

Personality, Emotional Intelligence and Work Preferences in Software Engineering: An Empirical Study

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Abstract

Context: There is an increasing awareness among Software Engineering (SE) researchers and practitioners that more focus is needed on understanding the engineers developing software. Previous studies show significant associations between the personalities of software engineers and their work preferences.

Objective: Various studies on personality in SE have found large, small or no effects and there is no consensus on the importance of psychometric measurements in SE. There is also a lack of studies employing other psychometric instruments or using larger datasets. We aim to evaluate our results in a larger sample, with software engineers in an earlier state of their career, using advanced statistics.

Method: An operational replication study where extensive psychometric data from 279 master level students have been collected in a SE program at a Swedish University. Personality data based on the Five-Factor Model, Trait Emotional Intelligence Questionnaire and Self-compassion have been collected. Statistical analysis investigated associations between psychometrics and work preferences and the results were compared to our previous findings from 47 SE professionals.

Results: Analysis confirms existence of two main clusters of software engineers; one with more “intense” personalities than the other. This corroborates our earlier results on SE professionals. The student data also show similar associations between personalities and work preferences. However, for other associations there are differences due to the different population of subjects. We also found connections between the emotional intelligence and work preferences, while no associations were found for self-compassion.

Conclusion: The associations can help managers to predict and adapt projects and tasks to available staff. The results also show that the Emotional Intelligence instrument can be predictive. The research methods and analytical tools we employ can detect subtle associations and reflect differences between different groups and populations and thus can be important tools for future research as well as industrial practice.

Keywords: Software engineering, Personality, Empirical study, Five Factor Model, Self-Compassion, TEIQue

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1 Introduction

There have been several calls to value and study human factors in SE [1, 2, 3] and in recent years there has also been an increase in empirical studies [4, 5, 6, 7]. Even though technical and methodological innovation and improvement is essential to progress the developers themselves are often the same and their motivations, needs, characteristics and even idiosyncrasies must be understood to improve the socio-technical system as a whole. As a related example, Glass [2] stated that “*The most important factor in software work is not the tools and the techniques used by the programmers, but rather the quality of the programmers themselves*”. Studies performed during the last decades have made personality one subject of this call for a larger focus on the individuals and their characteristics even though it was recognized already early in the development of the field [8, 9].

However, the connections between factors like personality, job attitude and performance are not simple. This is likely the reason why some studies show clear links [6] while others show little or no effects [4] of personality of developers on their preferences and performance in the software development process. This does not come as a surprise if we take into account that personality is one of the most complex concepts in the social sciences and its conceptualization and analysis is one of the most challenging tasks in psychology [10]. Even so, the prediction of performance on specific tasks [11], building effective teams [12] or peers in pair programming [13] and, more generally, the search for the most suitable person for a specific IT job [14] shows that personality-focused SE research is both an active area and has many practical applications.

Despite the research interest shown during the last decades on the importance of human factors in SE and particularly the personal characteristics of the humans involved in the SE processes, such factors have been largely disregarded or were not empirically studied [15, 16, 17, 18, 19]. When studies have considered the personality of developers empirically, they have primarily used dated models or metrics that have been criticized within psychology [20], in particular the Myers-Briggs Type Indicator (MBTI) [21, 22, 23, 24, 25]. In contrast, Feldt et al. [6] used the modern and more scientifically validated Five-Factor Model (FFM) and found significant associations between personality factors and the attitudes and preferences² of 47 industrial software developers. The more detailed and nuanced picture of personality offered by the five-factor model allows statistical analysis that can help identify and quantify complex relations between individual, team and project factors in SE projects. Despite these advances, the knowledge linking individual characteristics of software engineers to their SE performance is in a nascent state; there is a general lack of large, empirical studies and there is a lack of information on whether personality effects are stable over the age and length of experience of the investigated subjects. The latter is important if we are to exploit a deeper knowledge in practical guidance on team formation and role and career decisions.

In the quest of a deeper understanding of the preferences of software engineers and how their personal characteristics can affect their professional decisions, this paper presents an operational, external replication study [26] of our previous study [6] in which we keep our measured constructs and the

² It is a fine line between an attitude and a preference and some of our questions are more clearly the former while some are about the latter; in the following we use the terms interchangeably.

statistical analysis methods intact, while extending with additional psychometric instruments and using a different, larger set of subjects. The data we investigate is the responses to three different psychometric instruments by a total of 279 graduate students in a Master of Science program in Software Engineering at a Swedish University. The measurements were taken over three years (2010-2012) and involved students enrolled during a 5-year period (2008-2012). All of these subjects have at least bachelor degrees in Software Engineering or Computer Science and can thus be expected to be representative³ to software engineers at a very early stage of their careers, i.e. fresh out of university. This is in contrast to our previous study that focused on industrial practitioners with a generally longer experience from software projects and industrial practice.

Additionally, to investigate if other psychometric instruments can be of use in understanding and characterizing software engineers, we broaden the study by including two additional psychometric instruments, the Self-compassion test [27] and the Trait Emotional Intelligence Questionnaire (TEIQue) [28]. There is a plethora of psychometric instruments to choose from, but we selected these two as they aim to represent psychological constructs that are different from personality and thus can add additional predictive power. Furthermore they have been quite recently introduced and investigated empirically. Emotional intelligence has also gotten a lot of attention in lay press through the work of Goleman [29] with claims that it is an important indicator of success in life and at the workplace. Both of the added psychometric instruments have been found to be associated to attributes such as creativity and social functioning, which is likely to be important in the often knowledge-intensive and team-based work life of modern software companies [30, 31, 32].

Overall, our goals are to evaluate our results and methods in a larger sample, using software engineers in an earlier state of their career. We employ advanced statistical methods in order to evaluate connections between questions and psychological constructs and to derive understandable, predictive models from one to the other. Our contributions are:

- results for the present set of subjects that are partially consistent with our previous results in [6], thus further strengthening them and the methods used,
- to show that one new (emotional intelligence) but not another (self-compassion) psychometric construct show associations to software development preferences,
- further statistical analysis of association between the software development preferences and
- a concrete example of an operational replication study in SE.

Overall, our results show that individual differences are reflected in different SE preferences and that the instruments and analytical methods proposed can detect such connections.

Section 2 of this paper provides the theoretical background on psychometrics and personality testing and present previous studies in SE and software development that have used such tests. Next, in Section 3, we describe the design of our empirical study, followed by the results and statistical analysis

³ Some bias, of course, exist due to the bachelor level students all having decided to continue their studies towards a masters degree.

in Section 4. Section 5 involves the investigation of Trait Emotional Intelligence Questionnaire (TEIQue) and Self-compassion tools as supplementary psychometric tools in order to examine if similar outcomes can be derived. We discuss the results and try to answer to the research questions previously posted. Finally, we conclude with Section 6 summarizing the results and impact of our work.

2 Background

Various psychometric instruments and models have been used in previous studies for different purposes. In the following subsections we give a brief overview over these psychometric instruments and models and then summarize the related research in software engineering and software development.

2.1 Personality Models, Metrics and other Psychometric Instruments

Years of research and studies in the personality psychology field have led to one of many views, which concerns the description of personality by a set of traits, that is a set of factors or attributes that harbor information of how a person feels, thinks and behaves [33, 34]. These traits, combined with other attitude aspects and empirical models can be used to, at least to some degree, predict how a person acts in certain circumstances.

Since 1930, different trait-based personality theories have been proposed, and then gained wider acceptance and interest in the 1970s. Meanwhile, a variety of practical tests to measure personality types have been proposed, such as the MBTI, the FFM, Self – compassion and TEIQue.

An important, first step was taken by Briggs and Myers [35] when they published in 1961 the initial MBTI psychometric questionnaire. The questionnaire and its traits were loosely based on Jung's theories, published in 1923 in "Psychological Types" [36], in an attempt to measure Jungian functions and attitudes. Jung studied the history of psychological typologies from the classical literature and poetry having as a basis of his formulations the writings of James [37]. Myers and Briggs, using their own observations and Jung's writings, created a psychometric instrument (MBTI, [38]) that focuses not only on professionals and their use cases but also individuals who want to better understand themselves. Specifically, the test consists of a set of four dichotomies: Extraversion – Introversion (EI), Sensing – Intuition (SN), Thinking – Feeling (TF) and Judgment – Perceiving (JP). For each index, a continuous score that contrasts strengths of opposing preferences can be calculated. The test is typically⁴ based on 93 forced-choice items and a MBTI assessor can find the type of a person by the largest score of each bipolar dimension. MBTI can classify individuals into 16 different types that can also be viewed as collections of four-letter codes, which give the type of classification (ENTJ etc.). The MBTI has had a large influence in practice and is widely used for personality assessment in for example job screening and interview situations [39].

⁴ Several variants exist.

Since the 1980s though, doubts have risen whether MBTI can measure qualitatively distinct personality types [37]. Questions also exist regarding the power of the JP dimension. An alternative to the MBTI is the FFM [40], which is a hierarchical organization of personality traits in five dimensions, namely: Extraversion (E), Agreeableness (A), Conscientiousness (C), Openness⁵ (O) and Neuroticism (N) / Emotional Stability [41]. These dimensions originated in studies of natural language trait terms [43]. As it is stated in McCrae and John [40], the model is appealing due to the fact that it integrates a wide array of personality constructs, making communication among researchers from different fields and orientations easier. The model is comprehensive and provides a basis for further exploitation of relations between personality and other factors, such as student's attitude and preferences. It is also efficient as it provides a global description of personality with only five scores, which represent the five fundamental dimensions of personality [40]. On the other hand, the model has received not little criticism by personality psychologists [44, 45, 46] regarding the number of factors describing personality and the nature of the factors themselves. However, the model has gained a wide acceptance in literature, being today a default model of personality structure [47].

The NEO PI-R [48] is the most used instrument to assess the five domain factors of the FFM and their 30 facets (6 for each factor with 8 items for each facet for a total of 240 items). It takes approximately 40 minutes to complete for one individual. There is also the NEO FFI version, which is scaled down to 60 items and takes only 15 minutes to complete. Both of these instruments are however "closed" and training as well as a license is required in order to be able to use them.

