

# Investigating Correlations Between Usage of Communication Apps and Instant Messenger and a Smartphone User's Extraversion

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**Abstract** Smartphones are widely used and an integral part of our everyday lives. They are a main means for communication with friends and family. Due to the manifoldness of instant messengers, it is possible to chat or talk to others easily, anytime and anywhere. However, smartphone users' differ among each others: while some prefer to talk to others and share their thoughts on social media, others prefer privacy and restrict interaction to a necessary minimum. We want investigate correlations between the user's extraversion personality trait and their use of communication apps and instant messenger. Within a user study with 23 participants over the course of up to 28 days, we collected data about call and SMS history as well as notification reception and app usage. Our results revealed statistically significant correlations between call duration – overall, but also for outgoing or incoming calls – and number of notifications per day and different levels of extraversion. Future research might include the analysis of rich media notifications, notification content, social media activity, but also considering formality of a notification and type of interlocutor.

## 1 Introduction

Smartphones became an essential part of our everyday life and accompany us throughout the day. User's even spend around 90% of their day in the same room as their mobile phone [12]. While a large proportion of people of different age owns smartphones, digital natives are still the largest group to own a mobile device – some sources even claim that the "age group 18-29 has 100% of cell phone ownership in the USA" [20]. Hence, it is advisable to focus on this age group and investigate their smartphone usage behavior.

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Most interactions with the device are of a communicative nature [29]: calls, SMS, instant messaging services or social media channels, for example. Since communicative behavior relates to the personality trait of extraversion [17, 25, 35], the question arises if this trait also influences which apps are used and with what level of intensity. Miller proposed that the smartphone is a promising sensing device for objective data assessment in psychology [24] – but can it reveal information about the extent of the extraversion trait. We investigate if there is a correlation between the smartphone usage behavior – with a focus on instant messaging and social media usage – and the user’s extraversion.

## 2 Related Work

There are different definitions of personality, but the most-commonly used definition are the Big Five Personality Traits, including the five dimensions: Agreeableness, Conscientiousness, Extraversion, Neuroticism, and Openness. Usually, each dimension contains of a spectrum that ranges from a low to a high intensity of a trait, e.g., from introversion to extraversion for the *Extraversion* dimension. Depending on the assessment methods, the spectrum might be fine or coarse-granulated. In case of the "NEO - Personality Inventory - Revised" (NEO-PI-R) [9], each trait has a rating between 0 and 4.

A lot of literature investigated relations between the Big Five personality traits and user-specific smartphone usage, for example about:

- *Smartphone adoption* [11, 18, 19, 26, 31, 33]
- *Problematic smartphone use* [2, 3, 7, 16, 27, 28]
- *The handling of smartphone notifications* [8, 22, 36]
- *General smartphone and app usage* [3, 6, 4, 5, 19, 14, 34]

Our focus is on the work related to app usage, especially the use of communication apps – this relates to the papers assigned to the last item of the above list. However, communicative behavior via instant messengers or social media was fairly neglected so far. For example, Butt and Lane do not investigate it at all [3, 19], Ehrenberg et al. just focused on the time spent on instant massaging [14], and Chittaranjan only assessed the number of times a messenger app was opened [4]. Xu et al. hypothesized that "extroverted people are expected to be more likely to adopt mobile social apps" [34], but could not confirm this hypotheses. We hope that our examinations can shed more light on this issue by focussing on a more specific aspect of social app usage.

While some works rely on self-reported smartphone usage [3, 14, 19], the trend is to gather data automatically in the background while the owner uses their device [4, 22, 34].

In summary, we want to close a gap in related work by investigating automatically assessed, objective data about the *communication behavior* of smartphone users via *instant messenger and social media apps* in relation to their *extraversion*.

### 3 Study Design

In the following, we will introduce our study design and assessment app. First, we explain which sensors and data sources were selected and why. Next, we give an overview of the data collection app. Finally, we present the course of the study and a descriptions of the sample of participants.

#### 3.1 Assessment of Smartphone Data

In accordance to related work, we decided to track the call and SMS history [1], assess properties of notifications [21, 32], and analyse "UsageStats" [1, 13, 15]. All data was stored locally at the smartphone in a SQLite database. A complete overview of features can be found in Table 1.

