The Entrepreneurial Engineer: A Quantitative Analysis of Personality Factors in the Social Cognitive Career Theory

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At Stanford she has served a chair of the faculty senate, and recently served as Associate Vice Provost for Graduate Education.
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Abstract

Which personality traits foster Entrepreneurship in Engineering? What implications for Engineering/Entrepreneurship Education can be derived? Until today, most of the research about Personality and Entrepreneurship compared Entrepreneurs to Managers. This work focuses on Engineers and combines two validated constructs: the Big Five Personality Traits (BFPT: Openness to new experiences, Conscientiousness, Extraversion, Agreeableness and Emotional Stability [1]) and the Social Cognitive Career Theory (SCCT [2]). The research question is: How can we describe the relationship between the BFPT and SCCT constructs? We conducted a (mainly quantitative) online-survey (n=465) among Alumni of the Stanford School of Engineering who graduated between 1 and 17 years ago and who had successfully the course ME203: Design and Manufacturing. Over 20 percent of the respondents had founded a venture. Results show that three out of the five personality traits have a significant positive relationship to certain SCCT constructs: a. Openness to new experiences and Extraversion are correlated to Entrepreneurial Self Efficacy, Entrepreneurial Intention, Entrepreneurial Outcome Expectations, Innovation Self Efficacy and Entrepreneurial Learning Experiences. and b. Emotional Stability correlated to Innovation Self Efficacy and Entrepreneurial Learning Experiences. Finally, we draw practical implications of these relationships for Entrepreneurship and Engineering Education, while at the same time keeping in mind that you cannot just “make” someone an Entrepreneur or change his or her personality. This paper is an explorative starting point that results in various findings that suggest future research. We recommend focusing on the three personality traits that showed significant results.
1. Introduction

Some of the biggest economic success stories were written by people who had an idea and founded their own company. An example would be Sergey Brin and Larry Page who founded Google in 1998. Today, the company employs over 72,000 people and generated almost $82 Billion in revenue in 2016 [3]. There are companies founded every day. Not all of them will be “the next Google”, but also smaller companies create jobs and increase the gross domestic product [4]. Knowing who and how many people decide to become Entrepreneurs is crucial for society as a whole due to the described economic impact of such activities.

In particular, entrepreneurs who found tech companies have the potential to influence the lives of many individuals as well as disrupt various industry sectors [5]. Research has shown that the individuals’ personality has an impact on the likelihood of founding a company [6]. Due to their technical knowledge engineers hold a key role in tech start-ups. However, less is known about the pathways of engineers themselves into the role of an entrepreneur, and how engineers’ personality characteristics (among many variables) link to entrepreneurship. This paper aims to fill this void by investigating the relationship between the personality make up of engineers and their entrepreneurial behaviour. Specifically, this research aims to shed light on which personality traits foster entrepreneurial learning, entrepreneurial intentions, entrepreneurial outcomes and entrepreneurial outcome expectations. The underlying research question is: How can we describe the relationship between the Big Five Personality Traits (BFPT: Openness to new experiences, Conscientiousness, Extraversion, Agreeableness and Emotional Stability) and the constructs of Social Cognitive Career Theory (SCCT)? The SCCT states that Career Interests are formed through various interacting constructs, such as Person Inputs (including personality), Learning Experiences and your confidence in your skills.

This research study uses an exploratory approach and is based on the work of Schaub and Tokar, one of the few published investigations on the role of BFPT in the SCCT [7]. The goal of the current paper is to expand these findings to engineers, which has not been done before. While there is a lot of research on the role of personality in Entrepreneurship, most of it is focused on comparing entrepreneurs to managers. We surveyed alumni of a Stanford University engineering course (2001 – 2017) to investigate the research question. Since more than one out of five respondents founded a venture, we figured the sample to be suitable and interesting. After explaining the state of previous research, the theoretical background and the
method, the results are presented and practical implications for Entrepreneurship and Engineering Education are outlined.

2. State of Research and Theoretical Framework

2.1 The Social Cognitive Career Theory applied to Personality and Entrepreneurship

Social Cognitive Career Theory

The underlying theoretical framework for this work is the Social Cognitive Career Theory (SCCT) which was developed by Lent et al. in 1994 [2]. A well-established theory, it has been validated and applied in various studies regarding career development, innovation, entrepreneurship and engineering education. SCCT is based on Banduras’ Social Cognitive Theory which states that learning is caused by the replication of others’ actions. This means it is not only about trying something (and succeeding or failing) but also about observing others in various contexts [8]. Previous theories tried to explain the complex variables involved in career development; however, the SCCT is one of the few that brings together multiple factors in a comprehensive and dynamic way. The SCCT consists of several elements which are depicted in Figure 1. The model states that an individual’s input (e.g., demographic, personality) and background factors (e.g., impact from their environment) influence Self-Efficacy beliefs and Outcome Expectations. Self-Efficacy and Outcome Expectations, in turn, influence Career Interests which subsequently have an impact on goals, actions and performance domains [2], [9], [10]. Figure 1 shows that this paper concentrates on personality traits as part of Person Inputs. As indicated by the additions in parentheses, all model elements are consisted in relation to Entrepreneurship.

Self-Efficacy describes a dynamic set of self-beliefs about performance domains that are influenced by social and environmental factors [9]. In simplified terms, it answers the questions of “Am I capable of doing it?” According to Bandura, there are four sources of Self-Efficacy beliefs: Personal performance accomplishments, vicarious learning, social persuasion, and physiological or effective states [11]. Outcome Expectations answer the question: “If I do this, what will happen?”. They address personal beliefs about consequences of a specific behavior. If someone has a high Self-Efficacy he or she should have positive outcome expectations due to this self-confidence in his abilities. This means that an individual with low Self-Efficacy, low Outcome Expectations and therefore low interest in a certain area,
is very unlikely to pursue that area. However, feeling competent and expecting valued outcomes directs the individual down the desired career path (or so the SCCT model says).

Besides the mentioned application of the SCCT in career choice, it has been deployed in and extended to other areas as well. Innovation Self-Efficacy, Engineering Task Self-Efficacy and Entrepreneurial Self-Efficacy are concepts that were developed and validated [12]–[15]. They focus on the confidence in your own ability in the respective area. Even though there has been decades of research on entrepreneurial education and factors determining the decision to become an entrepreneur, due to the complexity of factors and variables involved, the understanding is still limited [16]. Low consistency of findings and use of isolated variables can be explained by the lack of a strong theoretical framework [17]. This is why SCCT is increasingly used in entrepreneurship research and is also the foundation of this work.

