Con Óg Ó Laoghaire
Software Engineering
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Engineering Psychometrics

A report considering the ways in which software engineers and their companies can be psychologically measured and assessed in terms of measurable data, an overview of the computational platforms available to perform this work, the algorithmic approaches available, and the ethical concerns surrounding this kind of analytics.

Psychometrics: A brief history

Quantitative Psychology, also known as Psychological Measurement or Psychometrics, bases its methodology upon the statistical analysis of psychological data. A well-known example of the kind of methodology developed by quantitative psychologists for the use of other researchers is the Intelligence Quotient (IQ) and the tests designed to measure it.

Psychometric means often take on a life of their own after they have been developed. The information acquired by psychologists through IQ testing has been applied in a number of areas outside psychology, including education, health and medicine, and criminal justice.

The means of gathering data that allowed for IQ scores are quite basic in comparison with contemporary means. The technology that these means depend upon is currently leaping ahead, and this field is yet to catch up. Hence we can speculate that unprecedented rates of development are to come.

Mean of collecting measurable data

Before the widespread availability of electronic monitoring tools, digital footprints, and the Internet of Things the field lacked the measurable data for significant development.
The research method used the vast majority of the time has been survey research, with emphasis on quantitative analysis.

Perhaps the first major case of contemporary means of data collection being used was in 2007. “Dr David Stillwell built an application for an online networking site that was starting to explode: Facebook. His app, myPersonality, allowed users to complete a range of psychometric tests, get feedback on their scores and share it with friends. By 2012, more than six million people had completed the test, with many users allowing researchers access to their profile data. It contains the moods, musings and characteristics of millions – a holy grail of psychological data unthinkable until a few years ago.”

“Meanwhile, the Cambridge Psychometrics team devised their own complex algorithms to read patterns in the data. Resulting publications caused media scrums, with a paper published in early 2015 generating nervous headlines around the world about computers knowing your personality better than your parents.
But how surprising is this really, given the amount we casually share about ourselves online every day? And not just through social media, but also through web browsing, internet purchases, and so on. Every interaction creates a trace, which all add up to a ‘digital footprint’ of who we are, what we do and how we feel.”
— www.cam.ac.uk/research/features/how-to-read-a-digital-footprint

Recent application of psychometrics

To date, most psychometrics have been for the sake of curiosity and/or marketing. It is only quite recently that political and psycho-analytical agendas have entered the field.

The commercial and political data application opportunities vary depending on the legal system in which the organisation is operating. In the USA, commercial data collectors and synthesisers can claim ownership of the data collected from individuals and are be able to sell it. Whereas the European Union having GDPR (General Data Protection Regulations), allows for consumers to claim ownership.

To circumnavigate the regulations in the EU, companies sell anonymous data, data analytic services or statistics based on the data gathered from consumers similar to Google’s Analytics

services where statistics and analytical services based on anonymous data is sold rather than raw individually identifiable data (The Persuasion Machine, 2019).

Cambridge Analytica (CA) was a psychometrics evaluating company that attempted to predict people's personality based on Facebook activity to then target differently styled adverts based on the individual's temperaments and psychometrics (The Persuasion Machine, 2019). CA used well-known psychological frameworks such as the Five factor theory of personality to target ads. The technology used can be demonstrated at applymagicsauce.com/demo.

CA suggested that gathering data from Facebook would enable them to predict individual personalities accurately and to be able to use them for psychographic micro targeting. We know that from personality we can predict behaviour (J.Jaccard, 1974). But was CA able to adequately predict personalities based on Facebook behaviours and target them effectively?

Computer based personality judgement methods do have the potential of being more accurate than humans (Youyou, et al., 2015) and in particular, is almost on par with spouses. However, it is still uncertain whether Cambridge Analytica could leverage these methods to shape their audience and their view (Kris-Stella, 2018).

It was also found that five factor personality traits (FFPT)—often used to explain individual's political views—only account for around five percent of the variation in people's political stances leaving more factors to explain the totality of the variance (G.Sibley, et al., 2012) (Furnham & Fenton-O'Creevy, 2018).