**Table 1** Overview of all features assessed by our smartphone app.

Call Features	SMS Features	Notification Features	UsageStats Features
Number of calls (all   outgoing   incoming   missed)	Number of SMS (all   sent   received)	Notification package	Package name
Average duration of calls (all   outgoing   incoming)	Average number of SMS characters (all   sent   received)	Title (hashed)	Usage Time
Unique caller ID (hashed)		Notification length	
Maximum number of calls		Time of arrival	

For data protection reasons, we hashed the caller ID. This allows us to know if calls were made from or to the same person without revealing the identity of this person. The same was done for the notification title which often contains the name of an interlocutor – especially for communication apps. To reduce the number of data to be collected – for privacy issues, among others – we restricted the notification and app usage tracking to certain applications that are categorized as communication-related:

- Facebook
- Facebook Messenger
- Google Hangouts
- Signal
- Skype
- Telegram
- Twitter
- Whatsapp

#### 3.2 Course of the Study

Prior to the main study, we ran a pre-study with three participants. Over a course of five days, the participants tested the application and acted like in the main study. The objective of the pre-study was to figure out if all tasks are understandable and if the data collection works correctly. Each participant confirmed the correctness of the data and provided some improvements for the user interface that were implemented afterwards. After all was safe and sound, we started the main study.

At the beginning, we met with all participants and informed them about the objective of the study and the data to be collected. When participants felt well-informed and did not have further questions, we handed out a consent form and ask them to sign it. Next, they provided demographic information and filled out the NEO-PI-R questionnaire used to assess their big five personality traits. Afterwards, the study leader collected the questionnaire and installed our application on the participant's smartphones. This introductory part took 35 to 45 minutes.

During the study the participants had to use their smartphone normally. Since we only collected data in the background and did not apply any experience sampling or other direct communication with the participants, they had nothing more to do. After a period of at least 10 days but up to 28 days, we met again to export the data from the smartphone and thanked the participants for taking part in our study.

### 3.3 Participants

25 volunteers agreed to participate in our study. 19 of them were male, 6 female. They were between 20 and 26 years old. All of them owned an Android smartphone, 3 participants Android 6 and all remaining Android 5.

Only 23 participants finished the study. One participant dropped out due to a critical system error that kept them from running the application. Another participant figured that they would not be able to participate for the whole course of the study and quit after filling out the NEO-PI-R questionnaire.

## 4 Results

Figure 1 gives an overview of all types of data that was collected and considered for the evaluation. In the following, we will first describe the dataset and second present the results of the NEO-PI-R assessment of extraversion. Third, we will investigate if there are correlations among these datasets. The corresponding results are also included in Figure 1.

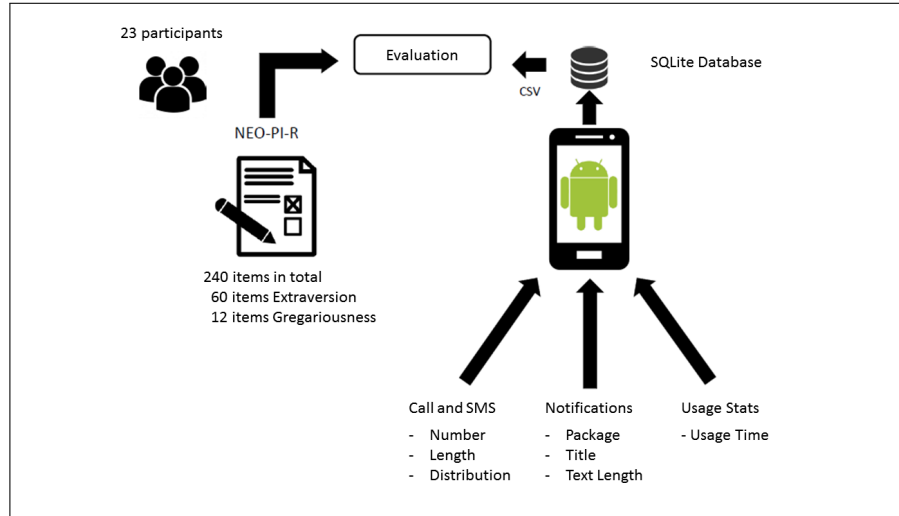
### 4.1 Description of the Dataset

The dataset consists of measurements for all features mentioned in Table 1 for each of the 23 participants. Table 2 provides an overview of the values inferred from call history, SMS history, and notifications, respectively. It is visible that the participants had very different habits in call and SMS usage. There is also a huge deviation in numbers of notifications received per day. On the first view, it is not easy to

**Table 2** Overview of the gathered data per assessed feature. For numeric values, the table provides mean (and standard deviation), minimum and maximum value as well as results of the linear regression and Spearman's correlation analysis. For nominal values, we provided the number of occurrences within the set of top responses per participant.