The relevance of the field of entrepreneurial career choice and entrepreneurial learning is mainly driven by two forces: the impact of learning on Entrepreneurial Self-Efficacy and the economic impact of entrepreneurship. An increasing number of universities are offering programs with an entrepreneurship focus [18], [19]. Entrepreneurial Learning Experiences should increase Entrepreneurial Self-Efficacy and therefore the likelihood to found your own company. In other words, people participating in entrepreneurship programs are more likely to start their own businesses leading to economic wealth on micro- [20] and macro-level [21].

**Personality Factors as Person Inputs**

You cannot just send people to pursue an entrepreneurial education and “make” them entrepreneurs. As stated in SCCT, there are a vast number of other influential factors. Within
this paper, there is a specific focus placed on Person Input, especially on Personality. The reason for this is that so far most of the SCCT research was focused on the other elements of SCCT, whereas considerably less research has been done on Person Inputs [7]. Schaub and Tokar are one of the few who concentrated on personality, one aspect of Person Inputs. Personality plays a major role in other career theories [22] and there is plenty of empirical evidence that personality traits influence vocational interests [23].

The role of personality in entrepreneurial career intentions is developed in various studies [24]. Findings from these studies are consistent with the interactional psychology approach [25], [26] which states that the environment has an impact on people and vice versa. Characteristics of an environment are influenced by the individual selecting and interpreting a particular environment. Individuals strive for environments where they can play out their strengths [22]. This means that people with certain personality traits create situations where those traits are an advantage.

There are three main reasons why personality in the context of entrepreneurial career choice is highly relevant:

1. Individuals with certain personality traits favor an entrepreneurial form of employment whereas others prefer a job with a tenure position. People with less risk affinity might prefer a regular income to financial uncertainty [27].
2. Other stakeholders who are relevant to founding a company (e.g. venture capitalists, investment bankers, business partners, employees etc.) are more attracted to individuals with certain personality traits such as openness, extraversion and/or passion [28]–[30].
3. Individuals with certain personality traits are more likely to find working as an entrepreneur fulfilling and satisfying and therefore persist longer in the job [6], [31], [32]

Most of the research in entrepreneurial personality to date has been focused on a comparison between entrepreneurs and managers. The reason for this comparison is that both groups have, in some way, similar knowledge and exposure to business opportunities [6], [33]–[35]. There are certainly many other groups of individuals that have the potential to found a venture. The current work is focused on engineers, in relation to entrepreneurship, is pursued for three main reasons:
• An inventive mind that is focused on the product, as one might expect among engineers engaged in design, can be a driving force when it comes to founding a company.

• Innovation can happen when someone is just tinkering with something due to his/her technological enthusiasm (and engineers often have such enthusiasm).

• Technology, which is key component of engineering, becomes extremely important for the current start-up scene.

The Big Five Personality Traits

The Big Five Personality Traits (BFPT) break down the human personality into five dimensions: Openness to new experiences, Conscientiousness, Extraversion, Agreeableness and Emotional Stability. Capturing human personality with five dimensions is a challenge. Nonetheless, the BFPT is one of the most used and validated concepts in psychology. The BFPT model has been evaluated in over 50 years of research on personality, including in an entrepreneurial context [6].

There is existing literature about the BFPT of engineers but most of it is either not focused on the United States [36], [37] or if engineers are as extraverted as non-engineers [38], [39] is disputed. Therefore, there is the need to further investigate the engineer’s personality, especially with a focus on entrepreneurship.

The already mentioned paper from Schaub and Tokar is one of the few investigating the role of personality in SCCT [7]. They asked college students from various academic majors about their BFPT and their interests. One of the major findings was that personality has a significant and direct positive effect on interests. Also, they found that this relationship is partially mediated by Learning Experiences. In addition, learning experiences was a strong positive predictor of Self-Efficacy. Furthermore, Learning Experiences had significant and substantial total effects on Outcome Expectations. Also, personality was positively predictive of Learning Experiences in almost all relations tested. These findings support the relations posited in SCCT by Lent et al. [2]. Schaub and Tokar encouraged future research with additional and more representative samples on this topic. Also, they criticise that SCCT is not acknowledging the direct influence of personality on interests enough. Finally, they state that there needs to be additional research in order to further generalize the results on non-college students [7]. These aspects lead to the research focus of this work.
2.2 Explorative Relationships

Except for the work of Schaub and Tokar, there has not been much research on personality’s role in entrepreneurship and innovation in engineering using the SCCT. As a result, this paper explores potential relationships rather than hypothesizing direct causal effects.

Schaub and Tokar found a significant positive effect of BFPT on Interests. In our case, the Career Interests are Entrepreneurial Intentions. We also assume that the BFPT are related to Entrepreneurial Intentions (iii), as illustrated in Figure 2 by path (iii) in terms of SCCT constructs.

Furthermore, Schaub and Tokar found that personality positively predicts learning experiences [7]. In this paper, the goal is to test if this is also the case for Engineers and/or Entrepreneurs. Therefore, we assume a positive relationship of the BFPT on Entrepreneurial Learning Experiences (iv).

In addition, the relationship between the BFPT and Entrepreneurial/Innovation Self-Efficacy will be explored (i). We assume that the confidence in your own ability to succeed is also influenced by your personality. Furthermore, the relationship between BFPT and Entrepreneurial Outcome Expectations is investigated (ii). According to the SCCT, Learning Experiences affect Outcome Expectations and Self-Efficacy. Since Schaub and Tokar found an effect of personality on Learning Experiences, there could also be an effect on Outcome Expectations and Self-Efficacy [7]. The relationships that are investigated in this work are mapped on the SCCT in Figure 2, where red arrows show the proven relationships in Schaub and Tokar’s work, which are now examined with a focus on Engineering and Entrepreneurship. The dotted line arrows (i and ii)) indicate our own exploratory analysis. Black lines show the relationships proven in the initial SCCT model [9].

From now on, the SCCT constructs will be abbreviated in the following way: Innovation Self-Efficacy (ISE), Entrepreneurial Self-Efficacy (ESE), Entrepreneurial Outcome Expectations (EOE) and Entrepreneurial Intentions (EI).

To be more specific, we expect that higher scores in Extraversion, Openness to new experience and Emotional Stability come with higher scores in ISE, ESE, EOE and EI. This assumption is backed by prior findings [6] which found out that these three dimensions are crucial for entrepreneurial behavior.
3. Method

3.1 Sample and Participants

The survey, conducted in May of 2017, was sent to alumni of the Stanford University course ME203 “Design and Manufacturing”. Alumni from 2001 to 2016 were invited to fill out the survey. This practical design course concentrates on need finding, product definition, conceptual design, detail design, prototype manufacture and public presentation of outcomes. A large portion of it is hands-on and involves creating your own product as part of the Product Realization Lab, which is comparable to a Maker’s Space. The course is key in the Mechanical Engineering Curriculum at Stanford since the students can directly apply their knowledge in practice.

