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THE EFFECTS OF LOCUS OF CONTROL AND BIG FIVE PERSONALITY TRAITS ON COLLABORATIVE ENGINEERING DESIGN TASKS WITH NEGOTIATION

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ABSTRACT

Collaborative systems design is a human-centered activity dependent on individual decision-making processes. Personality traits have been found to influence individual behaviors and tendencies to compete or cooperate. This paper investigates the effects of Big Five and Locus of Control personality traits on negotiated outcomes of a simplified collaborative engineering design task. Secondary data includes results from short-form personality inventories and outcomes of pair design tasks. The data includes ten sessions of four participants each, where each participant completes a sequence of 12 pair tasks involving design space exploration and negotiation. Regression analysis shows a statistically-significant relationship between Big Five and Locus of Control and total individual value accumulated across the 12 design tasks. Results show the Big Five, aggregating extraversion, agreeableness, conscientiousness, neuroticism, and intellect/imagination to a single factor, negatively affects individual value and internal Locus of Control positively affects individual value. Future work should consider a dedicated experiment to refine understanding of how personality traits influence collaborative systems design and propose interventions to improve collaborative design processes.

1 INTRODUCTION

Over centuries, engineering has grown broader as an integrative discipline producing technology with rapidly increasing complexity. Engineers have been entrusted to fulfill increasing societal demands leading to rapid technological innovations and more complex engineering products. Increased product complexity demands collaboration of many engineers with different backgrounds. Complex engineering design today requires participation of hundreds to thousands of stakeholders in an engineering system [1]. For example, aircraft design requires cooperation of disciplinary engineers (mechanical, electrical, and software) with other units including business and policy. Modern engineering design is a human-centered discipline dependent on human interactions and a human decision-making process.

Systems design problems have several self-interested agents who must work together towards a common system-level goal despite different local objectives [2]. Conflicts between individuals may cause unexpected negative system-level outcomes. Effective collaboration must consider opportunities for cooperation but also realities of competition and conflict. Research on *collaborative* engineering design emphasizes the highly human-dependent engineering systems with multiple interdependent participants [3]. Developing better collaborative engineering processes can lead to more efficient and improved task results, avoiding delays, breakdowns, and effort overruns [1].

Although performance of engineering systems is usually assessed in a top-down fashion, a bottoms-up approach focusing

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on human behavior could help identify important factors contributing to overall effectiveness. Individual differences influence human behaviors in work settings [4] and competitive environments [5], suggesting personality traits may influence the outcome of collaborative engineering tasks. Individual personality differences can help predict an individual's task performance and their tendency to cooperate or compete in games [6].

This paper studies the relationship between personality differences and outcomes of decision-making processes in a simplified collaborative engineering design experiment with two self-interested actors. It considers two particular personality inventories: the Big Five (extraversion, agreeableness, conscientiousness, neuroticism, intellect/imagination) and Locus of Control (LOC). These six personality factors can be observed in different countries, languages and cultures [4], improving the ability to transfer results to new contexts. Analysis of secondary data from a designer experiment indicates LOC and an aggregation of Big Five traits are significant factors for individual outcomes.

2 LITERATURE REVIEW

2.1 Collaborative Design and Personality

Lu et al. define collaboration as "the process of multiple people working together interdependently to achieve a greater goal than is possible for any individual to accomplish alone" [1]. In a collaborative design decision-making process, negotiation is an essential tool for exchange of resources, information and finding a common ground between participants [7]. Engineering collaboration via negotiation (ECN) investigates the behaviors, actions and decision-making principles of multiple participants in collaborative engineering [1].

Klein et al. investigate negotiations with *hill-climber* actors who concentrate on maximizing individual utility [3] and *annealers* who probabilistically accept lower local utilities increasing the global utility. Different combinations of hill-climber and annealer participants in a negotiation induces variations in the outcome. Personality traits may help to analyze certain characteristics of hill-climbers and annealers and give deeper understanding of their roles in collaborations.