There is an "open" alternative to the former instruments, widely known as IPIP, which is a freely available tool based on the FFM [41, 49]. In previous work we used the short version of the IPIP [6] and here we use a new and even shorter version of IPIP, the mini-IPIP instrument [50] (a 20-item tool, having 4 items per each one of the five FFM traits) that has shown results consistent with the longer versions. We use the shorter form to minimize the test time since we employ multiple psychometric instruments in the present study. Thus we base our research on measuring the five personality factors: Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Intellect/Imagination.

Additionally, there are other psychological tests documented in the literature. From the many documented, but not used in the context of SE we incorporated in this study two additional psychometric tools, namely: the Self-compassion scale and the Trait Emotional Intelligence Questionnaire (TEIQue). Given the fact that these two tools have not been used yet in the context of SE, we found it interesting to explore the outcomes of these two psychological tests in relation to other aspects of individual views and attitudes. Since they aim to measure psychological constructs that are different from personality they can provide some evidence for whether future SE research should investigate additional psychometric instruments. Furthermore, TEIQue is related to emotional intelligence as it has been popularized in recent years in the popular press through the work of Goleman [29]. We have found no studies that use emotional intelligence in software engineering. However, in Crowder et al. [51] emotional intelligence is used in the context of Artificial Intelligence

⁵ The Openness factor is sometimes called "Intelligence / Imagination" in some studies [42], we mostly use the latter since it has been adopted in the IPIP mini instrument we use in the present study.

in an attempt to design and implement human-like behavior to improve learning systems. In Psychology, emotional intelligence has been claimed to be a strong predictor of work performance and career success even though there is a debate as to the strength of scientific evidence for such a link [52]. We base our work on one of the recent, and more scientifically studied EI instruments, the TEIQue [53]. Trait emotional intelligence is a “compound personality construct” [31] and even though it was found to be related to several of the personality factors of the FFM it had additional predictive power in relation to four out of six different criteria investigated.

We have further chosen to include the Self-compassion scale as an example of a psychometric instrument from the tradition of “Positive Psychology” [54], since it has been shown in recent years to be a possibly better predictor of success than self-confidence [27]. A growing body of evidence suggests that self-compassion is associated with psychological health but it has also been connected to such positive characteristics as increased levels of personal initiative, curiosity and creativity [30]. Since the latter are the type of characteristics that are often requested in the type of project-driven, knowledge-intensive and high paced work environment that often characterizes software development companies it is a potentially useful construct to investigate [32]. Furthermore Neff and Vonk [30] showed that even though it was associated with several of the five factors in the FFM it “*still predicted unique variance in positive functioning after controlling for personality variables*” [30]. Below we describe these two psychometric instruments in more detail.

According to the dictionary, compassion is “the human quality of understanding the suffering of others and wanting to do something about it” [55]. Buddhist traditions, however, consider equally important to offer compassion to the self [56, 57, 56]. Neff [27], based on various Buddhist writings [59, 60, 61] defines three main components of Self-compassion: Self-kindness, Common humanity, and Mindfulness. Each one of these three components has a negative respective value (Self-judgment, Isolation and Over-identification correspondingly). There is a growing number of researchers that link self-compassion to psychological health, while others, relate self-compassion with less anxiety and depression [27, 62, 63, 64]. The Self-compassion questionnaire is comprised of 26 items, from which 6 subscale scores (previously reported) are computed by calculating the mean of subscale item responses. Responses are given on a 5-level scale from “Almost never” to “Almost always”. The total mean of the 6 subscales gives the calculation of the aggregate Self-compassion score, which we use in our analysis.

The Trait Emotional Intelligence Questionnaire (TEIQue) is an integral part of the academic research program on trait emotional intelligence theory (EI), which conceptualizes emotional intelligence as a personality trait, located at the lower levels of personality hierarchies [31]. The questionnaire is comprised of 30 items (15 facets with 2 items each) and calculates 4 factors; Emotionality, Self-control, Sociability, Well-being and one global trait, the EI score, which is calculated from the former values. EI has values from a range of 1-7.

In our analysis we investigate the students’ attitudes with respect to: the 5 IPIP personality factors, Self-compassion and EI, which are considered from now on as the analysis’s dependent variables. In the following section we review studies where psychological tests have been used to find associations and connections between personality and other human aspects in SE.

2.2 Studies on Personality and Software Development

There are multiple studies in the literature that try to find links between personality and SE, software development activities and performance. Some of the studies are focused in specific aspects of SE and can be generally categorized in three main segments, targeting Pair Programming (PP), team effectiveness and role assignment, respectively. As reported by Cruz et al. [65] 56% of the studies performed until 2011 have as subject of investigation students and their main research topics are PP or team effectiveness. An overview of the studies presented below is given in Table 1. In particular, the table shows that there is no clear consensus on whether personality is an important factor; while some studies have found connections, not all have found any.

Regarding PP, Dick and Zarnett [66] stated that personality traits are necessary in order to distinguish candidates that are talented in PP. Contrary to the previous study, Chao and Atli [24] used statistics to show if higher quality of code developed by pairs of programmers could be matched to four personality traits they used in their analysis, but found no statistically significant connections. Salleh et al. [67] performed a study based on students and the FFM. They reported that differences in personality did not affect the academic performance of students who pair programmed. Walle and Hannay [68] examined the influence of personality on the nature of collaboration in PP, using the Big-Five factor model. Evidence was found supporting that personality affects the type of collaboration occurring in pairs. In Sfetsos et al. [13] more advanced statistics were applied indicating better communication, pair performance and pair collaboration-viability for pairs with heterogeneous personalities and temperaments. One year later, in 2010, Hannay et al. [4] using the FF model tried to explore the effect of personality on PP performance, without finding any strong indications. Consequently, Salleh et al. [69, 5] conducted two studies regarding the effect of conscientiousness and neuroticism on PP. They did not find evidence for distinguishing the performance of paired students between different levels of either conscientiousness or neuroticism. Additionally, Salleh et al. [70] investigated the effects of the FFM traits on PP's effectiveness. More specifically they investigated if differences in Neuroticism, Conscientiousness and Openness levels affected the paired students' academic performance. Differences in Neuroticism and Conscientiousness levels did not significantly affect the paired students' academic performance. On the other hand Openness was found to have substantial impact towards paired students' performance. To sum up, the findings of the studies addressed to PP are contradictory, with some studies showing evidence for an impact of personality on PP, while other studies find no such impact/relation.

Apropos teamwork management and performance, Karn and Crowling [25] investigated the effects of personality on the performance of SE teams, using the MBTI personality types. The study demonstrated that teams can work satisfactorily despite significant ethnic, religious and personality differences between individual members. The impact of personality characteristics on individual performance within a team environment was also tested by Bell et al. [71] and no strong correlations were found. The latter came in contrast to Acuña et al. [72] reporting a significant relationship between personality and team job satisfaction. Studies in the direction of role assignment try to probe the relationship between personality and performance with respect to technical roles in the software

development process. Capretz [73] in his study proposes how to map personality types to technical roles using the MBTI personality test. Additionally, Acuña and Juristo [23] in their study show that assigning people to roles according to their capabilities and personality, improves software development. On the subject of suiting people to a particular stage of the development process life cycle, Capretz and Ahmed [14] suggest that taking personality into account in the assignment process increases the chances of the projects' success. The same year they proposed a theoretical method to show which personality types better suit a specific projects life cycle stage, using the MBTI test [74]. Martinez et al. [75], working in the direction of role assignment, introduce RAMSET, which is a role assignment methodology that relates personality, abilities and software roles for the integration of SE teams. It applies sociometric and psychometric techniques through a fuzzy approach. The methodology is applied in SE courses [7] and according to the writers it can improve the efficiency of the classroom teams. Recently, Rehman et al. [76] using the FF model show that software analysts should have extraversion and agreeableness as main personality traits. Software designers should be highly agreeable and open to experience, software developers should be extroverted, open to experience and agreeable, software testers should have openness to experience and conscientiousness while software maintenance engineers should have openness to experience and conscientiousness as dominant personality features.

Common denominator of many studies so far is the use of the MBTI test, which does not consider the strengths of personality along different dimensions. This fact downgrades statistical analysis results and hide possible associations between personality factors and traits related to performance, attitude etc. Moreover, the existing empirical studies that link personality to working preferences towards software development are contradictory. It is important to mention at this point the need of advanced multivariate statistical analysis in cases when several attributes have to be statistically studied simultaneously. Most of the previous studies are either characterized by total lack of statistical tests relying on theoretical basis to make inference or the use of simple univariate descriptive statistics, or even at best correlation analysis, ANOVA or regression analysis. In studies where multivariate analysis was applied, either no relations were found [4] or only one personality factor was taken into consideration [67]. Finally, noteworthy are studies where fuzzy techniques [75, 7] and decision trees analysis [4] were applied.

Feldt et al. [6], using advanced statistical methods and the scientifically validated five-factor model, found clear links between personality factors and the attitudes and preferences of 47 industrial software developers. In our study we replicate the Feldt et al. [6] methodology with the suitable and advanced statistical tests to the nature of the data. Particularly, we use cluster analysis, which is a multivariate statistical method, which uses all the attributes to reveal natural groupings (or clusters) within the dataset. Additionally, we explore further the discovered clusters reducing our space in two dimension using Factor Analysis (FA), also a multivariate statistical test. Finally, in order to avoid erroneous associations because of multiple comparisons performed in ANOVA, use Generalized Linear Models (GLM), a multivariate analysis, in order to model the relations between personality traits and the attitude variables.