A total of 2,730 alumni took part in the course between 2001 and 2016. There was contact data available for 2,617 of them. Some 465 completed our survey which is described in the next chapter. This sample is 56.3% male, and 42.6% female (with one person selecting “other” and four selecting “I prefer not to answer”). The most frequent Racial/Ethnic Identifications are presented in Table 1. Respondents had to choose one option.
The average respondent was 30 years old and had 5.9 years of working experience. Nearly 50% of the respondents hold a Bachelor’s Degree, 44.9% a Master’s Degree and 5.2% a Ph.D.

Most of the survey participants are Mechanical Engineer majors (75.9%), the second largest group is Computer Science majors (2.3%) and third is Aeronautics & Astronautics (1.9%). Given the fact that ME203 is a compulsory module in the Mechanical Engineering curriculum these numbers are not surprising. The rest of the sample distributed among other disciplines such as Environmental Engineering (1.7%), Business (1.7%) or Bioengineering (1.5%). This distribution indicates that this sample can be seen as representative of Mechanical Engineering at Stanford University.

The amount of work experience has a high variance, ranging from 0 years for the graduates of 2016 to 15 years for the graduates from 2001. Also, this sample is suitable for finding out more about the impact of personality, since some of the other variables are relatively similar: survey participants had comparable learning experiences at Stanford, ME203, Mechanical Engineering) and a comparable local environment during their school time at Stanford. This means that school-related contextual influences and learning experiences were somewhat similar.

Stanford is located in the Silicon Valley which has a tightly knit connection to entrepreneurship. This means that it is not uncommon for Engineering students to found their own companies, a tendency also supported by our survey data: 20.2% of the respondents founded a venture and the average respondent worked 1.68 years for a start-up.

### Table 1: Most frequent Racial/Ethnic Identifications (n=465)

<table>
<thead>
<tr>
<th>Racial/Ethnic Identification</th>
<th>White</th>
<th>Asian/Asian American</th>
<th>Hispanic/Latina/o</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>49%</td>
<td>24.3%</td>
<td>7.7%</td>
</tr>
</tbody>
</table>

Most of the respondents (48.6%) started their career in a medium- or large-size company. As you can see from Table 2, only 32% work for a medium- or large-size company today. Since the percentage for females in medium- or large-size companies falls by a factor of two, female
respondents seem to move on after starting their career in a big corporate. While only 3% of the respondents did not work in one of these organizations in their first job, at the time of the survey 24.3% of them do not. While the percentage of women who picked “None” in the beginning was 4.0%, it grew to 30.8% at the time of the survey. The gender difference in unemployment could be due to a range of workplace, socio-economic and socio-cultural, and family-related factors. We do not know respondents’ 1) reasons for not being employed and 2) current job-seeking behavior in the sample for this study. In addition, it is noticeable that the percentage of men is higher in all categories except for “Non-profit” and “None”.

As depicted in Table 3, the top five industries do not change much when you compare industries at the beginning of respondents’ careers to their current industries. For beginning careers, Aerospace is popular, but it does not appear in the ranking of current jobs. By contrast, education is introduced in third place on the current ranking, although it does not appear in the top five of first jobs.

Table 3: Top five industries in the first / current job (n=465)

<table>
<thead>
<tr>
<th>Top five industries (first job)</th>
<th>Technology</th>
<th>Consumer products</th>
<th>Medical devices &amp; supplies</th>
<th>Aerospace</th>
<th>Consulting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>9.7</td>
<td>9.5</td>
<td>8.6</td>
<td>8.0</td>
<td>5.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top five industries (current job)</th>
<th>Technology</th>
<th>Consumer products</th>
<th>Education</th>
<th>Medical devices &amp; supplies</th>
<th>Consulting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>11.4</td>
<td>7.1</td>
<td>5.2</td>
<td>4.3</td>
<td>4.7</td>
</tr>
</tbody>
</table>

3.2 Data Collection Procedure
The survey contained 33 questions – two of them open ended – and took about 10 minutes to complete. Alumni of ME203 were invited to fill the survey out via e-mail. A total of 2,617 people were contacted with three mails: one initial invitation and two reminders. This led to 798 started surveys, out of which 465 were completed. The response rate was 17.8%, which is a remarkable result if you keep in mind that some of the respondents graduated 16 years ago. In order to increase response-rate we took multiple actions that were developed based on past experiences and best practices [40]:

- The invitations and survey featured clear but appealing design with photos of the course
• We ensured concise content without unnecessary details. The content of the three e-mails varied slightly, highlighting various values for the respondent each time: the opportunity to give something back to their alma mater and prospective students by further improving the curriculum; the chance to reflect on their own educational and career goals; and an opportunity to win a prize.
• The initial drafts took 20 minutes in pretesting, so we narrowed them down to the most important questions.
• The e-mails were sent out at different times and days in order to reach the ones who would find time to fill out a survey during work (midmorning), after work (evening) as well as on the weekend (Sunday).
• Professor David Beach (the instructor of the course which all alumni were part of) sent the e-mails and we included a picture of him in the footer. This way the receivers were reminded of the sender and would be more likely to respond.
• Additionally, the respondents could choose if they would rather win a “virtual lunch” (video call during lunch time) with their former Professor or a t-shirt designed by the course’s Teaching Assistants. These individualized prizes were supposed to further boost the response rate.

3.3 Instruments

The constructs which were operationalized in the survey are based on the described SCCT. Most of the constructs have already been used and extensively validated by other authors in other surveys. The value of this work is the recombination of these instruments, the application to a unique sample (Engineers) and the focus on Entrepreneurship.

Personality is part of Person Inputs in the SCCT. Personality is highly complex and the understanding is rather blurry in research and common sense. Broadly, personality traits consist of abilities, motives, attitudes and characteristics of temperament that lead to certain experiences and actions. One of the most used and validated constructs for personality is the Big Five Personality Traits (BFPT), comprised of Openness to new experience, Conscientiousness, Extraversion, Agreeableness and Emotional Stability. Each personality dimension describes a broad domain of psychological functioning that is composed from a set of more specific and narrow traits. This model was evaluated in over 50 years of research on the behavioral, emotional and interpersonal style of people [6].
Even though these traits are usually measured by asking how people think, feel or act in given situations, the personality traits are regarded as the cause of these mental or behavioural processes [41]. The self-reports are just indicators of the real internal cause [42]. Given the limited time of the survey, we used a short ten-item measure for the BFPT. The BFPT were applied successfully multiple times in Entrepreneurship Research [6]. The operationalization of the BFPT as well as the other SCCT constructs are described in the following.