Personality traits have a key role in the decision-making process of an individual or a team [8, 9]. They have a significant effect on creative problem solving skills of scientists [10]. Ogot and Okudan emphasize the importance of dependency between team performance and personality traits [11]. Team efficiency benefits from team members with mixed personality traits [12]. Kichuk and Wiesner find teams with lower neuroticisim, higher extraversion and agreeableness are more successful [13]. Personality traits also affect negotiation outcomes by influencing negotiators' behaviors [14]. However, little work specifically investigates the relationship between competitive engineering design environments and personality traits.

2.2 Big Five Personality Traits

The Big Five personality traits include five dimensions in Table 1 that characterize a person at a global level [15]. There are a variety of specific traits subsumed under these five factors [5]. The Big Five model only provides larger constellations of more specific personality traits [16]. Although the Big Five cannot explain everything about someone's personality, it is useful for differentiating fundamental characteristics of individuals relevant for an engineering design task [17].

Individuals show some possible tendencies based on personality traits. People who score higher in ***extraversion*** (extraverts), tend to be more social, spend more time with others and, accordingly, tend to agree more during a negotiation [16] which makes extraverts less successful in those competitive environments. Contrary to this statement, Yiu and Lee find extraversion positively affects the negotiation outcome because of an outgoing characteristic [18]. It stated that team performance was not significantly related with heterogeneity of extraversion [13].

People with a higher ***agreeableness*** tend to sympathize and trust others more and are also more trustable, leading towards choosing cooperation. Since they do not prefer to use tactics and try to avoid conflicts, agreeable individuals generally try to find a joint gain in a negotiation [19]. When paired with someone who is less agreeable, agreeable people may lose more.

A higher score in ***conscientiousness*** indicates a better organized, responsible, motivated individual. People expressing this trait try to avoid win-lose agreements compared to others [18]. Kichuk and Wiesner find a team's performance is negatively correlated with heterogeneity of conscientiousness [13].

The ***intellect/imagination*** trait indicates creativity, curiosity, and imagination. People who score high on this trait tend to create different strategies, think more flexibly and are not susceptible to a "fixed pie" bias [18]. Divergent thinking can improve deals during a negotiation.

Finally, people with a high ***neuroticism*** score feel sadness, guilt, worry, anger strongly. The impact of neuroticism on ownership bias has been observed in design education [20].

Several inventories are available to measure the Big Five personality traits in conjunction with design/experiments [21–24]. For a design task demanding the full concentration of the participant, administering a long questionnaire with more than 40 questions can be challenging. A long assessment can contribute to careless responses or a lack of concentration and poses logistical challenges for time management in a short experimental window. When these kinds of concerns are taken into consideration, the 20-item version of the lexical Big Five Inventory (a.k.a. "Mini-IPIP") is preferred [25]. The Mini-IPIP test is publicly available for researchers at `https://ipip.ori.org/MiniIPIPKey.htm`.

TABLE 1: FIVE FACTORS INVESTIGATED IN THE MINI-IPIP QUESTIONNAIRE [11]

Factor	Meaning of Low Traits	Meaning of High Traits
Extraversion	**Introvert**: reserved, loner, stays in background, less active, low need for thrills and less enthusiastic	**Extravert**: friendly, prefers company, assertive, active, craves excitement and cheerful
Agreeableness	**Challenger**: skeptical, guarded, reluctant to get involved, aggressive, hard headed and has feelings of superiority	**Adapter**: good-natured, cooperative, forgiving and frank
Conscientiousness	**Flexible**: unprepared, disorganized, casual, distracted and has low need for achievement	**Focused**: thorough, achievement-oriented, reliable, organized, self-disciplined
Neuroticism	**Resilient**: calm, composed, rarely discouraged, hard to embarrass, resistant to urges and stress	**Reactive**: uneasy, quickly angered, easily discouraged, embarrassed or tempted and susceptible to stress
Intellect/Imagination	**Preserver**: focuses on here/now, has no interest in art, ignores feelings, prefers familiar, narrower intellectual focus	**Explorer**: imaginative, appreciates art, values emotions, prefers variety, broad intellectual curiosity

2.3 Locus of Control Personality Trait

The Locus of Control (LOC) personality trait measures how people perceive the world. It can be explained in two extremes: external LOC and internal LOC. People with an external LOC believe they do not have control over their life. They believe they are guided by fate, luck or other external circumstances that they cannot control. Individuals with an internal LOC believe they can influence events and create their own outcomes. They support the idea that their decisions and efforts guide their life [26]. Weiss and Sherman demonstrate the LOC personality trait impacts a wide variety of human action outcomes including academic and professional performance [27]. Green and Fisher show people with an internal LOC complete tasks faster [28]. Internals have better motivation to finish/resolve a difficult task and have better problem solving skills compared to externals [27].