Table 1 Summary of literature on connections between personality and SE covariates

Author(s)	Year	Psychometric instr.	SE covariate(s)	Summary
Acuña et al. [72]	2009	IPIP	Team job satisfaction / software quality	Several connections were found
Walle & Hannay [68]	2009	IPIP	Nature of Collaboration in Pair Programming (PP)	Several connections were found
Sfetsos et al. [13]	2009	Keirsev Temperament Sorter [78]	Pair effectiveness in PP	Several connections were found
Feldt et al. [6]	2010	IPIP	General SE preferences	Several connections were found
Martinez et al. [75]	2010	IPIP	Role assignment	Several connections were found
Rehman et al. [76]	2012	IPIP	Job requirement mapping in SE	Several connections were found
Martinez et al. [7]	2011	MBTI	Role assignment	Some connections were found
Dick & Zarnett [66]	2002	Not applicable	Pair Programming	Communication, comfortableness working in a team, confidence and ability to compromise are critical personality traits for PP success.
Acuña & Juristo [23]	2004	16PF [79]	Role assignment	Assigning people to roles according to their capabilities and personality, improves software development
Karn & Cowling [25]	2006	MBTI	Performance of SE Teams	Teams can work satisfactorily despite significant ethnic, religious and personality differences
Capretz & Ahmed [14]	2010a	MBTI	Software development	Taking personality into account in the assignment process increases the chances of the projects' success
Salleh et al. [70]	2012	Neuroticism, Conscientiousness and Openness to experience (IPIP)	PP effectiveness in academic performance	Students consisting of high Openness achieved significantly better performance compared to their counterparts.
Bell et al. [71]	2010	IPIP	Software Engineering Group Work & Performance	No strong connections were found
Chao & Atli [24]	2006	Personality characteristics (Univ. of Denver Career Centre)	Pair Programming	No connections were found
Salleh et al. [67]	2009	IPIP	PP effectiveness in academic performance	Differences in personality traits did not significantly affect the academic performance of students who pair programmed.
Hannay et al. [4]	2010	IPIP	Pair Programming	No connections were found
Salleh et al. [69]	2010a	Conscientiousness (IPIP)	Pair Programming	No connections were found
Salleh et al. [5]	2010b	Neuroticism (IPIP)	Pair Programming	No connections were found
Capretz & Ahmed [74]	2010b	MBTI	Role assignment	Theoretical methodology approach

3 Method

Like our previous study, the basic research approach of this study is that of an extensive statistical analysis of questionnaire data collected through web-based forms [6]. Thus, the overall research method can be described as a correlational study, i.e. we measured several variables and compared in a large group of individuals [77]. However, in this study, compared to our previous, we have more control over the sampling procedure and response rate since the subjects are students in Master level courses taught by one of the authors (Feldt). We thus have almost a 100% response rate (with the exception of data collection mishaps affecting a few subjects whose (incomplete) responses were subsequently excluded from the analysis). Another difference is that since a larger number of psychometric instruments have been used in this study we had to limit the length of each one; in this study we thus use the shortest form available for all of the included psychometric instruments and also limit the software engineering specific questions involved to the ones that was found the most relevant in our previous study. This study can thus be characterized as an *external*, operational replication study [26] since the specific measurements taken are different even though they aim to measure the same underlying constructs. But it is an operational replication since we have extended the design with additional measurements as well as analysis techniques.

Our overall aim is similar to the study we replicate, i.e. to investigate if there are groups of individuals with differing personality characteristics and to analyze how these personality groups are associated with answers on the attitude questions. More specifically we investigate the questions:

RQ1: Are there groupings of respondents according to their personalities as measured by the five personality traits?

RQ2: In case the respondents form personality clusters, are there associations between these clusters and the answers to the attitude/preference questions?

RQ3: Are there differences in the means of each one of the personality traits among the different answers of each attitude question?

RQ4: How can we model the relations between personality traits and the attitude variables?

Additionally, by comparing the results of our detailed analysis to the results from the replicated study we can investigate if there are any notable differences.

Below we discuss the subjects and the questionnaires in more details. The statistical methods used are described with the corresponding analysis in section 4.

3.1 Subjects

The participants are the first-year students in the 2 year long Master of Science program in Software Engineering at the Chalmers University of Technology and Gothenburg University in Gothenburg, Sweden. The program is shared between the two universities and students are eligible for studying in the program when they have taken a bachelor in Software Engineering or in Computer Science. In rare exceptional cases, students can also be admitted if they have a bachelor degree within related areas and

can show through prior work experience that they have software development experience corresponding to a bachelor programs. About 50-100 students start this program every year.

We administered personality tests and the SE preference questions in the first course of the program, a Requirements Engineering course, given in September to October of each academic year. The additional psychometric instruments were not used in all three years of the study. Thus, there are fewer responses to these two than the IPIP personality based one (see Table 2). Also, due to some students quitting the program or switching programs or electing to take one or both of the courses at a later point in their studies there is not a perfect match between responses for each student for all instruments. Our data is thus the combined data over all three years and a total of three measurement events, constituting a total of 279 unique subjects. All subjects answered the IPIP-mini personality item while only subsets took the Self compassion and Emotional Intelligence instruments. The number of responses was the highest the first year since this was the first time the Requirements Engineering course was given at the program. Students that had been admitted to the SE program in the preceding two years were thus also allowed in the course, which lead to a larger course and more responses. Table 2 summarizes the number of students per year and personality instrument, that of the total three measurement events. Furthermore, in Figures 1, 2 and 3, we present the dependent variables of our analysis, in the form of boxplots, which we investigate in our study in relation to the students' work preferences. Each one of the boxplots represents the range of values for each dependent variable, which is represented in the y-axis of each figure. The mean and standard deviation of our dependent variables are shown in Tables 3 and 4.

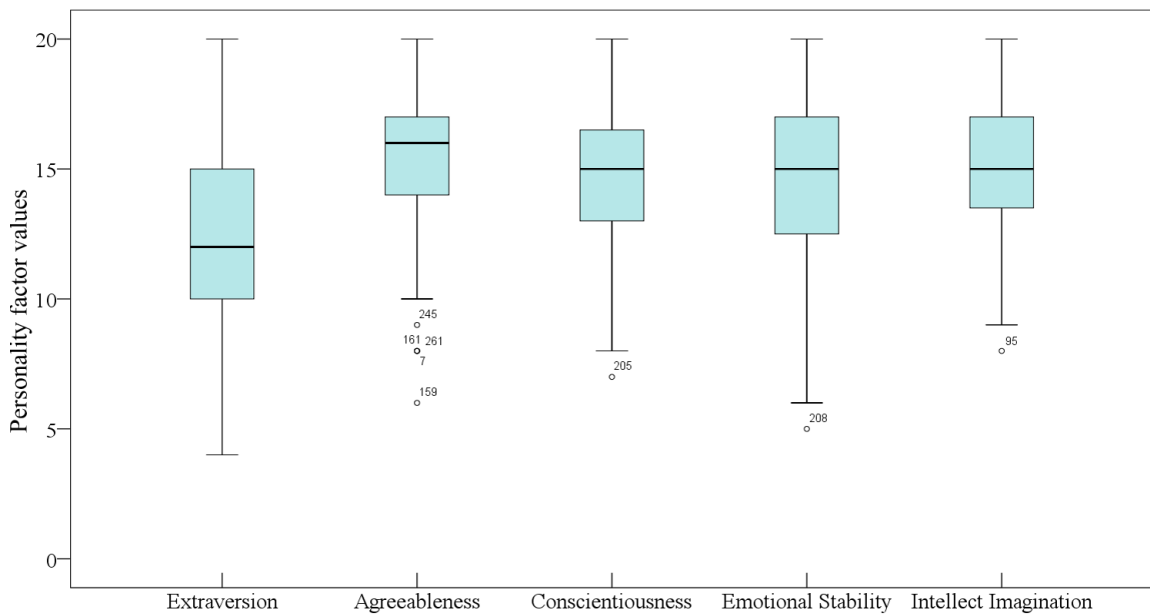


Figure 1 The IPIP five personality factors

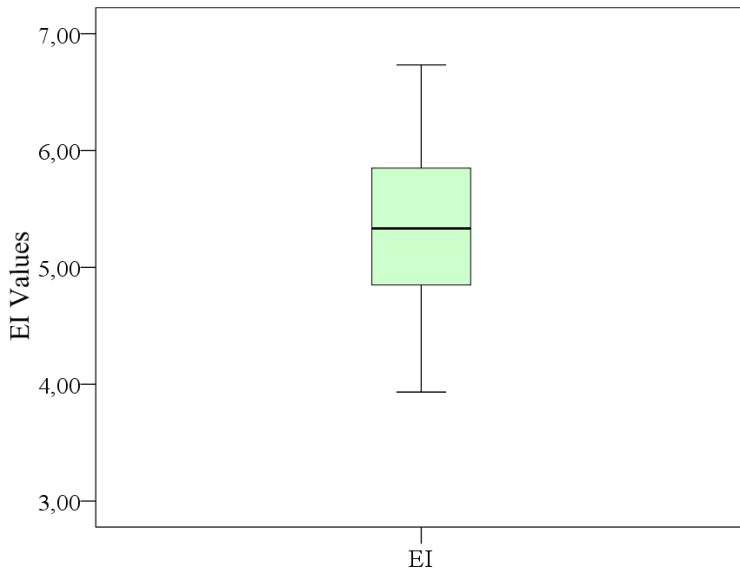


Figure 2 Distribution of the Emotional Intelligence dependent variable

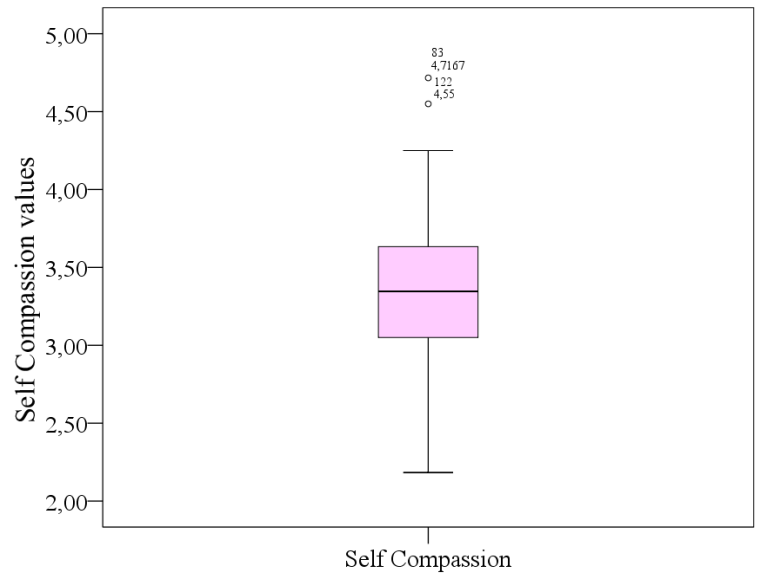


Figure 3 Distribution of the Self-Compassion dependent variable

Table 2 Summary table with the number of responses per year and per personality instrument

	Nr./Year	IPIP	TEIQue	Self-compassion
2010	148	272 (7 missing)	-	142 (6 missing)
2011	73		119 (12 missing)	-
2012	58		-	-
<i>Total</i>	<i>279</i>	<i>279</i>	<i>131</i>	<i>148</i>

Table 3 Mean and standard deviation of the IPIP factors

	Extraversion	Agreeableness	Conscientiousness	Emotional Stability	Intellect / Imagination
Mean	12.3	15.4	14.8	13.5	15.3
Standard Deviation	3.5	2.6	2.6	3.5	2.7

Table 4 Mean and standard deviation of EI and Self-compassion

	Emotional Intelligence	Self-Compassion
Mean	5.4	3.3
Standard Deviation	0.7	0.4

3.2 Questions and answer alternatives

The data were collected during three years, in which different questionnaires were used. With the purpose of being able to apply statistics to the total number of respondents, we merged the three separate datasets, based on their common parts (questions). The final chosen questions appear in the Appendix of this paper; 2 questions of demographic nature and 9 questions on software development preferences in addition to the psychometric instruments (used as is). From the questions of work

preferences only a subset of question was found to be associated with personality in our previous study [6]. Since students do not work in an organization or company or use a coherent set of tools or standards several preference questions were not relevant in this study. Furthermore since additional psychometric instruments were used in this study the total number of questions included had to be controlled for. Otherwise, the time to answer the survey instruments might be excessive which could lead to lower response rates or insincere answers by some subjects. Thus only the subset of preference questions, named “Your preferences”, is included in this operational replication study.

