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The sociability score: App-based social profiling from a healthcare perspective

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ABSTRACT

As the smartphone becomes an integral part of our lives, its value as a rich data source reaches an increasing potential. Several previous studies have used smartphone-derived data to discover relationships between user characteristics and different types of smartphone use. However, none tried to use smartphone data to capture an individual's social behavior into one profile, aimed at providing additional information for the diagnostic evaluation of social deficits. This study presents a novel way of combining different modalities of smartphone data for the creation of sociability profiles using a scoring mechanism that allows for easy addition and removal of data sources. Following installation of the smartphone application, data is being sampled in the background to allow for the assessment of spontaneous smartphone use. Sociability scores were based on the integration of social communication and social exploration scores derived from smartphone use and environmental data sampling (e.g., GPS and external Bluetooth signals). Finally, we have applied our Sociability model to create social profiles of ten test subjects as a baseline for future studies. This pilot study provided insight in the usability of the individual sociability scores for future smartphone application to provide longitudinal objective measures of normal and atypical human social behavioral profiles in their natural environment.

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1. Introduction: smartphone-based social profiling in healthcare

According to a survey by Ernst and Young, Dutch citizens are dissatisfied about IT-innovation in the healthcare sector, which is explained by the fact that healthcare specialists provide human-centered services and are not focused, nor trained, on applying IT-solutions to improve their business processes (Ernst & Young, 2011). This observation also suggests a wealth of opportunities present in this sector for new technologies, one of which consists of the exploration of ways smartphones can aid in professional healthcare. The larger the role of smartphones becomes in our lives, the more interesting these devices will become for healthcare, given that the information held by these smartphones could provide objective insights into the owner's lifestyle and possibly, into

their psychological wellbeing. Currently, many data mining techniques exist that can extract data from smartphones about the user's smartphone use. But in order to analyze aspects of social behavior based on a large set of extracted data from a large group, a validated, scientific model should be developed. Subsequently, this information can be used in the psychological domain to create distinctive social profiles and thus create valuable insights in a person's level of sociability. Finally, this information can be a valuable addition in a clinical context, with the potential to contribute to the accuracy of medical diagnoses in the cognitive-behavioral domains and therefore improving the overall efficiency of subsequent treatment.

Currently, the department of Translational Neuroscience and the department of Psychiatry at the University Medical Center Utrecht, in cooperation with a third party software vendor, develop a smartphone application with the aim to create additional digital assistance for the objective and longitudinal observation of social behavior and, potentially for the diagnosis and early detection of patients with (possible) social deficits. Furthermore, in view of treatment efficacy monitoring of these patients, there is a great need to obtain information regarding spontaneous human social

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behavior in their natural environment. Current methods are mainly based on self-reports, obtained either through questionnaires, or through life or phone-based interviews. The two largest disadvantages of these currently used methods are the restricted amount of information these sessions deliver and the questionable reliability of the information given the inherent subjective quality of the data. As literature states, self-reported statements can only be interpreted when handled with great care, as people may change the truth consciously or unconsciously to get a desired outcome or because they have a wrong impression of their own situation (Straka, Fish, Benson, & Suh, 1997; De Reuver et al., 2012).

The smartphone as an objective instrument eliminates both of these disadvantages that are connected with the current diagnostic method, since a smartphone can collect information both extensively and objectively. Therefore it is interesting to examine the role smartphones can play in current diagnosing methods for social deficits. Many studies show the possibilities of smartphones as a data source for all types of social purposes such as user profiling, user tracing, and activity recognition. But little research has been done to utilize these possibilities to fit healthcare purposes (e.g. Meulendijk, Meulendijks, Jansen, Numans, & Spruit, 2014), and more specifically in the psychological healthcare domain. To discover the potential of smartphones for clinical purposes, additional research is required that may uncover the possibilities of smartphone data in the diagnosis and treatment of people with possible social deficits. As an introduction to this topic, this research involves uncovering the potential of the smartphone as a measurement instrument for the psychological healthcare domain. We therefore formulate the following research question.

Can individual social profiles be created for psychological healthcare purposes based on smartphone usage and smartphone-registered behavior?

