smaller variety of tweet contents, i.e., we would expect tweets with *#CoronaWarnApp* to vary less in content

<sup>6</sup>Note that *data protection* is one word in German: *Datenschutz*.

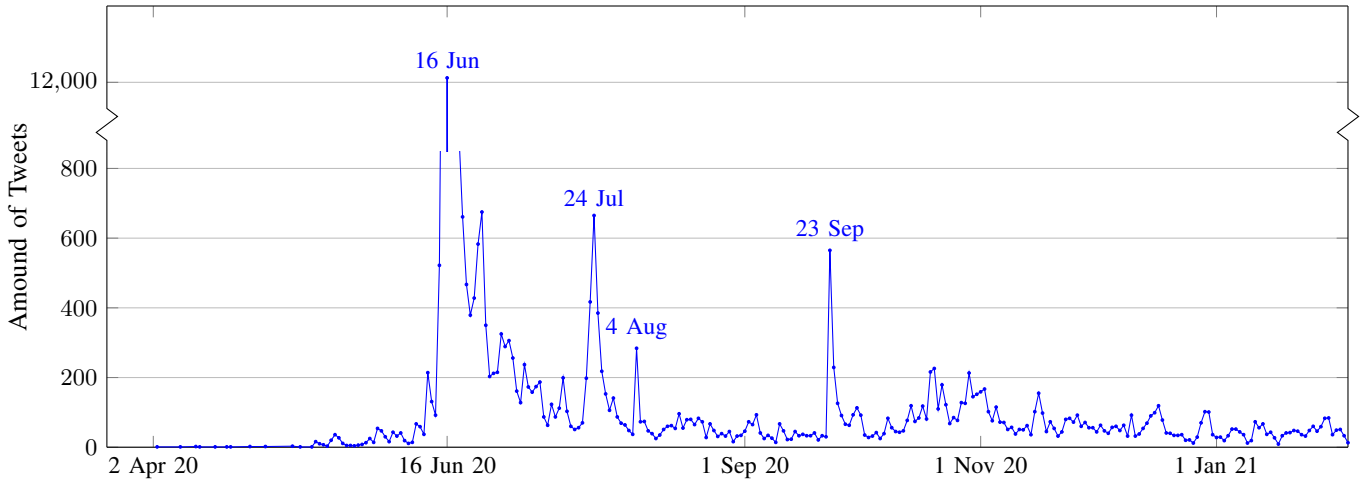


Fig. 5. Original tweets per day with #CoronaWarnApp.

TABLE IV  
MOST FREQUENT HASHTAGS IN ORIGINAL TWEETS WITH  
#CORONAWARNAPP, DISREGARDING HASHTAGS DIRECTLY RELATED TO  
THE VIRUS.

Hashtag	Translation/Explanation	Occurrences
#Datenschutz	data protection	831 (2.3%)
#IchAppMit	roughly: I am also using the app	777 (2.1%)
#Maskenpflicht	mandatory mask-wearing	416 (1.1%)
#RKI	Robert Koch Inst., see Section II	381 (1.0%)
#Spahn	German federal minister of health	376 (1.0%)
#Merkel	German chancellor	320 (0.9%)
#App		317 (0.9%)
#Covidioten	<i>covidiots</i>	307 (0.9%)
#Grundrechte	basic rights	255 (0.7%)

compared to tweets about the coronavirus in general. This, in turn, means that tweets with #CoronaWarnApp are likely more similar to each other compared to tweets from a broader topic, leading to the much higher frequencies of words we observed.

Next, we looked into the hashtags used in tweets containing #CoronaWarnApp. Leaving out those directly related to corona (like #Corona, #COVID19, etc.), and disregarding the case of the letters, the most common hashtags are given in Table IV. The content here is much less focused on technical aspects. The names of politicians, terminology commonly associated with political debate, like *mandatory mask-wearing*, *data protection*, *covidiot*, or *basic rights* are evidence for rather political than technical tweets. Additionally, #IchAppMit, which uses *app* as a verb and signals being part of the group that uses Corona-Warn-App, indicates promoting using the app.

## V. DISCUSSION

First, we note the low rate of reviews compared to the number of downloads. As app download numbers are not publicly available in the Apple App Store, and Google Play only reports broad ranges of download numbers, we look at a different area for comparison and interpretability. For measuring success on

YouTube, successful videos gain a comments-to-view ratio of 0.5%<sup>7</sup>, which is similar to the review-to-download ratio (0.7%) for Corona-Warn-App. Maybe using this metric as a metric for success does not translate from YouTube to app reviews, but the comparison helps explaining the seemingly low interaction rate.