4 Results and analysis

A total of 279 unique students answered the set of web-based surveys, administered over 3 different years (2010-2012). In order to find links and associations between the different attributes and factors of the responses, a variety of statistical methods were applied, such as descriptive statistics, statistical tests, one way analysis of variance (ANOVA), clustering and Generalized Linear Models (GLMs). Additionally, we use a number of different graphics and tables, to facilitate the interpretation of statistical results.

The structure of our analysis is similar to the one used in [6]. After analyzing descriptive statistics for the SE preference questions we investigate if there are any groups of differing personalities with a cluster analysis. We then study if the identified groups differ in their connection to the preference questions using a χ^2 –analysis (chi square). An ANOVA analysis of the connection of each personality factor to each preference question is then performed. This is followed by the detailed analysis of such associations through GLMs. We then check for associations within the set of preference questions.

Since this study involves an extended set of psychometric instruments, a further analysis section (Section 5), contains a statistical analysis based on this extended data. In particular we study if EI (TEIQue) and/or self-compassion show any association to the SE preferences and if they give additional discriminatory power and understanding compared to the IPIP personality measurements. Thus, we performed similar analysis with that applied in the IPIP data, to the extra tests (TEIQue and Self-compassion)

For all statistical tests, a statistically significant difference is assessed when $p < 0.05$. Since the tests are two tailed, however, we also report cases with $p < 0.1$ to reveal possibly significant differences or dependencies. In the following sections we present our results per statistical test for all three psychological tests and in order to answer the research questions stated in the method section above.

4.1 Descriptive statistics

After dataset cleaning, 272 Web questionnaires were used out of the 279 filled in by the students in three different semesters (years 2010, 2011 and 2012). Of the 272 respondents, 21% were female and 79% male. 50.4% were between 25-30 years old, 42.6% between 20-24 years old and a small percentage of 7% between 31-50 years old. 51% of the students had 1-3 years of full time experience in software development. From three to five years of full time experience we had 23% of the respondents.

19.6% had less than one year of experience and small amount of 6.4% had full time experience ranging from 5 to 20 years. The remaining descriptive statistics are shown in Table 5.

Table 5 Descriptive statistics of the respondents who answered the IPIP questionnaire

iv. In your previous software development projects do you prefer to work:?	(%)	v. Do you prefer working with:?	(%)	vi. Do you prefer working:?	(%)
After a given schedule / project plan	78.9	Several things at once	34.3	In a team	83.0
As the day develops	21.1	One thing at a time	65.7	By yourself	17.0
vii. Do you prefer to be responsible for:?	(%)	viii. Do you prefer to work in:?	(%)	x. If you could choose would you prefer to work with:?	(%)
Entire development process	43.3	Longer projects lasting for several months up to a year	35.3	Technical parts of a software development project	41.5
Particular part of development	56.7	Short projects lasting up to a couple of months	64.7	"Softer" / Management parts of a software development project	58.5
ix. Do you prefer to work:?	(%)	xi. You work best / most efficiently when:?	(%)		
On project startup	13.7	When a manager prioritizes your tasks	20.6		
From project start to project end	79.7	When you can prioritize your own tasks	79.4		
Short contributions as needed	6.6				

4.2 Cluster analysis of personality factors

Since each person's personality is characterized by a number of attributes in our samples, it is interesting to investigate the existence of groupings in the data. We utilize these groups with the purpose of performing comparisons and discover associations with the attitudes. Ergo, we consider all attributes together instead of testing each one of them separately.

For this reason, we used the multivariate statistical method, known as cluster analysis [80]. This method uses all the attributes together in order to identify homogeneous, mutually exclusive subsets, and reveal natural groupings (or clusters) within the dataset that would not be apparent otherwise. For our cluster analysis, we applied the PASW® algorithm "Two-Step Cluster Analysis" (TSCA) on the personality factors [81]. This specific algorithm was employed because it can automatically determine the optimal number of clusters by comparing the values of a model choice criterion across different clustering solutions. It is worth mentioning that the TSCA algorithm not only divides the data into clusters, but also includes statistical tests and graphs for the validation of the clusters found. Furthermore, another advantage of the algorithm is that it is quite robust in the violation of certain assumptions, like the independency between variables. In our case, this is violated since according to Pearson's correlation coefficient for the IPIP attributes there is significant correlation ($p < 0.001$) between: (a) Extraversion and Agreeableness, (b) Extraversion and Emotional Stability, (c) Extraversion and Intellect/Imagination, (d) Intellect/Imagination and Agreeableness and (e) Emotional Stability and Intellect/Imagination.

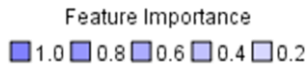
After extensive experimentation with the various parameters of the algorithm, we used the AIC (Akaike's Information Criterion) [82] as our information criterion with the log-likelihood distance measure. The likelihood measure places a probability distribution on the variables, which are assumed to be normally distributed. The distance between two clusters is related to the reduction in log-likelihood as they are conjoined into one cluster. The assumption of normality was tested using the Kolmogorov–Smirnov test [83]. The variables were found to be not significantly different from the normal distribution.

Once we performed TSCA on the five personality factors, the algorithm resulted in two clusters. From the 272 participants, 167 were assigned to Cluster 1 and 105 to Cluster 2. The statistics associated with the importance of the variables with respect to their grouping properties are depicted in Figure 4 and Figure 5.

The participants in Cluster 1 seem to have higher values in all personality factors. Cluster 1 can be characterized as the “intensive” one, since it has higher average numerical values for all five factors. Cluster 2, can be considered as the “moderate” one. From the two Figures we also observe how the factors affect the differentiation of participants. Namely, Agreeableness, Extraversion, and Intellect/Imagination are the variables with the higher importance in the definition of clusters. Overall we can summarize that in our sample we have two general personality types characterized mainly by differences in Intellect/Imagination, Agreeableness and Extraversion and partly by Emotional Stability and Conscientiousness.

In order to be able to portray graphically the two clusters, we have to reduce the five - dimensional space. This can be achieved by a projection on a space of two dimensions, after performing a factor analysis (FA) [80]. Specifically, a FA with principal component extraction (or Principal Component Analysis, PCA) was conducted on the five factors with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis, $KMO = 0.63$ (in [84], a bare minimum of 0.5 is recommended), and all KMO values for individual factors were >0.8 , which is well above the acceptable limit of 0.5 [85]. Bartlett's test of sphericity $\chi^2 (272) = 90.8$, $p < 0.001$, indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data.

Clusters



Cluster	1	2
Size	61.4% (167)	38.6% (105)
Features	Agreeableness 16.70	Agreeableness 13.38
	Extraversion 13.78	Extraversion 9.94
	Intellect Imagination 16.41	Intellect Imagination 13.56
	Emotional Stability 15.10	Emotional Stability 13.45
	Conscientiousness 15.09	Conscientiousness 14.30

Figure 4 The two clusters based on the TSCA algorithm

Cluster Comparison

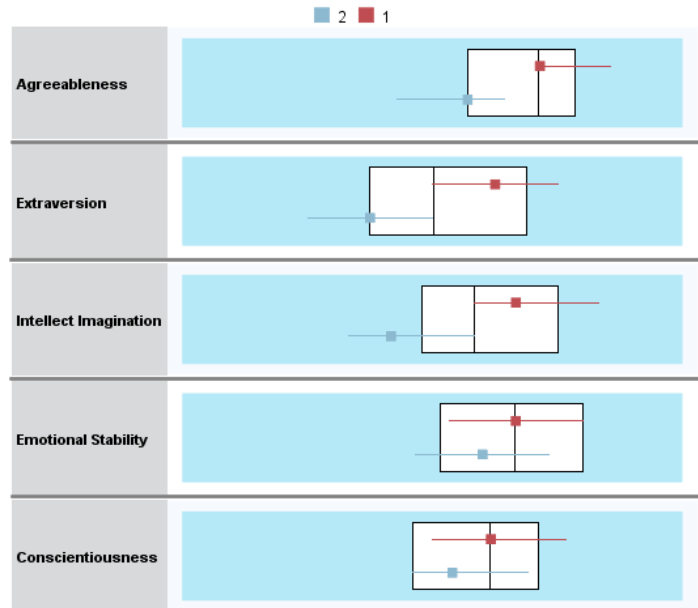


Figure 5 Differences between the two clusters (expressed by the median of each variable in the two clusters). The red box represents the median of Cl. 1 and the light blue box represents the median of Cl. 2 per factor.