Despite its shortness the Ten-Item Personality Inventory (TIPI) from Gosling et al. [1] has proven its validity many times. Gosling suggests using the TIPI, if a very short measure is needed due to time constraints or if you “can tolerate the somewhat diminished psychometric properties associated with very brief measures” [1]. Also, Gosling found that TIPI has “(a) convergence with widely used Big-Five measures in self, observer, and peer reports, (b) test–retest reliability, (c) patterns of predicted external correlates, and (d) convergence between self and observer ratings”[1]. The TIPI is asking the following question on a 7-point likert-scale

(1 = disagree strongly; 7 = agree strongly): I see myself as…

- Extraverted, enthusiastic.
- Critical, quarrelsome.
- Dependable, self-disciplined.
- Anxious, easily upset.
- Open to new experiences, complex.
- Reserved, quiet.
- Sympathetic, warm.
- Disorganized, careless.
- Calm, emotionally stable.
- Conventional, uncreative.

For Entrepreneurial Self-Efficacy, we used the 4-item measure ($\alpha = .792$) developed by Zhao et al. [14], which is asking the participants how confident they are in successfully identifying new business opportunities, creating new products, thinking creatively, and commercializing an idea or new development. We added a question asking for stressful situations [43] and based on the findings of Ratten [44], a question on dealing with risk. This construct – as well as all the following – was measured using a 5-point Likert-scale.

Since all studies in the past were focused on students and not on people in the workforce, no measure for Entrepreneurial Learning Experience was suitable. This is why the authors came up with a new form of measure ($\alpha = .817$) by combining items from Oosterbeek et al. [45] and a question from the Pathways of Engineering Alumni Research Survey (PEARS) [13].
Oosterbeek et al. state that the three main skills for an Entrepreneur are flexibility, market awareness and creativity. The authors operationalized these three with the following three items: Within my professional live I learned how to…

- adapt to fast changing situations (flexibility)
- sympathize with needs of clients (market awareness)
- come up with creative solutions (creativity).

Also, there were another four items added which are based on the PEARs [13] and in addition match the entrepreneurial traits defined by Oosterbeek et al. [46] :

- manage uncertainty
- deal with stressful situations
- take risks
- manage teams

**Entrepreneurial Outcome Expectations** are assessed using a 4-item-set ($\alpha = .681$) which is based on Krueger et al. [47] and Vanevenhoven and Ligouri [48]. The question asked was: To what extend do you expect to achieve the following, if you would start your own venture? And the four items are:

- Financial rewards
- Independence/autonomy
- Personal rewards (e.g. public recognition)
- Family security

Furthermore, we also asked for their *Innovation Self-Efficacy* which is not so much focused on Entrepreneurship but more on innovation in general. We used the items, that were deployed in the *Engineering Majors Survey (EMS)* which are based on Dyer et al. [15], [49]. We chose the 5-item measure ($\alpha = .752$) which Schar et al. suggest [15]. To measure *ISE*, we asked: How confident are you in your ability to do each of the following at this time? Then the respondents could choose on a 5-point likert-scale from 1 (not confident) to 5 (extremely confident):

- Ask a lot of questions
- Generate new ideas by observing the world
- Experiment as a way to understand how things work
- Actively search for new ideas through experimenting
- Build a large network of contacts with whom I can interact to get new ideas for products or services
Entrepreneurial Intentions are assessed by 6-items (α = .857) [50]. We asked participants on a 7-point Likert-scale from 1 (very untrue) to 5 (very true): Thinking of yourself, how true is it that you…

- .. intend to set up a company in the future?
- ... search for business start-up opportunities?
- ... are saving money to start a business?
- ... do not read books on how to set up a firm?
- ... have no plans to launch your own business?
- ... spend time learning about starting a firm?

The following quote describes why it is a reasonable choice: “This measure was selected for two reasons: (1) it was developed following thorough scale development procedures, as opposed to the Gaicomin et al. (2010) and Wilson et al. (2007) single-item measures, each of which involved no substantive validation; and (2) it offered parsimony over other existing measures of EI (cf., Liñán & Chen, 2009; Mazzarol et al., 1999; Krueger, 1993) […]” [48]. With this measure, we tried to assess how likely they are to set up a venture in the future.

4. Results

4.1 Frequencies and Correlations

In the first part of the result chapter the frequency measures are described. First, we focus on the independent variables, the BFPT. Afterwards, the dependent variables – SCCT constructs – are elaborated. The BFPT indices are presented on a scale of 1 to 7 in Table 4.

**Table 4: Frequency measures of the BFPT (n=465)**

<table>
<thead>
<tr>
<th></th>
<th>Openness to new experience</th>
<th>Conscientiousness</th>
<th>Extraversion</th>
<th>Agreeableness</th>
<th>Emotional Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.74</td>
<td>5.83</td>
<td>4.60</td>
<td>5.03</td>
<td>5.27</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.96</td>
<td>1.06</td>
<td>1.31</td>
<td>1.27</td>
<td>1.18</td>
</tr>
<tr>
<td>Variance</td>
<td>0.916</td>
<td>1.13</td>
<td>1.83</td>
<td>1.60</td>
<td>1.38</td>
</tr>
</tbody>
</table>

**Table 5: Frequency measures of the SCCT constructs (n=465)**

<table>
<thead>
<tr>
<th></th>
<th>Innovation Self-Efficacy*</th>
<th>Entrepreneurial Self-Efficacy*</th>
<th>Entrepreneurial Outcome Expectations**</th>
<th>Entrepreneurial Learning Experiences*</th>
<th>Entrepreneurial Intentions**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.871</td>
<td>2.573</td>
<td>4.764</td>
<td>4.223</td>
<td>3.955</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.613</td>
<td>0.558</td>
<td>1.025</td>
<td>0.567</td>
<td>0.887</td>
</tr>
<tr>
<td>Variance</td>
<td>0.375</td>
<td>0.310</td>
<td>1.052</td>
<td>0.322</td>
<td>0.787</td>
</tr>
<tr>
<td>Cronbach's Alpha</td>
<td>0.752</td>
<td>0.792</td>
<td>0.681</td>
<td>0.817</td>
<td>0.857</td>
</tr>
</tbody>
</table>

* Measured on a 1 to 5 scale. ** Measured on a 1 to 7 scale.
As you can see in Table 4, the Means of Openness to new experience and Conscientiousness are the highest between 5.7 and 5.9. Agreeableness and Emotional Stability in contrary have values between 5.0 and 5.3. Extraversion has the lowest mean with 4.60. To put this in perspective we can compare these values with the ones reported from Gosling who surveyed Psychology students from Texas. Even though he used the same instrument and the same scaling, he found lower mean values for Extraversion, Openness to new experiences, Emotional Stability and Conscientiousness and a higher mean value for Agreeableness [1]. As you can see from Table 6, we performed a T-test to validate this statement and all of the differences were significant.