The reactions and emotions of internals and externals differ towards success and failure. Internals believe they are responsible for their own outcome and feel shame in bad outcomes and take pride in good outcomes [29]. In contrast, externals do not feel intense emotions towards an outcome because they believe it happened beyond their own control. Internals act with a higher motivation because they believe they can master their environment and control their outcomes. Externals show more passivity and low motivation in their actions since they believe their effort would be futile [30]. Rotter suggests a relationship between internal and external control of reinforcements and the need for achievement [31]. Previous works suggest people with a high need for achievement believe their efforts, ability and skills determine the outcome of an event [32]. Phillips and Gully suggest LOC has an effect on goal orientation and self-efficacy where external LOC is associated with lower self-efficacy [33].

Internals are more manipulative to control the outcomes and obtain higher valued results in games [6]. They are more controlling over other players by changing their behaviors of being cooperative or competitive. Conversely, externals are more rigid in their behaviors. Internals adapt to aggressive game styles whereas externals stay more helpless in these environments.

The Locus of Control-Rational Scale inventory by Levenson measures the LOC personality trait [34]. Persons scoring higher on the test are internals while persons scoring lower on the test are externals [35]. This questionnaire is also open for the public and is available at `https://ipip.ori.org/newSingleConstructsKey.htm#Locus-of-Control`.

2.4 Research Objective

Previous research shows personality traits have a significant effect on team performance and negotiation outcomes. Observations indicate the Big Five traits carry different influences on the outcome of events and heterogeneity in traits increases cooperative efficiency in team environments. Background information suggests an internal LOC personality trait will positively influence outcomes of individual performance and negotiations. There is a literature gap in understanding the effects of personality traits in collaborative design tasks which combine features of individual cognition and collective negotiation.

This research tries to enlighten deeper understanding about effects of Big Five and LOC personality traits in engineering de-

sign with the stated research question: *How do Big Five and LOC personality traits affect individual outcomes of collaborative engineering design tasks?*

An initial study focuses on the interactions between two self-interested agents in engineering design tasks. Essential features include design space exploration where participants search for desirable decision alternatives and negotiation where participants discuss how interacting design decisions influence potentially-competing objectives. The given task is considered to be an ECN because the players first explored the design space then negotiate to reach an agreement. Players decide either to cooperate for overall welfare or to compete for personal success.

Based on literature, this study evaluates two hypotheses:

1. The Big Five personality traits affect individual final scores in an ECN design task.
2. An internal LOC personality trait increases individual final scores in an ECN design task.

Hypothesis 1 only investigates whether the Big Five personality traits influence ECN because of diverging effects reported in literature. Hypothesis 2 makes a clearer statement about the effects of LOC based on synthesized literature.

3 STUDY METHODOLOGY

This study uses secondary data from an experiment consisting of questionnaires and a series of design tasks to investigate how problem structure and other contextual factors (e.g. demographics, personality traits) influence individual and overall collective performance in a collaborative design (CoDe) process. The experimental protocol was approved by the Institutional Review Board. Each session gathered four participants and lasted approximately 60 minutes as follows:

+ 1 min: Introduction to study
+ 5 min: Demographics and personality questionnaires
+ 17 min: Introduction to CoDe experiment and training tasks
+ 35 min: Main CoDe experiment tasks (12 total)
+ 2 min: Post-study feedback from participants.

Participants earned a base compensation of USD 10.00 plus a bonus of up to USD 10.00 based on relative individual performance among the four participants during the CoDe experiment.

3.1 Participant Demographics

A total of 40 subjects (15 women and 25 men) participated in the study. Participants provided demographics (i.e. age, gender, education, language) and level of social familiarity about each other. Subjects ranged between 20–41 years of age with 55% between the ages of 20 and 27. All participants completed or were in their last year of STEM undergraduate studies, with half pursuing a graduate engineering degree. Participants did not generally have prior experience working with each other: at least one participant did not consider any others in their social network in seven sessions and about half the participants were unfamiliar to each other in every session.