The first step in answering the main question is to identify and define the different factors that can be considered as the building blocks of a social exploration profile. In the context of this research, all of these factors derived from smartphone-retrieved data, including smartphone-activity data and data retrieved from smartphone sensors, which are used to directly or indirectly describe an aspect of a user's sociability. It should be taken into consideration however that some of these factors may be explained by certain user characteristics and demographics and are of no direct consequence regarding a person's sociability.

This research has relevance for multiple target groups when looked at from different perspectives. First, the scientific community gains new insights into the possibilities of smartphone data for social studies and, more specifically, into using information about an individual's smartphone use as an additional source for describing the sociability of an individual. From a business perspective, a description about an individual's sociability levels can function as an additional source for physicians during the process of diagnosis, which ideally can gain hospitals an increased effectiveness and efficiency of several treatments in the psychological domain, reducing treatment times, waiting lists and overall treatment costs. Finally, from a social point of view, patients and hospitals both benefit as it is also in their best interest to improve quality of diagnosis and treatment.

The structure of this paper is as follows. First, a theoretical background will be provided for this topic in the form of a systematic literature review; exploring the current best practices in the field of smartphone mining and sociability. Then, both the research and data mining method will be described in the research approach chapter to provide structure to the research process. Next, the sociability model will be presented, which will be tested subsequently by applying the model in a test group of 10 individuals of which the results will be presented in the results chapter. Finally, in

the conclusion and discussion sections we evaluate the results and describe future research opportunities.

2. Theoretical background

First, we select the top predictors that may serve as confounding factors for the creation of a social profile. As the theory of behavior model suggests, we should determine the possible impact several categories have on our research, to avoid having confounding factors determining the social profile. The categories described by the theory of behavior include consumer attributes, user-context, service characteristics, intentions, and technology enablers (Maheshwari, Ylä-Jääski, Verkasalo, & Hämmäinen, 2009). When observing people's social activities, the biggest impact is created by the person confounding factors, which include user characteristics and user demographics (Steg, Buunk, & Rothengatter, 2008). These factors are user-specific, and are proven to influence social behavior in several ways. The social cognitive theory confirms that personal factors influence social behavior and adds to the importance of environmental factors which partly overlap with the user-context attributes described in the theory of behavior model (Bandura, 1986). The remaining categories intentions, service characteristics and technology enablers only indirectly influence social behavior through increased/reduced smartphone use and therefore are not confounding factors for a sociability profile. As an example of the category intentions, performance expectancy influences the consideration to use the smartphone for communication, but when the user decides not to use the smartphone for communication, he will choose a different medium for communication which does not make him less sociable. Also, having unlimited internet access or a smartphone with a high-capacity battery will increase overall smartphone use which will also result in increased social smartphone use. This however does not implicate that the person is more sociable, while a sociable person will again search for alternative ways of communication when the phone battery is fully drained or when internet access is unavailable. In conclusion, only the personal factors and user-context factors are influences that should be accounted for when observing social smartphone use in more detail. We will explain the explicit factors in more detail in Sections 4 and 5.

The first data source category is social media usage, including social behavior on platforms such as Facebook, Twitter, and Tagged. In the context of social media, research to date is limited to studies that describe social media usage (e.g. Buijs & Spruit, 2015), regardless whether the platform is either a PC, smartphone or tablet. Considering again the Theory of Behavior model by Maheshwari et al. (2009), the findings associate personal characteristics with social media usage, making personal factors again a potential confounding factor, in this case, for examining social media usage. No research however has been done to investigate the influence of user-context on social media usage, making it unclear whether user-context has the same influence on social media usage as it has on smartphone use in general. Additionally, factors that could be placed under the remaining categories of the theory of behavior model; intentions, service characteristics and technology enablers, are not found in present literature. As for the largest difference between general social media usage for the PC and the smartphone, Kaikkonen concludes that people use mobile internet mostly for following social media sites. Desktop computers on the other hand are used for active contribution to social websites, which was less common when using mobile devices (Kaikkonen, 2008). Twitter usage was found to be used more extensively on the smartphone, which was explained due to the short attention span required for tweeting (Grace, Zhao, & Boyd, 2010). In short, our literature review indicates that several research gaps exist concerning social media usage on smartphones, which underlines

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