One could argue that the difference between Engineering students and Psychology students can be explained by the academic background, but also other papers assessing the personality of Engineers have a high variance in their results [38], [39]. Williamson et al. [37] found that Engineers have lower means in all five of the personality dimensions, as compared to Non-engineers (people from a variety of occupations).

In Table 7, we compare the means of the SCCT constructs in our sample to studies from other authors.

**Table 6: Comparison of BFPT means in our sample (n=465) to Goslings’ sample**

<table>
<thead>
<tr>
<th></th>
<th>Openness to new experience</th>
<th>Conscientiousness</th>
<th>Extraversion</th>
<th>Agreeableness</th>
<th>Emotional Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean in our sample</td>
<td>5.74</td>
<td>5.83</td>
<td>4.60</td>
<td>5.03</td>
<td>5.27</td>
</tr>
<tr>
<td>Mean in Gosling's sample</td>
<td>5.38</td>
<td>5.40</td>
<td>4.44</td>
<td>5.23</td>
<td>4.83</td>
</tr>
<tr>
<td>T-test</td>
<td>t(2,276) = -6.06, p&lt;0.001</td>
<td>t(2,276) = -6.51, p&lt;0.001</td>
<td>t(2,276) = -2.17, p=.031</td>
<td>t(2,276) = 3.62, p&lt;0.001</td>
<td>t(2,276) = -6.16, p&lt;0.001</td>
</tr>
</tbody>
</table>

**Table 7: Comparison of SCCT means in our sample (n=465) to other samples**

<table>
<thead>
<tr>
<th></th>
<th>Innovation Self-Efficacy*</th>
<th>Entrepreneurial Self-Efficacy*</th>
<th>Entrepreneurial Outcome Expectations**</th>
<th>Entrepreneurial Intentions**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean in our sample (SD)</td>
<td>3.871 (0.61)</td>
<td>2.573 (0.56)</td>
<td>4.764 (1.03)</td>
<td>3.955 (0.89)</td>
</tr>
<tr>
<td>Mean in Schar's sample (SD)</td>
<td>3.62 (0.79)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean in Zhaos' sample (SD)</td>
<td></td>
<td>3.41 (1.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean in Vanevenhoven &amp; Lianguori's sample (SD)</td>
<td></td>
<td>5.60 (1.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean in Thompson's sample (SD)</td>
<td></td>
<td></td>
<td></td>
<td>3.70 (1.34)</td>
</tr>
<tr>
<td>T-test</td>
<td>t(6,282) = -7.12, p&lt;0.001</td>
<td>t(728) = 17.73, p&lt;0.001</td>
<td>t(14,859) = 16.6, p&lt;0.001</td>
<td>t(640) = -2.8, p=.005</td>
</tr>
</tbody>
</table>

* Measured on a 1 to 5 scale. ** Measured on a 1 to 7 scale.
The mean for ISE is slightly higher than the mean reported (3.62) in the Engineering Majors Survey [15] which consisted of a stratified sample from 27 Engineering Schools in the United States. This suggests that the mean that Mechanical Engineers from Stanford tend to have a slightly higher ISE. Also, a T-test showed a statistical significant difference.

For ESE, Zhao et al. reported a higher mean (3.41) [14]. Again, this difference is statistical different according to a T-test. The distribution of men and women was roughly the same as in our sample, but they had different academic background: Zhao et al. surveyed MBA graduates which means also some of them had a focus on Entrepreneurship. We assume that the ESE was higher because two of the items are related to actual content of a MBA program: “identifying new business opportunities” and “commercializing an idea or new development”. For EOE Vanevenhoven and Liguori report a mean of 5.60 for their sample of 18,000 students from all over the world, which is higher than the mean in our sample [48]. This is also backed by the T-test performed.

For EI, Thompson found a mean of 3.70 for undergraduate and graduate students which is 0.2955 lower than our reported value [50]. Our T-test supports this finding.

We calculated correlations (Table 8) for the main variables (SCCT constructs, BFPT and Demographics) and found interesting patterns, as you can see from Table 8 on the next page.

a. There are significant correlations among all of the SCCT constructs. Especially ISE and ESE have a high correlation (.651). This finding is backed by the implied relations of the SCCT: ISE and ESE positively relate to each other. While both constructs certainly have overlaps, they do not measure the same thing.

b. Openness to new experiences, Extraversion and Emotional Stability stand out; they correlate with all of the SCCT constructs (exception: Emotional Stability and Entrepreneurial Intentions).

c. Regarding demographics: Gender does not correlate with any of the SCCT constructs. Years worked correlates with ISE, ESE and ELE.
When we look at Table 9, we realize that many of the BFTP have weak positive linear relationships among each other. This is no surprise since there is plenty of research with similar empirical evidence for intercorrelations of the BFPT scales [51], [52].

Table 8: Correlations between SCCT constructs and other variables (n=465)

<table>
<thead>
<tr>
<th></th>
<th>Innovation Self-Efficacy</th>
<th>Entrepreneurial Self-Efficacy</th>
<th>Entrepreneurial Outcome Expectations</th>
<th>Entrepreneurial Learning Experiences</th>
<th>Entrepreneurial Intentions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation Self Efficacy</td>
<td>1</td>
<td>.651**</td>
<td>.340**</td>
<td>.450**</td>
<td>.284**</td>
</tr>
<tr>
<td>Entrepreneurial Self Efficacy</td>
<td>.651**</td>
<td>1</td>
<td>.400**</td>
<td>.392**</td>
<td>.367**</td>
</tr>
<tr>
<td>Entrepreneurial Outcome Expectations</td>
<td>.340**</td>
<td>.400**</td>
<td>1</td>
<td>.235**</td>
<td>.308**</td>
</tr>
<tr>
<td>Entrepreneurial Learning Experiences</td>
<td>.450**</td>
<td>.392**</td>
<td>.235**</td>
<td>1</td>
<td>.199**</td>
</tr>
<tr>
<td>Entrepreneurial Intentions</td>
<td>.284**</td>
<td>.367**</td>
<td>.308**</td>
<td>.199**</td>
<td>1</td>
</tr>
<tr>
<td>Openness to new experiences</td>
<td>.371**</td>
<td>.318**</td>
<td>.182**</td>
<td>.190**</td>
<td>.242**</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
</tr>
<tr>
<td>Extraversion</td>
<td>.243**</td>
<td>.191**</td>
<td>.211**</td>
<td>.236**</td>
<td>.171**</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>Not significant</td>
<td>.098**</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>.240**</td>
<td>.173**</td>
<td>.117**</td>
<td>.180**</td>
<td>Not significant</td>
</tr>
<tr>
<td>Years worked</td>
<td>.206**</td>
<td>.134**</td>
<td>Not significant</td>
<td>Not significant</td>
<td>.289**</td>
</tr>
<tr>
<td>Gender</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

** Correlation is significant on the 0.01 level (2-tailed). The highest correlation for each variable is printed in bold.