Regarding means of communication, 34 of the 40 participants listed one of 14 different languages other than English as their native tongue. With respect to their English level proficiency, 30% of the subjects claimed to be fluent speakers and 40% reported having obtained TOEFL scores above 95 (IELTS $>$ 7.0) prior to beginning of their studies. Out of the remaining 12 subjects, only 1 reported having obtained a TOEFL score below 85 (IELTS $>$ 6.5).

3.2 Personality Inventories

Participants completed a questionnaire composed of the five-item rational scale of Locus of Control [34] and the 20-item version of the lexical Big Five (a.k.a. "Mini-IPIP") [25] inventories for multi-dimensional personality assessment from the International Personality Item Pool (IPIP) [22]. Four items measure each of the Big Five personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and intellect/imagination). The start of the questionnaire reads:

> "Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age".

Subsequently, respondents assess if each of the 25 statements is "Very Inaccurate", "Moderately Inaccurate", "Neither Accurate Nor Inaccurate", "Moderately Accurate", or "Very Accurate".

Response levels on the five-point Likert-type scale are assigned an integer value from 1 to 5 in ascending or descending order depending on whether the item is keyed positive ("+") or negative ("-"), respectively. The sum of the values of the items associated to each personality mapped from a subject's responses constitutes the subject's total scale score on that trait. Raw scores use a scale between 5 to 20 for Big Five personality traits and 5 to 25 for LOC personality trait before being normalized to a 0 to 1 scale. Personality trait scores distributions among participants are given in Fig. 1 and descriptive statistics are given in Table 2.

3.3 Design Experiment

The CoDe experiment design task is based on the bi-level model of decision-making introduced in [36] and extended in [37] to generate synthetic design problems with specified strategy dynamics. A series of time-constrained two-actor design space exploration and strategy selection tasks model, respectively, lower-level design decisions and upper-level strategy trade-offs stylized as a two-strategy normal-form game that high-

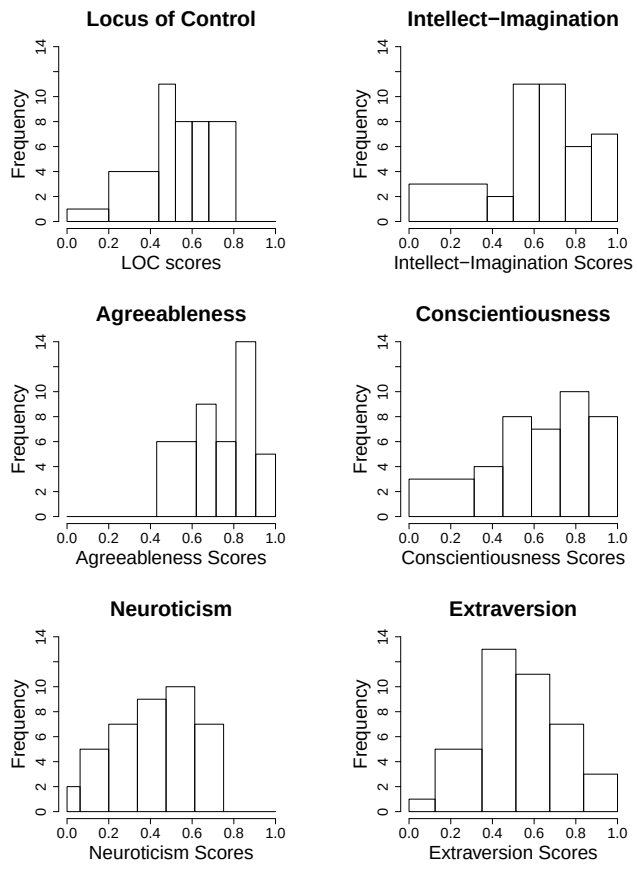

FIGURE 1: HISTOGRAM OF BIG FIVE AND LOCUS OF CONTROL SCORES (NORMALIZED)

lights cooperation, coexistence, bistability, or defection dynamics [38].