The evidence is still unclear whether CA were successful at leveraging psychographics micro-targeting methodology. But as the evidence shows, it would have had a negligible effect even if the firm predictions of personality were accurate. This is because in the past it has been reasonably unsuccessful at personality based targeting compared to other means.

Facebook and Google personally targeted adverts based on the data one openly shares on their platforms. These enterprises use all this data to make an accurate consumer profiles to them segment and target based on psychographics (interests, searches, likes etc.), demographics (age, marital status, education etc.), Geographic's (addressee, Facebook check- ins etc.) and behaviourally (site and digital navigation paths). Whereas Cambridge Analytica had a more aggressive targeting approach by attempting to predict and measure peoples' political positions, religion, sexual orientation and personality based on data publicly available on Facebook and then target based on these predictions (The Persuasion Machine, 2019).

HTTP cookies are also often used to improve customer experience and track consumer behaviour on the internet. They allow automatic authentication, page layout preferences, and long term record personalisation (Kristol, 2001). Through these little pieces of data sent back and forth between individuals' web browser and hosting servers, commercial

bodies can identify website navigation trends, predict peoples' favourite colours, etc. These are usually used by marketers to segment and target behaviourally. Factors as simple as colour personalisation of a website can sway individuals especially in a political context for example blue page layout for a democratic and red one for republican would be common to change in websites based on the data collected from these cookies. Or to analyse the most clicked buttons on a website to slowly cater the position and size of the button for this use.

IP addresses are mainly used for geographic segmentation and targeting. IP addresses can also be used to understand the cultural differences and pressures effecting individual's behaviour especially in a political context. Data is used to "monopolize human attention", exploit people's biases extremely accurately and manipulate or "nudge" individual's behaviour.

We know that, behind closed doors, corporations and governments use this data to 'target' us – our online actions mark us out as future customers, or even possible terrorists – and, for many, this reduction in privacy is a disturbing fact of 21st-century life.

Psychological traits and the software engineer

Empirically, the strongest psychological correlations to the competence of a software engineer are personality traits, although these are only relevant insofar as the engineer is motivated.

"In software engineering, motivation has been studied since the 1980's. A seminal work of Couger and Zawacki claimed that computing personnel have higher growth needs and lower social needs than the average population, implying that specific strategies of job design could be employed for this specific type of professional, in order to increase their job's motivational potential and consequently their performance at work.
Most of the results of these surveys point to the software engineering job itself as the main motivational factor, while performance improvements (e.g. product quality, productivity, and job excitement) and intention to leave the organisation are highlighted as the most important outcomes of, respectively, high and low motivation.
Some researchers claim that software engineers differ from the general population with respect to personality, needs, and other individual characteristics, and for this reason, what motivates software engineers is likely to be different from what motivates the

population in general. However, the difficulties in verifying these claims and the lack of understanding of exactly how these differences (if they exist) affect motivation make these claims not very useful in practice."

— Motivation in software engineering industrial practice: A cross-case analysis of two software organisations

"Personality variables play a critical role in determining interaction among programmers and in the work style of individual programmers

Within the context of software engineering, "team climate" can be defined as a combination of its team members' interactions in order to share their perceptions of the team's work procedures and practices. To date research has shown that there is a relation- ship between team personality composition and team performance and climate.

One of the most widely accepted personality models is the Big Five model [17], also known as Five Factor Model (FFM),

additionally also described as the OCEAN model that includes *Openness, Conscientiousness, Extroversion, Agreeableness* and *Neuroticism* [16]. This model has been used in many studies to understand the influence of the personality traits on team climate e.g. in an engineering team, "conscientiousness" was found among the team members to noticeably raise task performance, and those members who were found to be low in "extraversion" were found to be key in running product design processes. In another study where 10 teams consisting of 78 college students competing in a business simulation were observed it was found that the "emotional stability" (the alternate term for neuroticism) predicted task performance, and "agreeableness" predicted consistency within the work team.

The Keirsey temperament sorter (KTS) is an instrument based on theory developed by a behavioral scientist called David Keirsey.