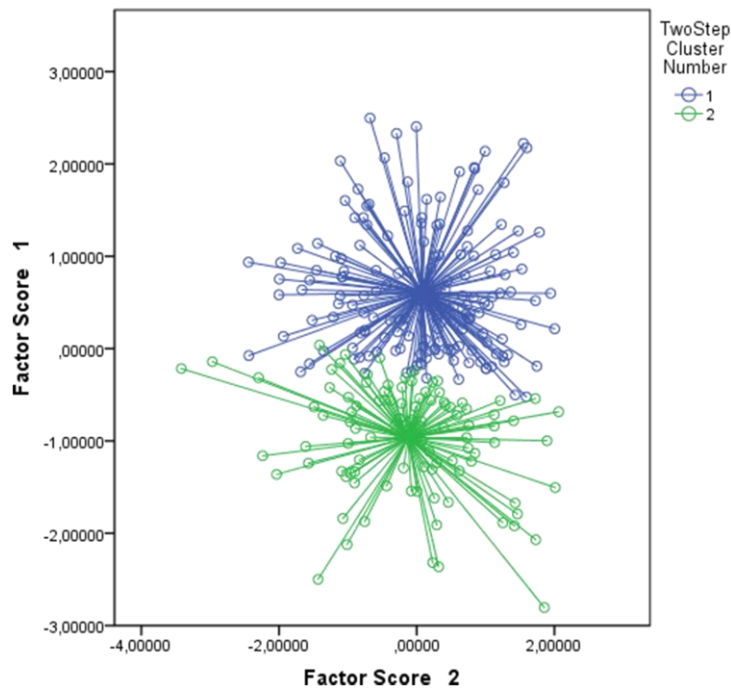


Figure 6 The two clusters, with distances to their centroids, in a 2D factor space after factor analysis

Two components had eigenvalues over Kaiser's criterion of 1 and in combination explained 54.6% of the variance. The Extraversion, Agreeableness, Intellect/Imagination and Emotional Stability personality factors were loaded together to component 1, while Conscientiousness was loaded to component 2.

Above (Figure 6), we can now see how the clusters exist in the two dimensional space we created. The clusters are visually distinguishable in the reduced space. The lines represent the distances from their new, 2D, centroids.

4.3 Clusters and attitude associations

Given the cluster analysis above it is interesting to see how the other variables, related to personal or attitude characteristics, connect with the 2 clusters. Table 6 shows the χ^2 significance levels for associations between the personality clusters and the attitude questions. In order to perform this analysis and the ones following, we excluded the “I have no experience” level from the answers and declared it as missing since it is completely meaningless to try to link that answer with personality. Significances above 0.05 were excluded.

Before reporting the results we explain the structure of Table 6, and provide some examples of interpretation of results. In Table 6 our variables are: (A), (B), (C), (D) (which correspond to questions vi. vii. ix. and x. of our questionnaire (see Appendix)) and the TwoStep Cluster Number. Primarily this table shows the significance of associations between variables (A), (B), (C) and (D) and the clustering variable. Specifically, we can see that in the last column, under the name of χ^2 -test significance level, p . The relation of the attitude variables to the clustering one is described in the cells under the column “TwoStep Cluster Number”. In order to facilitate the interpretation of the results we provide the following example, regarding question vi. (variable (A), as denoted in Table 6). From the students preferring to work in a team 66.2% belong to Cluster 1, while 33.8% belong to Cluster 2 (derived by the “% within Question vi.” table row). Likewise, from the students preferring to work by themselves 39.1% belong to Cluster 1., while 60.9% belong to Cluster 2. If we try to examine the relation from the Cluster Number point of view (derived by the “% within TSC Nr.” table row), from the students in Cluster 1., 89.2% prefer to work in a team, while 10.8% prefer to work by themselves. Similarly, for Cluster 2., from the students in Cluster 2., 73.1% prefer to work in a team, while 26.9% prefer to work by themselves. The results of Table 6 are summarized below.

The analysis showed that students with “intense” personality are more likely to prefer working in a team (89.2% Cluster 1 vs. 73.1% of Cluster 2, $p = 0.001$), to be responsible for the entire development process, to work from project start to project end and with “softer” parts of the software development project. On the other hand, students with “moderate” personality (Cluster 2) are more likely to prefer to work by themselves, in particular parts of the development process, would rather work on project startup or with short contributions and prefer to work with technical parts of a software project.

Table 6 Significance for difference between clusters

χ^2 -test on cluster vs. students' attitude and preference			TwoStep Cluster Number		χ^2 -test significance level, P
			1	2	
(A) vi. Do you prefer working: ?	In a team	% within Question vi. % within TSC Nr.	66.2% 89.2%	33.8% 73.1%	0.001
	By yourself	% within Question vi. % within TSC Nr.	39.1% 10.8%	60.9% 26.9%	
(B) vii. Do you prefer to be responsible for: ?	Entire development process	% within Question vii. % within TSC Nr.	72.0% 51.4%	28.0% 30.8%	0.002
	Particular part of development	% within Question vii. % within TSC Nr.	51.9% 48.6%	48.1% 69.2%	
(C) ix. Do you prefer to work: ?	On project startup	% within Question ix. % within TSC Nr.	56.8% 12.6%	43.2% 15.4%	<<0.001
	From project start to project end	% within Question ix. % within TSC Nr.	66.2% 85.6%	33.8% 70.2%	
	Short contributions as needed	% within Question ix. % within TSC Nr.	16.7% 1.8%	83.3% 14.4%	
(D) x. If you could choose would you prefer to work with: ?	Technical parts of a software development project	% within Question x. % within TSC Nr.	54.0% 36.5%	46.0% 49.5%	0.034
	"Softer" / Management parts of a software development project	% within Question x. % within TSC Nr.	66.7% 63.5%	33.3% 50.5%	

4.4 ANOVA, factor and attitude associations

In order to test the association between each personality trait and all the other categorical variables based on each of the questions; we performed ONE-WAY ANOVA with the dependent variable being each of the personality traits (factors) separately and as categorical variable the responses to each of the questions (demographic questions and student's attitude). ANOVA indicates if there is significant difference in the means of the dependent variable across the categories of the categorical one. When a difference is found we can assess association between the dependent variable (the personality factors) and the subject's attitude.

Table 7 ANOVA significance level for questions and personality factors

Nr.	Question	E, p	A, p	C, p	Em. Stab., p	I/Intellig., p
i.	Gender				0.015	
ii.	Age					
iii.	Development experience (years)					
iv.	Work schedule preference	0.039				
v.	Multitasking	0.084				0.005
vi.	Team work	0.002	0.007			
vii.	Proj. responsibility preference	<<0.001	0.095			<<0.001
viii.	Project size preference			0.013		
ix.	Do you prefer to work: (Startup, Start-End, Part. Parts)	0.002	0.036	0.017		
x.	Non-tech. preference	<<0.001	0.019			
xi.	Task prioritization			0.009		

Table 7 shows the significance levels between each of the personality factors and the questions where a significant dependence ($p < 0.1$) was found.

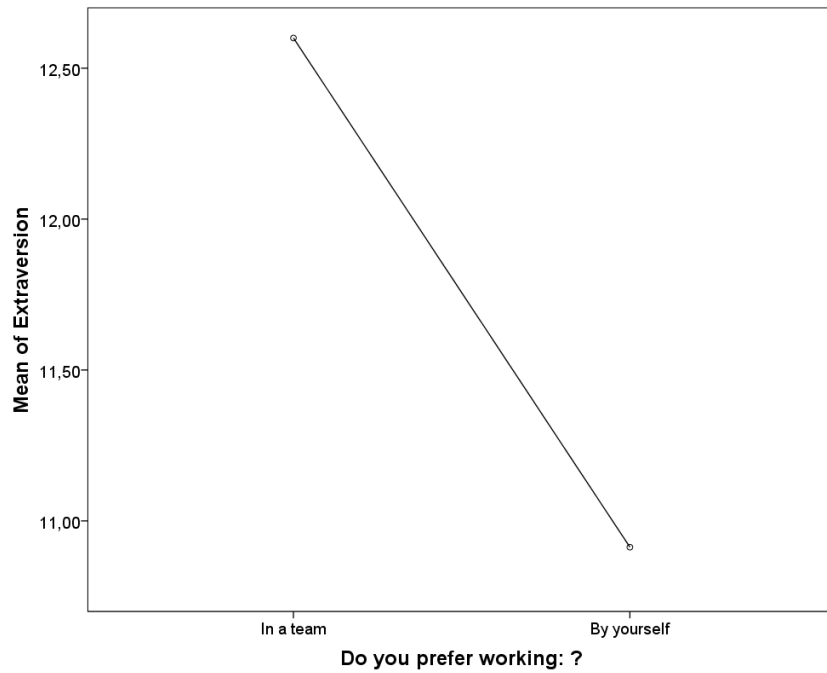


Figure 7 Mean of Extraversion vs. team work

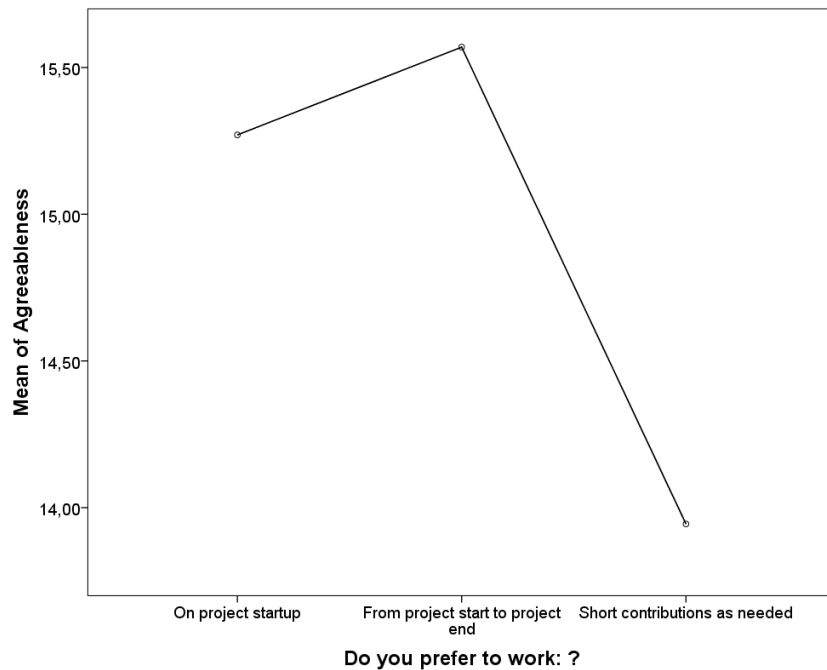


Figure 8 Mean of Agreeableness vs. project phase working preference

Higher levels of extraversion are associated with preferring to work in a team, being responsible for the entire development process, preferring to either work on project startup to working in short contributions or from project start to project end. Students with high extraversion also prefer to work on “Softer”/Management parts of the development procedure. Extraversion also seems to be associated

with preferences in working after a given schedule ($p = 0.039$) with several things at once ($p = 0.084$).