During a session, participants work on a series of tasks rotating between partners each round. Each participant plays four tasks with each other player (one for each strategic dynamic), finishing 12 pair tasks in total. In each task, pairs have two minutes to explore the value space and make a collective decision. They need to communicate and negotiate to maximize their individual values. While communicating, they can share as much as information as desired but cannot view each other's interface.

In each task, participants face two different value spaces, *red* and *blue*, each containing a 7*x*7 matrix named from *A* to *G*, illustrated in Fig. 2. The value spaces are partially hidden from the players, such that the player's goal is to explore the design spaces and maximize their individual score in each task. Movements of the pairs are dependent on each other: each player controls their own horizontal axis while their partner controls the vertical axis. The players must communicate to explore the design space and decide on the final cell to select; however, the values obtained by each player for each cell may differ.

TABLE 2: DESCRIPTIVE STATISTICS FOR PERSONALITY TRAIT SCORES (NORMALIZED)

Personality trait	**Mean**	**SD**
Locus of Control	0.563	0.129
Extraversion	0.545	0.191
Agreeableness	0.750	0.142
Conscientiousness	0.655	0.190
Neuroticism	0.419	0.193
Intellect/Imagination	0.712	0.177

After two minutes of design space exploration, the interface for exploring the design space locks and participants have 20 extra seconds to make a final strategy selection. Players decide between the design spaces, either choosing *red* or *blue* depending on their benefits. Agreeing to choose the same design space (*red* or *blue*) indicates cooperation and players receive the actual value observed on their selected cell. However, one of the players deciding to "defect" and choose the other space, for example one player chooses red and the other chooses blue, indicates they could not agree and prefer to compete. In this case, the players receive the value stated under the design space on the right side as *you choose red, your partner chooses blue* or *you choose blue, your partner chooses red.* In the end, there are three possible scenarios affecting players' individual values in a task: both cooperating, one cooperating and the other defecting, or both defecting. Accordingly, participants first explore the design spaces to find the best fitted cell and then select a strategy (blue or red design space) to maximize individual values through negotiation. Players finish 12 tasks with the same logic and total scores are calculated by accumulating the scores received from each task.

Aggregated scores are only released at the end of a session to eliminate boundary conditions and reputation effects. Participants are ranked based on their total accumulated score and privately paid a total of $10, $12, $15, and $20 for successive ranks. Table 3 shows the total accumulated score distribution, normalized based on the maximum score of 1200 across the 40 participants. Although the original experimental design investigates the effect of strategic dynamics on design task outcomes, this paper uses it as a secondary data source to study the effect of personality on design task outcomes.