4.2 Regression Models

The correlations presented in the prior section give a first rough overview about potential relationships. They will be further investigated by calculating regression models. Before we dive into that, some background information should be provided.

Since our approach is exploratory, the aim of the models is to describe the relationship between the predictors and response variable rather than predicting the response variable, inferring temporal order or stating causal effects. The question this paper is asking is: “How
are the personality factors related to the constructs of the SCCT?”. This implies that R squared is irrelevant since it only represents the scatter around the regression line and the precision of a prediction of the response variable. We created a total of 5 regression models, that will be presented attached to the Explorative Relationships i), ii), iii) and iv) which were described earlier (See Figure 2).

For an initial overview, see Table 10 reporting the p-values and β-values for all five models.

<table>
<thead>
<tr>
<th>Table 10: p- and β-values of the regression models (n=465)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Table" /></td>
</tr>
</tbody>
</table>

We would like to point out that all coefficients (β) of the BFPT are below 0.3 which means that the connection is weak. If you look at all relationships explored, you see that Openness to new experience had the highest β-value in the relationship between BFPT and ISE while Extraversion had the highest β-value for the relationship between BFPT and the other concepts (ESE, EI, ELE and EOE).

i) The BFPT are related to ISE and ESE.

The first regression model investigates the relationship between several independent variables and the dependent variable ISE. We entered the BFPT (Openness to experience, Conscientiousness, Extraversion, Agreeableness and Emotional Stability) into the model. Furthermore, we controlled for Years worked, Gender and Racial/Ethnic Identification. As for Years worked, one’s seniority and maturity might influence their confidence in their entrepreneurial or innovation skills; thus, this seemed like an appropriate control. To make up for the sample which mainly consisted of white males, we decided to control for Gender and Racial/Ethnic Identification as well.

---

1 Gender was operationalized as follows: Male, Female, Other and I prefer not to answer. No respondent chose “Other or “I prefer not to answer”. For Racial/Ethnic Identification respondents had the following options: American Indian or Alaska Native, Native Asian or Asian American, Black or African American, Hispanic or Latino/a, Native Hawaiian or Pacific Islander, White, I prefer not to answer, Other. Coefficients for control variables are available upon request.
The results indicate that *Openness to new experience* \((p = .000, \beta = .290)\), *Extraversion* \((p = .000, \beta = .200)\), *Emotional Stability* \((p = .001; \beta = .153)\) and *Years Worked* \((p = .000, \beta = .185)\) have a significant and positive relation to *ISE* – holding respective factors constant. The other variables (*Agreeableness, Conscientiousness, Gender* and *Racial/Ethnic Identification*) do not show significant results. Nonetheless, we decided to keep them in the model in order to control for them.

In the second regression model the aim was to find out more about the relationship of the mentioned independent variables (*BFPT*) and *ESE*.

The results are somewhat similar to the *ISE* regression model. This is not surprising since *ISE* and *ESE* are highly correlated. Therefore, further works needs to happen to tease these constructs out. *Openness to new experience* \((p = .000, \beta = .263)\), *Extraversion* \((p = .001, \beta = .150)\) and *Years Worked Total* \((p = .012, \beta = .110)\) have a significant positive relation to *ESE*, ceteris paribus. Contrary to the prior model, we only see a marginally significant result for *Emotional Stability* \((p = .090; \beta = .090)\). The other variables (*Agreeableness, Conscientiousness, Gender* and *Racial/Ethnic Identification*) do not have significant relationship to *ESE*.

**ii) The BFPT are related to EOE.**

In the third regression model, we investigate the relationship of the mentioned independent variables (*BFPT*) and *EOE*. As in the prior models, we control for *Gender, Years Worked Total* and *Racial/Ethnic Identification*.

The results are comparable to the *ESE* regression model. *Openness to new experience* \((p = .003, \beta = .140)\) and *Extraversion* \((p = .000, \beta = .186)\) have a significant positive relation to *EOE*, ceteris paribus. Contrary to the prior models *Emotional Stability* and *Years Worked Total* are not significant. Also, the other variables (*Agreeableness, Conscientiousness, Gender* and *Racial/Ethnic Identification*) do not have significant relationship to *EOE*.

**iii) The BFPT are related to EI.**

The fourth regression examines the relationship between the mentioned independent variables (*BFPT*) and *EI*. As in the other models, we control for the same variables. For the *BFPT*, we see similar results to the prior model: *Openness to new experience* \((p = .003, \beta = .244)\) and *Extraversion* \((p = .001, \beta = .144)\) have a significant positive relation to *EI*, ceteris paribus. Contrary to the prior model, there are also significant results for *Gender* \((p = .004, \beta = -.141)\).

Since males are coded as 0 and females as 1, this can be interpreted as “Males tend to have a
higher EI than females, ceteris paribus”. The other variables (Agreeableness, Conscientiousness, Emotional Stability, Years Worked Total and Racial/Ethnic Identification) do not have significant relationship to EI.

iv) The BFPT are related to ELE.

The last regression models the relationship between the mentioned independent variables (BFPT) and ELE. Again, we control for Gender, Racial/Ethnic Identification and Years Worked Total. The results resemble the first regression model for ISE. Openness to new experience \( (p = .021, \beta = .103) \), Extraversion \( (p = .000, \beta = .222) \), Emotional Stability \( (p = .002; \beta = .146) \) and Years Worked Total \( (p = .000, \beta = .293) \) have a significant positive relation to ELE – holding respective factors constant. The other variables (Agreeableness, Conscientiousness, Gender and Ethnic Racial Identification) do not show significant results.

Figure 3 gives an overview of the findings and depicts all the mentioned relationships between the BFPT and SCCT constructs. Most importantly, we found a significant and positive relationship between Extraversion / Openness to new experience and all the SCCT constructs – holding the other factors constant. Emotional Stability only had a significant and positive relationship to ISE and ELE, ceteris paribus. For Conscientiousness and Agreeableness, we did not find significant relationships.