Given that 36% of all reviews were from June 2020, the month of release of the app, it is likely that the users posting those very early reviews with relatively high ratings (see Figure 4) did not in fact use the app for very long, but used a positive app review as a means of supporting or promoting the app.

Looking at the average rating for the Android and the iOS app, we note a big difference (3.0 vs. 4.3). On the basis of those numbers only, it is difficult to draw conclusions about the reasons. One factor could be the variety of Android devices and the associated challenges for development. In an academic project, we released the Android app TYDR [7], [8] and with around 4,000 installations, we already identified more than 600 different devices.

From Google Play, for Corona-Warn-App, we could see the high response rates of the app developer of up to 60%. We interpret this as strong engagement with the users, to signal taking the reviews seriously and replying to questions, problems, and concerns.

Looking at the frequent words and n-grams in the reviews, we noted a focus on technical terms. We interpret this as users reporting about (issues in) their usage of the app. There could be several factors at play that have led to the large amount of negative reviews and the technical focus of the reviews. Users without proficiency in technology were likely not be able to distinguish between bugs in the app, (temporary) problems with the underlying Google/Apple *Exposure Notification Framework*, or system-wide settings, e.g., regarding Bluetooth or notifications. Thus, for example,

<sup>7</sup><https://tubularlabs.com/blog/3-metrics-youtube-success/>

it is hard to tell if a user that reported a problem ran into a well-known issue in the Android ecosystem, like the reliability of background processing, if he/she ran into a bug of Corona-Warn-App, (accidentally) turned his/her Bluetooth off, or did not understand how to interpret what is shown on the screen.

Another factor regarding the public perception of the app might be the world's reaction to the pandemic, with lockdowns and social distancing that likely no-one alive has ever seen to that extent before. Uncertainty and anxiety are likely widespread and might fuel dissatisfaction with Corona-Warn-App independent of its functionality and design. Some "legacy" real-world systems are integrated into Corona-Warn-App, e.g., getting the result of a test for the novel coronavirus. Waiting for the results might be frustrating and writing a review might be an easy outlet for that frustration.

Given the broad user base, and our hypotheses about different root-causes of the public perception of Corona-Warn-App, there might be multiple routes for future work. There might be technical problems within the app, and/or with the *Exposure Notification Framework*. Additionally, public education about technology might increase proper usage and help avoid confusion when using apps like Corona-Warn-App. Another field to research is the UX/UI of the app with the broad target audience and user base in mind. Lastly, the improvement of the integration of "legacy" real-world systems likely progresses slowly because laws and regulation might have to be changed.

Looking into the data we collected from Twitter, we firstly note that the user base being active on Twitter in Germany is much smaller than the number of people who downloaded the app. The volume of tweets per day already gives evidence about their content. 28% of all original tweets were published on June 16, 2020, see Section IV-B. We regard this as evidence that a large number of tweets might be news-related. The most frequent words and hashtags indicate that Twitter users are interested in political topics. Overall, given the data we analyzed, in the Twitter-sphere, the overall sentiment is a positive one towards using the app.

There has been work analyzing the spread of misinformation [9] and conspiracy theories [10], [11] during the COVID-19 pandemic. Based on the most frequent words, bigrams, and hahstags in the reviews and tweets, we find no evidence of wide-spread conspiracy theories related to Corona-Warn-App. Note that one limiting factor in drawing this conclusion is that Google, Apple, and Twitter might have already deleted such posts at the time we collected our data (beginning of 2021).

## VI. CONCLUSIONS AND FUTURE WORK

We collected and analyzed 78,963 app reviews about Corona-Warn-App and 43,083 original tweets containing #CoronaWarnApp. In the reviews, the users seem mostly interested in the apps' functionality, while Twitter was mostly used for news and promoting awareness of the app.

The reviews contain technical terms, often reporting issues. It remains open to what extent these reports are based on bugs in the app itself, on errors in the underlying OS or used

libraries, specifically the *Exposure Notification Framework*, or on misunderstandings by the user. The especially diverse user base, potentially containing users that are not familiar with using smartphones and apps, poses special challenges regarding the design of such an app.

Overall, both the timeline of tweets as well as the most frequent words and hashtags indicate that Twitter is being used for spreading news about the app and promoting its use. One limitation of our work is that both data sources are likely biased and thus cannot be considered representative for the German population. The reviews are only from people who downloaded the app, and the Twitter-sphere represents only a fraction of the German population.

Future work includes investigating how to better convey using apps to a non-tech-savvy audience. Additionally, future work should focus on the users' motivations to use the app and their acceptance of the app. Such insights can help to address the users' needs and expectations. This, in turn, could help to increase compliance with and efficacy of targeted prevention measures in the long term.

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