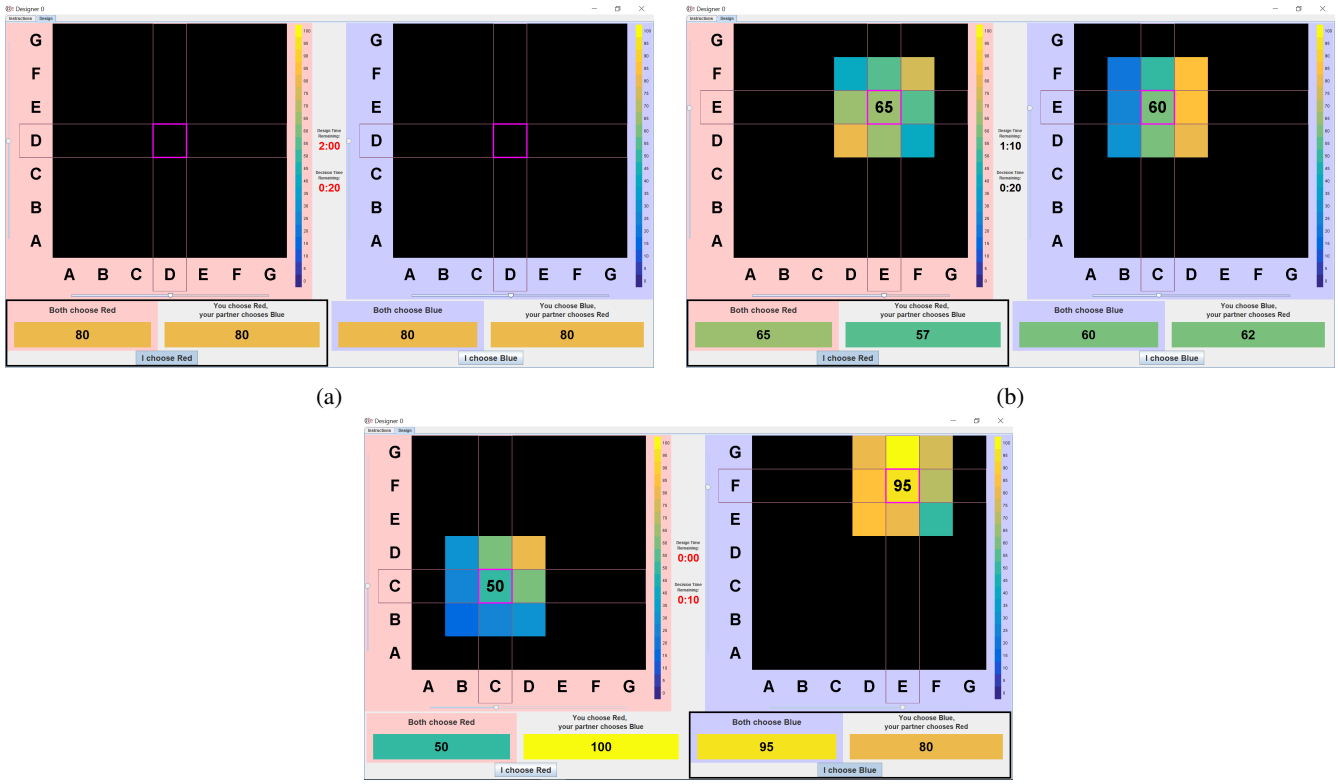

FIGURE 2: GRAPHICAL USER INTERFACE OF CODE EXPERIMENT INCLUDING (a) INITIAL VISUALIZATION, (b) DESIGN SPACE EXPLORATION, AND (c) DESIGN STRATEGY SELECTION.

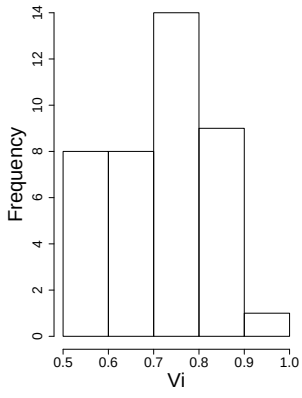

FIGURE 3: HISTOGRAM OF TOTAL ACCUMULATED INDIVIDUAL SCORE (NORMALIZED)

4 STATISTICAL ANALYSIS AND RESULTS

The secondary data source includes ten sessions, each with four participants, yielding 40 total data points. Statistical analysis investigates if there is a relationship between the individuals' final accumulated score and Big Five and LOC personality traits. The following variables express scores for each participant i: final score V_i, locus of control LOC_i, extraversion Ex_i, agreeableness Ag_i, conscientiousness Co_i, neuroticism Ne_i, and intellect/imagination Im_i.

Personality inventory questionnaires are scored on a scale between 5 to 20 for Big Five personality traits and on a scale between 5 to 25 for the LOC personality trait. Higher Big Five scores indicate the strength of a specific personality trait. Higher LOC scores indicate the strength of the internal type. All scores are normalized to a (0,1) scale for analysis.

Initial analysis considers the relationship between V_i and all six factors together (LOC_i, Ne_i, Im_i, Ex_i, Ag_i, Co_i). Initial results indicate demographic factors including level of English language and gender do not have a significant effect on outcomes. Regression results indicate LOC_i to be significant but do not provide enough evidence to support a relationship for the Big Five per-

TABLE 3: CORRELATION ANALYSIS RESULTS FOR PERSONALITY TRAITS

Personality trait	LOC_i	Im_i	Ag_i	Co_i	Ne_i
LOC_i	1.				
Im_i	0.188	1.			
Ag_i	-0.192	0.401^{*}	1.		
Co_i	0.053	-0.021	0.015	1.	
Ne_i	0.000	-0.086	-0.139	0.035	1.
Ex_i	-0.065	0.358	0.444^{**}	-0.115	-0.283^{***}

$^{*}p = 0.01, ^{**}p < 0.05, ^{***}p < 0.01$

sonality traits, possibly due to the relatively small sample size.