These four temperament types are namely *Artisan, Guardian, Idealist* and *Rational*. The KTS has been used by some researchers to measure the variance in the personalities of software engineers and their temperament when they are working as a team. Sfetsos et al. investigated developers' personalities and temperament and their effect on pair performance. In their research the KTS-test was used to interpret the subjects' personalities in the experiment. Their results showed that the heterogeneous personalities working in pairs possess better communication, pair performance and pair collaboration than the homogeneous personalities in pairs.

personality diversity had strong correlation with team success in the beginning of project development which grew weaker while projects reaching to the completion.

The importance of addressing personality in software development has been raised by many researchers (e.g. [22,23]). They claim that software project outcomes are very likely affected by the personality of the software engineers involved in the development process. This is because an engineer's or developer's personality influences the way they apply certain modeling methods or techniques, as these depend on several perspectives and abstractions that occur during the Software Development Life Cycle. In another study of Bedingfield and Thal [29] it is highlighted that personality of project managers is an important predictor for determining a project's success. In particular, their findings indicate that the personality traits Conscientiousness and Openness are positive predictors of a Project Manager's success.

Gómez and Acuña [30] performed a quasi-experiment to analyse how the personality and team climate influence software development teams' performance. Their experiment used university students as subjects, and was conducted in an academic setting. Results revealed that there is a significant correlation between the extroversion personality factor and software quality and with respect to team climate they found out that the team's perception of high participative safety correlates with better quality software. Participative safety is one of the team climate factors that refers to the sense of safety (i.e. trust and support) that team members feel exist within the group [10].

Cruz et al. [14] in their secondary study reviewed the literature covering personality in software engineering. They performed a SLR of peer reviewed studies published from 1970 to 2010. The main purpose of their work was to identify the methods used, topics addressed, personality tests applied, and reported the main findings produced in the research about personality in software engineering. They included studies that used undergraduate students as well as software professionals as subjects. One of their findings is that the number of studies that have focused on undergraduate student software teams and individuals as subjects is greater than the number of studies covering professional developers.

Most of the studies we found have focused on undergraduate software or computer student teams, where they have examined subjects as individuals or as a development team in an academic environment.

While conducting this SLR, which mainly focused on personality, team climate and performance, we have noticed that one of the known aspects related to personality: “personality disorders” or the “dark side of personality”, was not found in any of the primary studies. Thus, future research could address these missing areas related to the personality or other dimensions associated with the software team, team climate and

Table 13
Significant team climate factors affecting team performance.

Studies	Significant	Not significant
[PTC3], [PTC9], [PTC13]	Collaboration, cooperation, coordination	N/A
[PTC5]	Play advantages and abilities, job importance, clear work requirements, teamwork and support, commit to doing high quality work, and recognize or praise	N/A
[PTC7]	Commitment, trust, and coordination	N/A
[PTC9]	Agile values(trust, openness and respect) and collective thinking	N/A
[PTC2], [PTC11]	Role allocation	N/A
[PTC7], [PTC10]	Participatory safety	N/A
[PTC18]	Composition and project task	N/A
[PTC17]	User representativeness and team members' involvement in system design	Cohesion
[PTC32], [PTC34]	Communication	N/A

team performance.”
—The effect of software engineers’ personality traits on team climate and performance: A Systematic Literature Review

Psychological traits and software engineering companies

Case study 1: Public software organisation

Background
Government software organisation situated in Recife, Brazil, established in 1969 by Government of the State of Pernambuco. Its core mission was to provide Information Technology services to internal customers in several levels of the State Government administration and to the citizens of the State.

“«Task significance» and «job stability» constituted the core forces that attracted software engineers to work in the company, and acted as forces to decrease their «intention to leave». Both factors were mutually reinforcing with respect to motivation. On the other hand, frustrated «growth needs», caused by poor «career development support» and other organisational factors, were the core forces that reduced motivation, contributing to increasing the intention to leave the organisation (in particular for other public

organisations, thus keeping high job stability and task significance). The attraction forces caused by the job stability and the high task significance were in constant tension with the disruptive forces caused by the engineers' frustrated growth needs. Whenever the balance was broken, the individual left the organisation. Since it was difficult to make timely replacement because of legal and bureaucratic restrictions, the overall «workload» increased. Then, together with «poor management», the high workload reinforced the disruptive force caused by frustrated growth needs on those that stayed in the organisation."