Higher levels of agreeableness are connected with preferring to work in a team rather than by themselves, working from project start to project end rather than with short contributions and in “Softer”/Managerial parts of the development procedure. Also, students with high agreeableness seem to prefer being responsible for the entire development process, rather than for particular parts of development ($p = 0.095$).

Students with higher levels of conscientiousness prefer to prioritize their own tasks, prefer to work in long projects lasting from several months to a year and also prefer to work from the start to the end of the project rather than with short contributions to the project development process.

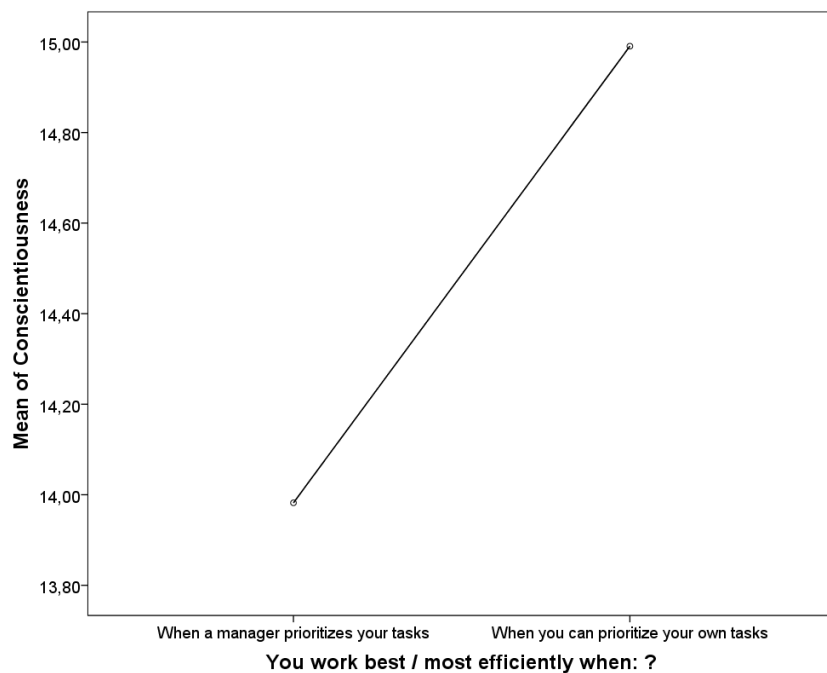


Figure 9 Mean of Conscientiousness vs. task prioritization

Students with higher levels of emotional stability are females. Additionally, students with higher levels of intellect/imagination would rather be responsible for the entire development process than a particular part of it. Students with high levels of Intellect/Imagination also prefer to work with several things at once. Figures 7-10 depict some of the associations found from the ANOVA analysis and described to this section.

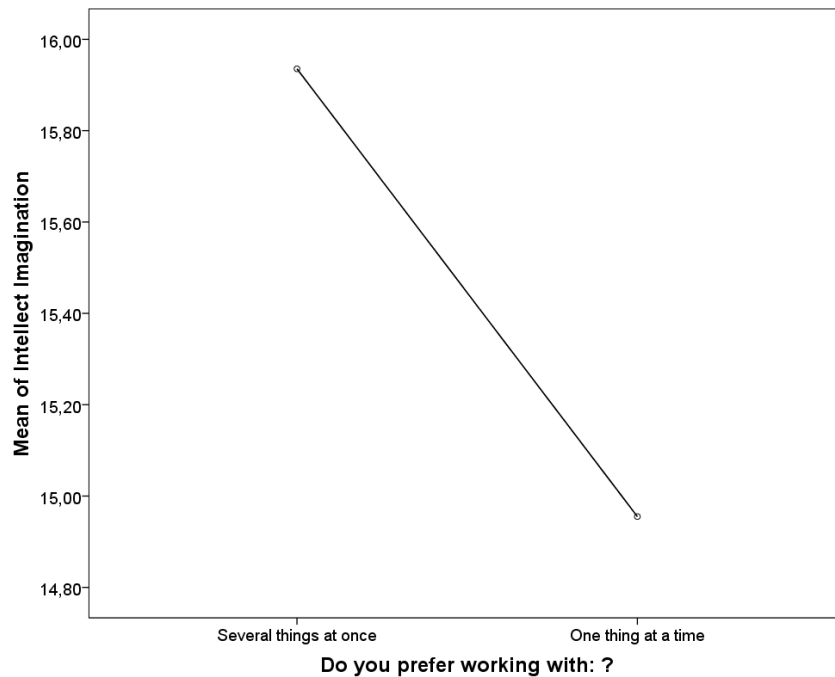


Figure 10 Mean of Intellect/Imagination vs. multitasking

4.5 Generalized Linear Models for factors based on attitudes

To avoid erroneous associations because of multiple comparisons performed in the previous sections, we proceed with a multivariate analysis, in order to model the relations between personality traits and the attitude variables. These associations were shown in Tables 6 and 7. This process involves the generation of Generalized Linear Models (GLM) in PASW®.

Generalized linear model are an expanded version of ANOVA so that the dependent variable is linearly related to the factors and covariates via a specified link function. Moreover, the model allows for the dependent variable to follow a non-normal distribution [86].

We declare each one of the five personality factors as a dependent (response) variable and the associated attitude questions (Table 7) as predictors. We do not intend to use the GLMs for predictions, but rather to explain the effect each factor has to the dependent variable.

For variable E(xtraversion) we found possible associations with questions:

- iv. Work schedule preference, 0.039
- v. Multitasking, 0.084
- vi. Team work, 0.002
- vii. Proj. responsibility preference, <<0,001
- ix. Do you prefer to work: (Startup, Start-End, Part. Parts), 0.002
- x. Non-tech. preference, <<0.001

The estimated GLM for these estimators is:

$$E = c + a_{vii} + a_{ix} + a_x$$

where:

$c = 10.336$ is the intercept,

$$a_{vii} = \begin{cases} 0.996 & \text{for answer "Entire development process"} \\ 0 & \text{for answer "Particular part of development"} \end{cases}$$

$$a_{ix} = \begin{cases} 3.329 & \text{for answer "On project startup"} \\ 2.442 & \text{for answer "From project start to project end"} \\ 0 & \text{for answer "Short contributions as needed"} \end{cases}$$

$$a_x = \begin{cases} -2.196 & \text{for answer "Technical parts of a software development project"} \\ 0 & \text{for answer "Softer/Management parts o a foftware development project"} \end{cases}$$

The α -coefficient denotes the effects of each attitude factor on the variability of E. We ran the model multiple times by removing each time those questions that were not significant to the model. In this case for example, while we had 6 questions to begin with the model, see Table 7, the non-significant questions were finally excluded from the model. All the effects and the intercept were statistically significant with $p < 0.05$. Additionally the model was also found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.001$. The latter shows that the model explains significant portion of the variability of E when compared to the intercept only model.

For variable A(greeableness) we found possible associations with questions:

- vi. Team work, 0.007
- vii. Proj. responsibility preference, 0.095
- ix. Do you prefer to work: (Startup, Start-End, Part. Parts), 0.036
- x. Non-tech. preference, 0.019

The estimated GLM for these estimators is:

$$A = 14.865 + a_{vi} + a_x$$

where:

$$a_{vi} = \begin{cases} 0.967 & \text{for answer "In a team"} \\ 0 & \text{for answer "By yourself"} \end{cases}$$

$$a_x = \begin{cases} -0.593 & \text{for answer "Technical parts of a software development project"} \\ 0 & \text{for answer "Softer/Management parts o a foftware development project"} \end{cases}$$

All the effects and intercept were found significant with $p \leq 0.05$. Also, the whole model was found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.005$.

For variable C(onscientiousness) we found associations with questions:

- viii. Project size preference, 0.013
- ix. Do you prefer to work: (Startup, Start-End, Part. Parts), 0.017
- xi. Task prioritization, 0.009

The estimated GLM for these estimators is:

$$C = 13.216 + a_{viii} + a_{ix} + a_{xi}$$

where:

$$a_{viii} = \begin{cases} 0.761 & \text{for answer "Longer projects lasting for several months up to a year"} \\ 0 & \text{for answer "Short projects lasting up to a couple of months"} \end{cases}$$

$$a_{ix} = \begin{cases} 0.736 & \text{for answer "On project startup"} \\ 1.668 & \text{for answer "From project start to project end"} \\ 0 & \text{for answer "Short contributions as needed"} \end{cases}$$

$$a_{xi} = \begin{cases} -0.732 & \text{for answer "When a manager prioritizes your tasks"} \\ 0 & \text{for answer "When you can prioritize your own tasks"} \end{cases}$$

All the effects and intercept were found significant with $p \leq 0.005$. Also, the whole model was found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.005$. Additionally, the effect of a_{xi} for "When a manager prioritizes your tasks" was not significant with $p \leq 0.424$.

For variable E(motional) S(tability) (E/S) we found associations with question:

- i. Gender, 0.015

The estimated GLM for these estimators is:

$$E/S = 13.661 + a_i$$

where:

$$a_i = \begin{cases} 1.05 & \text{for answer "Male"} \\ 0 & \text{for answer "Female"} \end{cases}$$

The effect and intercept were found significant with $p \leq 0.05$. Also, the whole model was found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.05$.

Finally, for variable **I**(ntellect/Imagination) we found associations with questions:

- v. Multitasking, 0.005
- vii. Proj. responsibility preference, $\ll 0.001$

The estimated GLM for these estimators is:

$$I = 14.679 + a_{vii}$$

where:

$$a_{vii} = \begin{cases} 1.451 & \text{for answer "Entire development process"} \\ 0 & \text{for answer "Particular part of development"} \end{cases}$$

The effect and intercept were found significant with $p \leq 0.005$. Also, the whole model was found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.001$.

4.6 Internal associations for the preference/attitude questions

We analyzed all the attitude questions in pairs using the χ^2 - test and found the following associations (with χ^2 significance level $p \leq 0.05$):

Students that prefer to work after a given schedule also prefer to work with “softer” parts of a software development project. On the other hand, subjects preferring to work as the day developed also preferred to work with technical parts of a software project. Students that prefer working with several things at once also prefer to be responsible for the entire development process. Those who would rather work with one thing at a time prefer to be responsible for a particular part of the development process.