Although observations were not significant in a disaggregated analysis, the Big Five may have a magnifying effect when combined. Correlation analysis in Table 3 indicates some significant collinearity among the Big Five traits, namely Ne_i, Im_i, Ex_i, and Ag_i. Various combinations of Big Five personality traits were analyzed; however, the best model uses as the geometric mean of all five traits in Eq. 1.

$$Big5_i = \sqrt[5]{Ne_i \cdot Im_i \cdot Ex_i \cdot Ag_i \cdot Co_i} \tag{1}$$

Residual analysis also suggested a transformation to better explain the relationship between V_i and LOC_i. Accordingly, Eq. 2 shows the best fitted mathematical model.

$$\bar{V} = \beta_0 + \beta_1 \cdot LOC^2 + \beta_2 \cdot Big5 \tag{2}$$

Regression analysis results in Table 4 indicate modest overall fit ($R = 0.52, R^2 = 0.27$) and significant relationships between LOC (p-value = 0.002), $Big5$ (p-value = 0.048), and individual final scores. Residual analysis in Fig. 4 shows good linear model fit. Random sampling with replacement was applied to mitigate over-fitting for the small sample and measure accuracy. Table 4 shows bootstrapping results. Bias values are smaller than 0.5, suggesting the regression test analysis supports a conclusion.

5 DISCUSSION

Various studies have investigated the effects of personality traits on team performance, engineering design tasks and negotiation outcomes. This paper introduces a new perspective: the

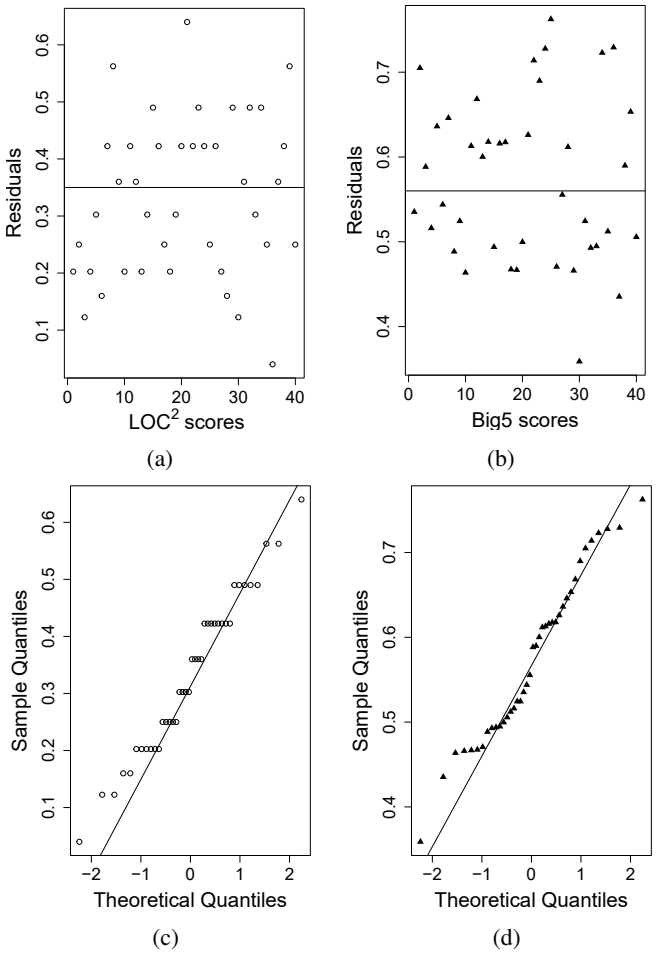

FIGURE 4: RESIDUAL PLOT FOR (a) LOC^2 AND (b) $Big5$ AND Q-Q PLOT FOR (c) LOC^2 AND (d) $Big5$

TABLE 4: BOOTSTRAP AND REGRESSION STATISTICS

	Original	Bias	Std. error
Intercept	0.775	−0.021	0.109
$Big5_i$	−0.306	0.030	0.167
LOC_i^2	0.344	0.008	0.106

Factor	Coefficients	Std. error	t-statistic	p-value
Intercept	0.775	0.091	8.550	< 0.001
$Big5_i$	−0.306	0.150	−2.041	0.048
LOC_i^2	0.344	0.104	3.306	0.002

effects of personality traits in a collaborative engineering design task. We observed participants' individual performances in a task consisting of competition and/or cooperation. Individual performance is dependent on both effort in a given task and their ability to negotiate. Analysis results show both the Big Five and LOC personality traits are significant factors.