![Figure 3: Overview of the significant positive relationships in our regression models](image)

4.3 Interpretation

To increase comprehensibility, the personality dimensions that showed significant relationships to the SCCT constructs will here be explained in more detail.

Openness to new experience can be described as follows: If you score high on this scale, you tend to seek new experiences and explore novel ideas. If you have a low score, your interests are rather narrow and you more hesitant towards entering unfamiliar settings [6]. One major
finding of this paper is that Openness to new experience is positively and significantly related to all the SCCT constructs (ELE, ISE/ESE, EOE and EI). This means that someone who is open to new experiences could also be more likely to believe in their entrepreneurial/innovative skills, to expect a successful result from them, to be exposed to entrepreneurial activities where they gather learning experiences and to intend to keep on doing so in the future. This finding is backed by Zhao and Seibert [6]; according to their meta-study, entrepreneurs do have a significantly higher Openness to new experience than managers.

As an entrepreneur, one is often confronted with a variety of types of problems. It may be crucial to take an innovative approach to them, think creatively and be open to alternative solutions. If you found your own venture, you are required to explore new ideas. Thus, if you prefer to stick with a routine and avoid leaving your comfort zone, you are most likely not the stereotypical Entrepreneur since you have a lower score in Openness for new experiences [6]. Dominant entrepreneurship channels select for people who show some evidence of “openness. Not everyone might have equal opportunity to “leave their comfort zone”, e.g., socioeconomic factors might mediate this relationship, such that people with more resources can be more open to new experiences/take those experiences (and risks) on [53].

*Extraversion* describes the extent to which people behave in an energetic, active, talkative and enthusiastic way [54]. They also do not have a problem with being the center of attention and are stimulated and excited by large groups. Introverts, by contrast, are rather reserved, quiet and like to spend time alone. For them, it can be exhausting to spend a lot of time in large groups, especially with new people. While the stereotypical Engineer might like to tinker with and puzzle over a problem alone, Entrepreneurs are most often rather extraverted [6]. This may be because the way entrepreneurial norms, cultures, and venture channels work essentially requires them to interact with people a lot (and rewards people who feel most comfortable doing so). Entrepreneurs often function as sales people who have to pitch their ideas to venture capitalists, customers or employees. Due to the lack of structure in a newly founded venture, most of the interaction is direct. Similar about what we have seen in relation to Openness to new experiences, someone who is extraverted is also more likely to believe in their entrepreneurial/innovative skills, to expect a successful result from them, to be exposed
to entrepreneurial activities where they gather learning experiences and to intend to keep on doing so in the future.

Someone with high Emotional Stability (and low Neuroticism) is calm, even tempered and relaxed in most situations. By contrast, someone with low Emotional Stability is impulsive and more vulnerable to stress. In other words, Emotional Stability describes individual differences in adjusting to stressful situations. Previous research suggests that high Emotional Stability is beneficial for becoming an Entrepreneur as well as for succeeding at being one [55]. As an Entrepreneur, one is exposed to multiple risks since they have substantial personal and financial stake in their company. Also, they typically work long hours, and the line between work and private life is blurred as they have a high responsibility for the venture. In addition, the environment of start-ups is rather unstructured when compared to a corporate career [6]. Emotional Stability is significantly positively related to Innovation Self-Efficacy and Entrepreneurial Learning Experiences. When you take a closer look at the items of ELE, you realize that a lot of them are also connected to Emotional Stability which reflects one’s ability to handle stress and uncertainty [56]: Within my professional life, I learned how to…

- … manage uncertainty
- … deal with stressful situations
- … take risks
- … manage teams

The linkage between ISE and Emotional Stability is harder to explain. One interpretation is that emotionally stable individuals also tend to be self-confident, which could also increase the values in the ISE-items since they measure your confidence in innovation skills. Our sample reported a slightly higher mean (5.27) for Emotional Stability in comparison to the value Gosling reported (4.83) [1]. We could speculate that Stanford tends to admit students with higher Emotional Stability since they receive better grades and are less likely to drop out due to their high resistance to stress. As prior research has shown, emotional stable pupils have higher educational achievements [57].

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2 The empirical research on whether Engineers are less extraverted than Non-engineers [36], [37] or equally extraverted [38], [39] is inconclusive. The results of this survey do not suggest that Mechanical Engineers at Stanford University are more introverted than other inhabitants of the United States. As mentioned, Gosling [1] who also used the TIPi instrument, reported a lower mean for Extraversion (4.44) for Psychology students from Texas than the mean of our results. Therefore, we conclude that the typical Mechanical Engineering graduate from Stanford University is not less extraverted than a Non-engineer. Keeping in mind that high Extraversion leads to an increase in all SCCT constructs, we can derive conclusions and practical implications for that in the following.
5. Implications for Entrepreneurship Education

There is strong evidence that personality measures are associated with Entrepreneurial Intentions, Entrepreneurial Behaviour and Entrepreneurial Performance [6], [58]. There is even evidence that personality has an impact on venture survival [59]. This paper supports these findings and extends them to Engineers and to the SCCT constructs under study. If we want more Engineers taking an entrepreneurial path and founding new ventures, we should think about adapting Entrepreneurship and Engineering Education to complement their specific personality profiles of Engineers.

So, we assume that it is desirable to offer the opportunity to Engineering students to explore Entrepreneurship and learn more about it. This means that there should be a special focus on students who are less likely to choose an entrepreneurial career path according to the research, e.g., students with low openness to new experiences, low emotional stability and introverts.

To draw the most concrete and practical conclusions possible, we consider the components of each of the personality traits that showed significant results [59], [60].

Openness to new experience can be broken down into two components: “intellect” and “open” [60]. “Intellect” describes being imaginative, attracted to abstract ideas, being analytical and introspective and enjoying philosophical debates. “Open” means being cultured, trying different things and enjoying art, music and literature. We definitely cannot force students with low openness to like some of these things, but there are certainly ways to make them more accessible, appealing and engaging. For example, teachers should encourage their students to dive into fields where they have zero experience. Nonetheless, the individual background such as socio-economic factors should be considered by the teachers since they can lead to different levels of risk affinity [53]. Also, they could demonstrate the benefits of a debating culture, exchanging (contrary) opinions and tolerating them. Ideally, we do not start in college but in early childhood with this kind of education [61].