We also found strong association between the team work question and the non - technical preference of students. Specifically, those who preferred working in a team also preferred to work with “softer” parts of the development process, while those who preferred working by themselves also preferred working in technical parts of the development process. Associations were found between the project responsibility preference and the non – technical preference questions. In detail, students who preferred being responsible for the entire development process also preferred working with “softer” parts of the development process. Those who showed their preference in being responsible for particular parts of the development process are also linked with the preference about working with the technical parts of the development process.

Relations were found also in students that preferred working with one thing at a time or particular parts of the development process with predisposition in working from project startup to project end or with short contributions. Those who preferred working with several things at once or being responsible in the entire project development process also linked with preference in working only in project startup. Finally, students that prefer a manager to prioritize their tasks also prefer to work with technical parts of a software development process, while those preferring to prioritize their own tasks prefer to work with more managerial part. The results of this analysis are presented in the following table (Table 8).

Table 8 Results of the internal associations of the preference/attitude questions

		If you could choose would you prefer to work with: ?		
		Technical parts of a software development project	"Softer" / Management parts of a software development project	
In your previous software development projects do you prefer to work:?	After a given schedule / project plan	37.7%	62.3%	
	As the day develops	61.2%	38.8%	
Do you prefer working: ?	In a team	36.9%	63.1%	
	By yourself	65.2%	34.8%	
Do you prefer to be responsible for: ?	Entire development process	30.0%	70.0%	
	Particular part of development	51.9%	48.1%	
You work best / most efficiently when: ?	When a manager prioritizes your tasks	58.9%	41.1%	
	When you can prioritize your own tasks	37.0%	63.0%	
		Do you prefer to be responsible for: ?		
		Entire development process	Particular part of development	
Do you prefer working with: ?	Several things at once	64.3%	35.7%	
	One thing at a time	31.3%	68.7%	
		Do you prefer to work: ?		
		On project startup	From project start to project end	Short contributions as needed
Do you prefer working with: ?	Several things at once	24.7%	72.0%	3.2%
	One thing at a time	7.9%	83.7%	8.4%
Do you prefer to be responsible for: ?	Entire development process	19.0%	80.0%	1.0%
	Particular part of development	9.2%	81.6%	9.2%

5 Investigation of TEIQue and Self-compassion as supplementary tools

There is a variety of tools that can be used in order to quantify a person's personality by a set of traits or to investigate other characteristics of an individual. In addition to using IPIP to measure personality according to the five-factor model this study used two additional psychometric tools that have been proposed and used within psychology but have not, to the authors knowledge, been previously applied in SE. These tools are the TEIQue and Self-compassion instruments [27, 28].

Since these tools have never been used in the context of software development, we believe it would be interesting to investigate the relations of the traits they assess with SE preferences. This can help us understand if the present focus on personality should be extended to other psychological constructs or if psychometric SE studies can continue using the current personality tools (FFM etc.). Aiming to discover such associations, we applied statistical methods to our data, in a similar manner as for the personality data, for instance using the above described ANOVA and GLMs. These statistical methods were mentioned and described in the previous sections. In this part of this study we focus only on the results that were statistically significant.

Thus, we collected data from 119 and 142 students regarding the TEIQue and the Self-compassion test, respectively. These tests measure two personality characteristics: Emotional Intelligence (TEIQue) and Self-compassion. In the case of the Self-compassion psychological test, we did not find any kind of association ($p \leq 0.05$) between self-compassion and the other categorical variables, which were related to the attitude or other characteristics (i.e. sex or age) of the questioned students. This led us not to explore further using Generalized Linear Models, since no associations were found.

On the other hand, after applying ANOVA to our data we found that emotional intelligence is significantly related ($p \leq 0.05$) with: (a) project responsibility preference, (b) project duration preference and (c) task prioritization preference (see Table 9). Specifically, students with higher levels of emotional intelligence would rather be responsible for the entire development process than a particular part of it, work in long projects lasting up to a year and also prefer to prioritize their own tasks.

Table 9 ANOVA significance level for questions and Emotional Intelligence

Nr.	Question	Emot/Intellig., <i>p</i>
i.	Gender	-
ii.	Age	-
iii.	Development experience (years)	-
iv.	Work schedule preference	-
v.	Multitasking	-
vi.	Team work	-
vii.	Proj. responsibility preference	0.011
viii.	Project duration preference	0.048
ix.	Do you prefer to work: (Startup, Start-End, Part. Parts)	-
x.	Non-tech. preference	-
xi.	Task prioritization	0.023

Consequently we modeled the found associations applying GLM. We declare emotional intelligence, the top-level measure of the TEIQue instrument, as a dependent (response) variable and the associated attitude questions (Table 9) as predictors. Similar to the data based on the FFM, we do not intend to use GLM for prediction, but only to explain the effect each preference variable has on the dependent personality factor.

For **E**(motional) **I**(ntelligence) (**E/I**) personality factor we found associations with question:

- vii. Proj. responsibility preference, 0.011
- viii. Project size preference, 0.048
- xi. Task prioritization, 0.023

The estimated GLM for these estimators is:

$$E / I = 5.323 + a_{vii} + a_{xi}$$

where:

$$a_{vii} = \begin{cases} 0.327 & \text{for answer "Entire development process"} \\ 0 & \text{for answer "Particular part of development"} \end{cases}$$

$$a_{xi} = \begin{cases} -0.47 & \text{for answer "When a manager prioritizes your tasks"} \\ 0 & \text{for answer "When you can prioritize your own tasks"} \end{cases}$$

The effect and intercept were found significant with $p \leq 0.05$. Also, the whole model was found significant by the likelihood ratio chi-square test used in GLMs, with $p \leq 0.05$.

6 Discussion

Our findings show that individual differences among SE graduate students are reflected in different SE preferences and that the instruments and analytical methods employed can detect such connections. Like in the study we have replicated, our subjects belong to two main clusters of personality, which in parts have similar SE preferences to our previous subjects. However, some of the connections are not the same, and even reversed, and thus it is unclear how they look for other populations of software staff. The additional psychometric instruments add little new compared to the personality based one, even though Emotional Intelligence showed associations while Self-compassion did not.

Below we structure our discussion into several parts, first discussing how the results compare to our previous study (6.1), then discussing the additional psychometric instruments included in this study (6.2) as well as the additional analysis among the preference questions (6.3), followed by a discussion on the implications for software engineers and managers (6.4). The discussion section is concluded with a discussion of the threats to validity (6.5).

6.1 Students compared to industrial software engineers

The subjects in this study, 279 first-year (master level) graduate students, are quite different from the ones in the study we replicate, that used 47 industrial software engineers (SEngs)⁶. Thus it is not clear that the same, or similar results, should or can be expected. There might well be age- or experience-related effects in the preferences of people developing software. In particular, one such effect was seen in our previous study, in that SEngs that were younger tended to belong to the cluster with more “intense” personalities which had specific preferences on the task and project preferences.

In fact, such a connection between personality and age is also, indirectly, supported by the data in this study. Since we here investigate students they can be considered to be substantially younger (the average age was 26 years of age). The “intense” cluster of personalities is also larger in this study, 61%, while it was 40% among the SEngs with an average age of around 36. Over time, there seems to be a slight tendency of people to become more “moderate” in their personalities with age. However, we cannot study this connection quantitatively in the present data set since there is very little age variation among the students.

Even though previously there has not been a consensus among researchers in Psychology on age differences in personality, large, cross-national studies in recent years confirm that there indeed exist age differences. Lucas and Donnellan [87] summarize the literature by stating that “as individuals grow older, they seem to increase on traits related to social interest and communion and decrease on traits related to agency and zestful approach to life”. They then present data from more than 34,000 subjects in two countries that show that Extraversion and Openness (Intellect/Imagination) decrease with age

⁶ Note that direct comparisons of the personality factor values or averages cannot be done since we use a shorter form of the IPIP to study the same five underlying personality factors in this study, compared to our previous one. In this discussion we compare the relative values and differences rather than the absolute ones.

while Agreeableness increases. Conscientiousness levels peaked for participants in middle age. The patterns for Emotional stability differed between the two countries.

Given our previous, replicated study there was a risk that the effects we saw could be attributed to differences mainly with age. Since the two clusters prevail in this replication, despite the different (compared to the previous) and homogenous age among this set of subjects, we can rule this possibility out. We found no statistically significant effects due to age in this data and the two personality clusters still prevail.

More basically, the cluster analysis still shows that the personality data can be characterized as two different clusters of people and that these clusters of people have varying preferences in relation to how their software development work is organized. Since our analysis shows that about 55% of the variance in personality can be explained by cluster membership there are bound to always be a lot of personal variation. However, this study corroborates our previous results that there is a continuum of personalities in SE, from more modest to more “intense” ones and that managers are advised to note and understand these differences since they are associated with preferences and might affect performance and long-term, work-related happiness [88]. Similar to our previous study the clusters differ the most when it comes to Openness and Extraversion but in this study Agreeableness is also important in separating the clusters while that was only partly important with the SEngs data.

The associations from the clusters to the preferences are different than in the previous data set. In our previous study respondents with a more “intense” personality preferred doing multiple things at a time and preferred contributing to a part of rather than working with it from the start to the end. These associations are not seen in the present data. More accurately, the respondents in the “intense” cluster prefer to work from start to end. Also they prefer to work with “softer” and management-related tasks, rather than technical issues, and there is no preference to working with multiple things at a time. Most respondents in this study, regardless of their personality, prefer to work in a team, even though the connection is stronger with respondents with “intense” personalities. We can only speculate as to these differences but it is possible that differences over generations can explain these changes. Our previous data showed an average age of 36 years and the data was collected in 2005, while the current data set was collected in 2010-2012 with an average subject age of 26 years. Thus there is a 15-20 year overall age difference among subjects in the two data sets. In a study from 2007 [89] it was found that “generational differences significantly impact employee attitudes and outcomes in the workplace” and that the so called “Generation Y”, to which the respondents in this study belong, need goal orientation and that the work environment better fit their views in order to remain with a company. Thus, rather than an age-related difference we speculate that we might see generational differences in how SEngs prefer to work. We consider this a very important area for future work.

An alternative speculation that might explain why respondents with more “intense” personalities prefer “softer” and management-related tasks might be because they are somewhat more ambitious and career-focused. Since “soft aspects” are often more important to make a career as a manager this might explain at least parts of this connection. However, this is our speculation based on personal experience

and not something we have measured in this study. We consider also this an important area for future work, though.