Statistically significant results are marked: \* $p < 0.05$ ; \*\* $p < 0.01$

Call Features	Mean	Min	Max	Linear Regression p Value	Spearman's $\rho$	Spearman p Value
Total number of calls	49.87 ( $\pm 65.88$ )	0	307	0.77	0.3486762	0.103
Number of incoming calls	13.65 ( $\pm 14.9$ )	0	48	0.747	0.3014619	0.1621
Number of outgoing calls	27 ( $\pm 43.14$ )	0	207	0.531	0.2628714	0.2256
Number of missed calls	9.22 ( $\pm 13.57$ )	0	52	0.355	0.3363835	0.1166
Average duration of all calls [s]	170.61 ( $\pm 159.8$ )	0	518	0.00764**	0.638456	0.001044**
Average duration of incoming calls [s]	270.83 ( $\pm 278.39$ )	0	927	0.0152*	0.4924525	0.01698*
Average duration of outgoing calls [s]	97.7 ( $\pm 101.2$ )	0	438	0.16	0.4178449	0.04726*
Number of unique callers	13.91 ( $\pm 12.32$ )	0	43	0.993	0.3687742	0.08335
Maximum number of calls from a unique caller	12.78 ( $\pm 20.32$ )	0	100	0.878	0.3522868	0.09922
Number of all SMS	29.13 ( $\pm 44.96$ )	0	186	0.552	-0.01809624	0.9347
Number of sent SMS	10.52 ( $\pm 23.44$ )	0	90	0.51	-0.1542526	0.4822
Number of received SMS	18.57 ( $\pm 22.24$ )	0	96	0.604	-0.01636912	0.9409
Average number of SMS characters in all SMS	93.13 ( $\pm 72.68$ )	0	255	0.463	0.06714582	0.7608
Average number of SMS characters in sent SMS	23.09 ( $\pm 29.11$ )	0	94	0.853	-0.1093549	0.6194
Average number of SMS characters in received SMS	98.26 ( $\pm 77.17$ )	0	275	0.623	0.05624392	0.7988
Average number of notifications per day	157.29 ( $\pm 370.28$ )	1	1866	0.0229*	-0.3232099	0.1325
Average length of notifications	43.74 ( $\pm 16.15$ )	10	74	0.118	-0.1196243	0.5867
Number of used apps	3.91 ( $\pm 1.59$ )	1	7	0.138	-0.2664857	0.219
Mostly Used App	WhatsApp (6), FacebookMessenger (4), Hangouts (3), Telegram (3), Signal (2), Skype (2), Other (2), GregApp (1)					
App with most conversations	WhatsApp (8), Hangouts (6), FacebookMessenger (2), Plume (1), Signal (1), Skype (1), Telegram (1), Twitter (1), Other (1), GregApp (1)					
App with on average longest notifications	Hangouts (5), Telegram (5), Signal (4), FacebookMessenger (2), Facebook (2), WhatsApp (2), Skype (1), Other (1), GregApp (1)					



**Fig. 1** Overview of our study. Data assessed from the NEO-PI-R was evaluated against features that we assessed from the smartphone and stored in a local database on the device.

spot correlations between features and different levels of extraversion. Hence, we performed statistical test to investigate it.

## 4.2 NEO-PI-R Results

Analyzing the result of all NEO-PI-R questionnaires revealed that one participants showed a very high, 8 a high, 4 an average, 6 a low and 4 a very low score for extraversion. These scores were rated in accordance to Costa and Crae's "NEO-PI-R Professional Manual" [10]. On a scale from 0 to 4, the mean score for extraversion was  $1.88(\pm 0.57)$  with a minimum value of 0.56 and a maximum value of 2.6.

## 4.3 Correlation Analysis

To infer findings about correlations between a participants personality traits of extraversion and gregariousness with smartphone usage and communication behavior, we performed different analyses.