Extraversion consists of the three components “ambition”, “sociability” and “individuality” [60]. “Ambition” describes initiative, impetuousness, leadership and persuasiveness. “Sociability” is about enjoyment of meeting new people and being talkative or gregarious. “Individuality” means enjoyment to take chances, stirring up excitement and showing off. For the first component, we suggest integrating teaching units in the curriculum that foster proactivity, including leading a group and persuasion skills. We should keep in mind that the goal is not to turn an introvert into an extravert. These characteristic features should not be
classified as one being better than the other. But we should still give introverts the possibility to increase their exposure to situations where they can practice skills which are typically in the repertoire of extraverts. Encouraging introverts to leave their comfort zone from time to time is key. Otherwise they might not gather experiences in this field or never discover hidden talents. You could also question, if entrepreneurial ecosystems have a bias towards extraversion which should or could be decreased.

*Emotional Stability* can be divided into the components “steady” and “security” [60]. “Steady” describes being even-tempered and emotionally steady. “Security” is about feeling secure about yourself and not being bothered by criticism. While the first component is hard to tackle with formal education, the second component can be targeted very well. Ability to take criticism can be increased by several exercises. We should teach students that they should not take criticism personally and rather see it as an opportunity to improve in certain aspects [62]. Also, the social environment is crucial: We need to establish a feedback culture where not only people are able to accept criticism, but also where everyone knows how to give feedback that is constructive and not undermining people with lower *Emotional Stability*. Individuals seek for feedback in particular when they are in uncertain situations or fear failure in attaining goals [63], [64].

### 6. Limitations and Future Research

This paper is an explorative starting point that results in various findings that need to be explored further. There are certainly several limitations that should be considered when conducting future research. First of all, future research should consider engineering graduates from various universities in order to be able to generalize findings/conclusions. Our population consisted of Stanford students only due to the easy access for the researchers. The importance of Entrepreneurship in the university’s region and to draw Stanford-specific conclusions for the Mechanical Engineering Curriculum are advantageous.

We suggest that future surveys on this topic should aim to conduct data from a population that is as representative for “the Engineer” as possible. When comparing our sample to other samples, it is hard to find out if differences can be explained by the fact that other samples consist of Non-Engineers or Non-Stanford students. It is difficult to draw conclusions for both (Non-Stanford students and Non-engineering students) at the same time. We recommend a sample that is stratified according to geographical factors (universities all over the country), gender, field of study and years of working experience. The population in our study mainly
consisted of Mechanical Engineers, but this could also be extended to Engineers in general. Therefore, future research should more systematically explore differences between personality scores of Engineers and Non-engineers. There are multiple studies which observed differences, but none of them succeeded in fully explaining them. We suggest to survey Engineers and Non-engineers, using Non-engineers as a control group. The BFPT are not equal in all cultures [65]. Future research can explore structural and cultural factors that help to explain and qualify the observed relationships.

Aside from the limitations to the sample, there are also some related to the survey design. We knew that personality is complex and therefore hard to operationalize. Thus, we carefully designed the survey instrument. The ten-item-scale (TIPI) to measure the BFPT was validated in several meta-analytical-studies [1] and is the most valid data you can receive in a short amount of time. In spite of that, it is easier to predict outcomes if you use more narrow personality traits instead of broad constructs such as “Openness to new experience” [66]. Therefore, we suggest to break down personality to more narrow components. A micro-level investigation is also suggested by Williamson et al. [37]. Our survey also included some additional questions which are not directly related to the research question of this paper. If you dedicate the whole survey to the relationship of the SCCT constructs to BFPT, there is certainly more room to concentrate on the traits that showed significant results (Extraversion, Openness to experience and Emotional Stability).

Considering that out of 798 started surveys, only 465 were completed, we suggest shortening the survey to less than ten minutes.

Another limitation which is hard to avoid is social desirability. Even though we tried to minimize the effect by conducting an anonymous online survey, respondents rather choose answers of whom they expect others’ (e.g., the researchers’) or society’s approval. We kept this effect in mind when interpreting our results. In addition, our survey mainly consisted of quantitative questions. Quantitative research always has advantages and disadvantages which means it might be a good idea to supplement it with additional qualitative research to gain a comprehensive understanding of trends that we discovered in our quantitative data.

Furthermore, we propose to also investigate in how far targeted education can help to increase the values of the three mentioned scores in Extraversion, Openness to experience and Emotional Stability. Also, a longitudinal study could lead to interesting findings in the change of BFPT and SCCT constructs over time.
7. Conclusion

Initially, we asked the following research question: “How can we describe the relationship between the big five personality traits (Openness to new experiences, Conscientiousness, Extraversion, Agreeableness, Emotional Stability) and the constructs of the SCCT?”.

The answer is: Stanford’s mechanical engineering graduates show a positive relationship between Extraversion / Openness to new experience and the constructs of the SCCT under study—holding the other factors in the model constant. Also, we found a positive relationship between Emotional Stability and Innovation Self-Efficacy / Entrepreneurial Learning Experiences, ceteris paribus. These results are unique, as it is the first time that the BFPT of engineers have been assessed within the framework of SCCT. This can be seen as a starting point for further research that should lead to practical implications for Entrepreneurial Education and Engineering Education. Mechanical Engineering students from Stanford tend to have higher mean values than non-engineers who are not at Stanford in Openness to new experiences, Extraversion and Emotional Stability. These are the three traits that have a positive relationship to most of the SCCT constructs that were studied here, and therefore could be some of the factors that explain why Mechanical Engineering students at Stanford found so many companies (20.2% are founders). This is a high value, e.g. compared to Iowa State University Alumni (16%) [67]. This is highly relevant since entrepreneurial activities lead to more innovation, employability and wealth for society as a whole. Especially in tech, there are many ventures that tackle the main problems of the twenty-first century. At Stanford for instance, the “Gross Domestic Product” of all companies founded by Stanford Alumni (~39,900) is $2.7 trillion. That would be the worlds’ 10th largest economy, creating 5.4 million jobs [5]. The economic impact of Entrepreneurship is immense.
8. Acknowledgment

We would like to thank all the people involved in the data collection and writing process. First of all, this work would not have been possible without the continuous support of Professor David Beach (Stanford University). Additionally, Nora Mary Sweeney helped us to craft the perfect e-mail to invite alumni. Second, we would like to thank all the members of the Designing Education Lab at Stanford University. Their feedback was extremely helpful. Especially, Fabian Hogrebe played a huge role in designing the survey. Third, we would like to thank Armin Granulo (TU Munich) for his valuable input. Lastly, we would like to thank the Friedrich Naumann Foundation for Freedom and the German Academic Exchange Service (DAAD) for financing Leon’s research.
9. References


[26] B. Schneider, “Interactional psychology and organizational behavior.”