6.2 Additional psychometrics: Emotional intelligence and Self-compassion

We found no statistically significant connection between self-compassion and SE preferences in this study and only a few connections from emotional intelligence. People with higher emotional intelligence prefer taking responsibility for the entire development process and prefer to prioritize their tasks themselves rather than having a manager do that.

Given the data from this study there is little to suggest that these additional psychometric tests add value compared to simply using personality measurements. We suspect that this is due to the fact that many psychometric instruments are, in some way, related to basic personality constructs as measured by the FFM. In fact, Petrides et al [31] found that although the TEIQue incrementally added predictive power compared to the FFM its sub-scales had several and strong associations to the FFM factors. Even though the TEIQue was only partly determined by the personality dimensions it has to be considered a more refined view of a person which is likely to be less clearly connected to attitudes and preferences than the more basic personality factors in the FFM. Maybe this is why we don't find many and strong associations to the software engineering preferences. We believe a similar argument can be made for self-compassion but here it is even less clear given that the concept is more recent and has been less studied than trait emotional intelligence.

In summary, based on the data from this study, we conclude that psychometric instruments that capture refined and additional factors from the basic personality ones are not currently warranted from a practitioner's point of view; they are not likely to have additional predictive power. If they are used the practitioner should have a specific quality in mind that she thinks is required for the job or role for which a person is being selected. However, from an academic point of view, more information is needed and additional studies should consider including other psychometric instruments even though little additional value was found here. The research on software engineering in connection to psychology and human factors is in such a nascent stage that we still need to explore constructs from that field that are predictive and important to better understand software engineers. If a researcher chooses to include such instruments we strongly encourage to select ones that are freely available and with existing empirical studies. There is a plethora of "commercial" psychometric instruments available which we have avoided since they make replication studies hard or even impossible. Both TEIQue and the Self-compassion scale were freely available and easy to work with.

6.3 Associations among the preference questions

It is not unexpected that we found associations between the answers to different SE preference questions. Working with "softer" aspects typically indicates a relatively larger interest in humans and a correspondingly smaller interest in purely technical questions although both the definitions of these terms and the interpretations of these terms among respondents likely differ. That a preference for "softer" aspects is associated with a preference for scheduled activities is likely just a reflection that agreed upon times are needed when interacting with multiple people, i.e. in team work. The fact that

preference for technical tasks is associated with a preference for a manager that prioritizes tasks can arise from the common situation that advancing to management positions likely requires an interest in “softer” aspects such as people management. Even though none of these associations are unexpected we here have seen empirical support supporting the generally accepted “truths”.

6.4 Implications for SE practice and research

Overall our results strengthens the observation that software engineers, whether fresh out of, or still in, school or after several years of experience from software development differ significantly in their personalities and that personality differences can be linked to work preferences in SE. This implies that personality should be considered as a possible confounding factor in SE research and that personality can be used to help setup better functioning work environments and project organizations.

However, a limit of our study is that we know very little about the relative effect of personality compared to other factors. It can still be the case that personality is too general and “coarse-grained” instrument in predicting work preferences. For example, Walle and Hannay [68] concluded that other factors were more predictive of pair programming performance. Thus, when a specific SE activity is considered a sensible strategy is to consider which specific cognitive or emotional skills are involved and consider if related and specific psychometric instruments are available for the activity in question. If not then a general psychometric tool of personality, such as the IPIP “open-source” instruments, is recommended. Overall, we note that even though personality might be an overall and rather broadly connected factor in explaining SE preferences and performance the costs with collecting psychometric data is minor and thus might have relative value.

6.5 Threats to validity

In our previous study we had no control over the response rate but we had indications it was low. This was considered a serious threat to our previous results; there can be biases in which respondents decided to answer. By using graduate students in this study, that we have a more direct contact to, we have an almost perfect response rate; a few percent of respondents did not answer or was not considered due to technical problems during data collection which invalidated parts of their answers. However, the response rate is more than 98% and should not pose a threat to our results. Similarly, the answer frequencies within questions was very high and do not pose any threat.

In the present study we used short forms of the selected psychometric instruments. It is possible that this could have affected our results and made it harder to uncover associations in the statistical analysis; with fewer questions there is less information that can be discriminative which makes analysis harder. However, all of the short forms of the instruments have been constructed by including the most important items and the empirical studies have shown that they have similar predictive power to their longer forms, even if the results cannot be refined in as many sub-constructs or scales. Since we would not have been able to conduct this study with the longer forms of the questionnaires we find this trade-off tolerable.

Like in the replicated study, and since psychometric studies are based on self-assessment there is a threat of evaluation apprehension. Humans want to “look good” and “smart” and it might affect the sincerity of their answers. This is a general problem with personality and any tests based on self-assessment but maybe this risk is even greater in this study since we investigate students that now that they are going to be evaluated at the end of the course. Even though we took special care to inform students that their answers would be anonymous it is likely some of them were afraid that their answers could affect their grades or education progress and thus might have a higher tendency to answer what they think the teachers are expecting or value. We tried to mitigate this risk by informing them that the data would not be used in this way, and that the link from the name to the analysis would be anonymous even among the researchers. However, it still might bias our results and we cannot control for it.

A threat to our study is that the examined SE preference questions do not give a detailed picture of the many possible SE preferences that individual software engineers have. In order to be able to replicate our previous study and compare the results we decided to keep a subset of the questions from the previous study and we selected the ones that were found most connected to personality in the previous study. For future work a more detailed set of questions might be needed; our initial set was initially created back in 2004 when data collection for the replicated study started.

The total number of respondents was quite large in this study and do not pose a serious threat. Our sample in this study can obviously not be claimed to be representative of the whole group of software engineers; as discussed they are a sub-sample of young, graduate students with a homogenous age span. Our population in this study should rather be considered as a sample from the generation of software engineers born in the 1980's. While the master programs have a large group of international students, a majority is still Swedish and it is unclear if there are country-based variations in either personality measurements or in SE preferences.

Our rigorous use of statistical analysis avoids many threats to conclusion validity. However, since we have performed a large number of statistical tests, we should formally correct our p values in order to avoid spurious associations being found simply due to the large number of tests having been performed. These types of corrections are not yet common in the SE literature and we consider the current state-of-the-art of our knowledge about the connections between personality and SE preferences too general to warrant such corrections. Future work with more detailed analysis can consider them.

7 Conclusions

In this study we presented data from three extended surveys, taken by a total of 279 students of a SE course, during three years, in a Swedish university. The questionnaires used were comprised of three parts: a 20-item personality test for the Big Five personality traits, based on the FFM theory, and one part of 11 questions representing SE preferences of the subjects. The third part was one of two additional psychometric instruments that measured either emotional intelligence or self-compassion, respectively. An extensive statistical analysis was carried out and is reported in this paper. Our study is a replication of a previous study but using a different population of subjects, additional psychometric instruments and more detailed analysis.

Cluster analysis discovered two personality types among the respondents, just like in the replicated study. Informally we called these groups “intense” and “moderate”, based on the mean numerical values of the five personality traits of each group. We called students with “intense” personality those who scored higher in all personality traits and “moderate” who scored lower. Afterwards, we investigated associations between the clusters and the preference questions and found that respondents with “intense” personality (Cluster 1) preferred to be responsible in the entire development process and would rather work in “Softer”/Management parts of the software development process. Additionally, respondents who preferred working in teams also had “intense” personality. Furthermore, students who favored working with short contributions to the project had “moderate” personality.

We also examined each one of the personality traits (Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Intellect/Imagination) separately and found several statistically significant associations. For example, higher levels of extraversion are associated with preferring to work in a team, being responsible for the entire development process, preferring to either work on project startup to working in short contributions or from project start to project end. Students with high extraversion also prefer to work from project start to project end to working with short contributions.

Moreover, a multivariate statistical analysis was performed in order to simultaneously model the associations found. We also considered links between the preferences themselves and stated the results. For instance, students who preferred being responsible for the entire development process also preferred working with “softer” parts of the development process. Or students that prefer a manager to prioritize their tasks also prefer to work with technical parts of a software development process, while those preferring to prioritize their own tasks would rather work with “softer” parts.

This paper also reports results using tests corresponding with the ones aforementioned, regarding the use of emotional intelligence and self-compassion personality traits in SE. These are personality characteristics quantified by the TEIQue and Self-compassion test respectively. We found that self-compassion could not reveal any associations with the preferences in SE. Emotional intelligence on the other hand was found to be related with: (a) project responsibility preference, (b) project size preference and (c) task prioritization preference (see Table 9).

Overall, we conclude that psychometric instruments that measure personality traits can be used to analyze and predict preferences for SE work. Furthermore, the analytical methods we have used can

detect and quantify such connections. Like in the study we have replicated our subjects belong to two main clusters of personality. The connection from the two clusters and from individual personality traits to the SE preferences are not exactly the same as in the replicated study but since the subjects studied here are both younger, come from another generation and have less experience from industry exactly the same connections cannot be expected. Rather these factors should be considered more in future research. In particular, we consider it important that future SE research investigate if generational differences, well known from social sciences, are likely to have large effects on the SE industry as a whole. Even though we found some evidence that non personality focused psychometric instruments can help in such an endeavor there is little indication from our data that they would add additional value. However, the methods we used for analysis are likely to detect associations if there are any and should thus be considered important tools for future work focusing on humans in SE.

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APPENDIX

The three semesters (three years, 2010, 2011 and 2012) common attitude and preference Questions

i. Gender

ii. Age

iii. How many years (full-time) of experience from software development do you have?

- 0 years (None)
- <1 year
- 1-3 years
- 3-5 years
- 5-10 years
- 10-20 years
- >20 years

iv. In your previous software development projects do you prefer to work:?

- After a given schedule / project plan
- As the day develops
- I have no experience

v. Do you prefer working with:?

- Several things at once
- One thing at a time

vi. Do you prefer working:?

- In a team
- By yourself

vii. Do you prefer to be responsible for:?

- Entire development process
- Particular part of development
- I have no experience

viii. Do you prefer to work in:?

- Longer projects lasting for several months up to a year
- Short projects lasting up to a couple of months
- I have no experience

ix. Do you prefer to work:?

- On project startup
- From project start to project end
- Short contributions as needed

x. If you could choose would you prefer to work with:?

- Technical parts of a software development project
- “Softer” / Management parts of a software development project

xi. You work best / most efficiently when:?

- When a manager prioritizes your tasks
- When you can prioritize your own tasks