First of all, we ran a linear regression between smartphone features and scores for extraversion. The results of this analysis are included in Table 2. Unfortunately, only the features "average duration of all calls", "average duration of incoming calls", and "number of notifications per day" managed to reveal statistically significant correlations. For all other features, we could not confirm a correlation. This might be

caused by the fact that the participants showed very diverse behavior in call and SMS usage as well as in their app usage. Especially the average duration of all calls has a high variation (confirmed by an analysis of variance (ANOVA)) which facilitates to differentiate between different levels of extraversion. It seems that more extroverted participants tend to talk longer on the phone than more introverted ones. For the number of notifications per day, this heavily depends on the number of installed and used apps and the kind of apps that are used. It also depends on the settings of the user, i.e., which apps are allowed to send notifications and which are not. It seems that more extroverted participants tend to receive a higher number of notifications per day.

In addition to a linear regression, we computed the correlation coefficient of Spearman's  $\rho$ . The results of this analysis are also included in Table 2. It is visible that there are some high correlations with statistical significance among the results. These are namely "average duration of all calls", "average duration of incoming calls", and "average duration of outgoing calls". This is similar to the results of the linear regression which revealed statistical significance for two of the three call duration features as well. We assume that the duration of a call, i.e., the length of an actual conversation with another person, relates best to a participant's extraversion while participants have very personal, probably personality-independent habits about other features such as SMS or instant messenger.

## 5 Discussion

It is surprising that only call duration made a statistical significant difference between the two user groups. It is possible that both extroverted and introverted persons use the smartphone rather excessively but for different reasons: while extroverts use the smartphone to keep up their daily conversations and social interactions, introverts might use it to avoid face to face meetings or direct interactions. Extroverted users might welcome every kind of communication while introverted users prefer asynchronous communication such as instant messenger, SMS, or email – making it not possible to differentiate both groups based on the usage of these communication channels. We assume that introverts only phone if it is necessary or unavoidable while extroverts are open for direct and symmetric conversation and enjoy calls more. Therefore, extroverts take more time when having calls what increases the duration of calls. This fits to our findings that only the call duration differs significantly between both groups but not the number of interactions or used communication apps.

However, since this information is available only if an app has the permission to access the call history, the assignment to one of both groups can only be used in a very limited context, e.g., only for advertisement in browsers or apps and only if the user granted this browser or app the required permission. A possible usage of this information could be the recommendation of communication apps in the app store or play store. We can also imagine that the smartphone offers shortcuts for calling people with whom the user interacts the most.

## 6 Limitations

There are several reasons why the results might not be as insightful as expected.

One severe limitation of our study that might have effected the results was the rather small sample. The homogeneity of the sample also restricts the generalizability of the results to young, technophile adults that are rather introverted. Future studies should include a bigger and more heterogeneous set of participants. A larger, more heterogeneous sample might reveal more correlations.

So far, we only considered a handful of features. Further communication features such as reaction to notifications [23] or rich media notifications [32] might differ between extraversion types and should be investigated. Analyzing the content of the notification might also improve the understanding of user behavior and personality as it might reveal the sentiment of a notification of its importance to the user. The formality of the conversation [30] or the type of interlocutor [23] are two other features that should be examined regarding their impact on how a user interacts with the device.

## 7 Conclusion

In this paper, we investigated correlations between smartphone usage – especially communication apps and instant messengers – and the personality trait of extraversion of the smartphone user.

Over a course of 10 to 28 days we collected data of 23 participants containing call and SMS history, notification logs and usage stats. In addition, every participant filled out a NEO-PI-R questionnaire to provide information about their personality traits. All gathered data was analysed using descriptive statistics, linear regression and Spearman’s correlation coefficient  $\rho$ .

Our results revealed statistically significant correlations between call duration – overall, but also for outgoing or incoming calls – and the number of notifications per day and different levels of extraversion. This makes sense since introverted people might avoid longer talks and prefer asynchronous, indirect communication instead of direct interaction while extroverted users might welcome every form of communication.

Future research might including the analysis of rich media notifications and notification content – users might react differently on media usage in messages and have different sentiments and different levels of subjective importance regarding the notification and its content. The formality of a notification and the type of interlocutor (family, friends, colleague, etc.) might also be of interest. The user’s activity on social media such as Facebook and Instagram should be considered as well since users tend to behave differently on these platforms what might be caused by different personality traits. Such findings can be used in the future to have the smartphone adapt to the user’s needs and preferences - not only on an objective basis but also related to the personality of the user.



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