"Political decisions overcoming technical criteria in *«goal and priority settings»* increased the effect of frustration on intention to leave. *«Task Variety»*, being contingent on the type of task (development of new systems or maintenance of legacy systems) and moderated by individual characteristics, acted in both directions as an attraction or a disruptive force according to these contingencies."

Case study 2: Private software organisation

Background

"A software company, formally established in 2006 by the initiative of five entrepreneurs from the Information Technology sector field, in Recife, Brazil. As a young company, its core mission was to support the development of people and organisations with software tools, by means of technical excellence and innovation.

The company was a small, young, and successful software development organisation.

Its flagship product, a corporate social network, provides support for intra-organisational innovation management. At the time of the study, the company served national and international customers, mostly medium and large companies. Internal products and external projects differed significantly in terms of requirements, type of management style, and time and effort pressures.

The company followed an agile-like software development process, broadly adopting practices such as regular delivery of software, adaptive management style (SCRUM based), small teams, face-to-face meetings, and customer authority. The organisational structure was flat, and the directors sometimes worked as part of the development teams. The directors themselves, who had a software engineering background, also managed all organisational issues, including the human resources.

Given the natural limitations of resources faced by organisations in this stage of business maturity, this company seemed to have adopted a strategy of being geographically close

to a University, offering students opportunities to carry out their internships and to learn and develop their technical knowledge, serving as a basis for their future career. On the other hand, the company benefited from the low wages at initial career stages. This organisational strategy had a strong impact on the motivation of this company's employees.

The essential driver of the motivated behaviour in this organisation was *«learning opportunities»*. Factors such as «*intellectual challenge»*, *«autonomy»*, *«collaborative work»*, and «*teammates' technical competence*» created an effective learning environment, which benefited the goal commitment of the software engineers. However, as time passed, their activities started to get repetitive and with low motivational potential in later phases of the projects, regardless of whether they were working for the internal products or for external customers.
This learning environment seemed to contribute to the engineers' job performance factors. On the other hand, three factors generated a large amount of requirements changes and rework, which negatively affected the engineers' job performance: (1) unclear *«task identity»* (the identification of individual work as part of a whole and identifiable piece of work) due to the confused requirement management process; (2) the low *«quality of intermediary artefacts»*; and (3) the low *«feedback»* due to distance between the end-user and the development teams.

The high *«sociable environment»* and *«team integration»* helped to create high *«team cohesion»*, building a very reciprocal work environment, filled with mutual help, shared experiences, and self-responsibility. *«Responsibility»*, in turn, was enhanced by high *«employee participation»*, supported by the structure of small teams and the direct participation of upper management in the development teams.

However, even with a highly agreed sense of *«commitment»* in the teams and the presence of several other contextual motivators, *«turnover»* rates were still high. Because the organisation did not offer long-term *«career opportunities»*, the «*growth needs»* of the software engineers had not been fulfilled, and external opportunities for career progression were constantly draining people off."

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Machine Learning the traits

In terms of the relevant algorithmic approaches available, Machine Learning seems to be the future of inferring conclusions from the various emerging means of gathering data on software engineers.

As we saw in the two case studies, some of the factors that determine the productivity of software engineers in an organisation are changeable, and others must be accepted as they are, for now or forever.

Lets define a variable that signifies success, perhaps the ratio between the resources of a company per capita, and the productivity of a company per capita.
With this generalised rating we would have a metric to compare sets of factor scores against.

Implications & Ethical concerns

Facebook and Google personally targeted adverts based on the data one openly shares on their platforms.

At ‘best’, prospective software engineers could be targeted based on their digital footprints.

This would be most ethically concerning if implemented by governments with little in the way of civil rights. Citizens could be drafted as software engineers, especially if demand for the profession continues to rise.

Ethical concerns arise when consumers are unaware of their data and its use.

Previous studies have used data submitted manually by software engineers. Recently various technologies have emerged that can track employees at all working hours. Data could passively be collected from employees. This would undoubtedly lead to more accurate data then the inherently biased self-analyses of the engineers. Another feasible source of more in-depth data would be processing the digital footprints of employees. Although, these means of collection clearly raise many ethical concerns.