5.1 Big Five

Analysis indicates high values of the geometric mean of Big Five personality traits has a negative effect on individual final values. However, there is not enough evidence to claim Big Five personality traits have an impact on individual performance when considered separately. Nevertheless, this section discusses several possible hypotheses explaining the negative impacts of aggregated Big Five personality traits.

Being more social makes ***extraverts*** more friendly and eager to befriend others compared to introverts. In a negotiation, this affable characteristic and desire to maintain friendly environment may lead extraverts to act towards mutual welfare.

People with higher ***agreeableness*** tend to sympathize and trust more compared to less agreeable people. More agreeable people tend to choose cooperation over competition. Accordingly, an agreeable person may lose if they pair up with a player who tends to act towards individual success and defect.

Having higher traits on ***conscientiousness*** tends to avoid a win-lose agreement [18]. Since people with higher conscientiousness are more organized, detailed-oriented and responsible, they may tend to focus on negative potential outcomes, leading to risk-averse behavior. They may tend to act in moderation and take fewer risks in a negotiation.

People with low levels of ***intellect/imagination*** may ignore feelings. Thinking from a more pragmatic approach and ignoring the outcome/feelings of the other player leads to success.

People who are more ***neurotic*** may respond more strongly to emotions, leading to worse performance in a negotiation. Their personality damages them more in uncertain processes like negotiations. Insecurity and fear of outcomes may contribute stress and less success in those environments.

5.2 Locus of Control

Previous work indicates a positive relationship between self-efficacy, goal orientation, achievement need of an individual and the LOC personality trait [32,33]. These previous works suggest that being an internal contributes to higher scores on the given collaborative engineering design task, as stated in Hypothesis 2. Statistical analysis in Table 4 supports the hypothesis. Compared to previous studies, this study focused on collaborative engineering design tasks using negotiation. Each task required individual abilities for design space exploration and negotiation, demonstrating broader effects of LOC.

Externals tend to believe they cannot control event results and subsequently do not fight for the success as much as the internals. Also, externals do not feel responsible for bad outcomes or feel success as strongly as internals. Accordingly, they are less motivated to exhibit effort for a given task. They tend to feel their performance is not going to change the results leading to worse results compared to internals in engineering design tasks.

In negotiations, differences in personalities give advantages to internals. Since internals feel they have the control of the outcome and are more motivated to achieve success, they tend to have better results in the given tasks. When an internal and external are paired up in a collaborative design task, internals become more manipulative. They take control and direct the negotiation towards their own benefit. These behaviours makes internals more successful in collaborative engineering design tasks.

5.3 Limitations

Results from this study are subject to several limitations. First, it uses secondary data from an experiment on the effect of strategic dynamics on designer behavior [37] and does not randomize or otherwise control the personality traits observed. The sampled population does not include all combinations of personality traits. The design task itself was minimally structured such that other uncontrolled factors such as varying levels of communication may also influence designer behavior. Other potential factors such as the interaction between personality traits in designer pairs could not be studied due to lack of statistical power.

The secondary data includes LOC inventory with a Cron-

bach's alpha of 0.61 as time limitations during design experiments required short-form personality inventories which may provide lower reliability compared to longer-form inventories. The short format only includes four items per Big Five trait and five items for LOC. Longer-form inventories, such as [34] 24-item LOC inventory, would provide additional measures of internal consistency or reliability.

Finally, this experiment used a highly simplified design task that is representative of collaborative design only at an abstract level. Tasks consider interactions between two participants at a time, take place over a short time period (minutes), have a small number of design variables without any design context, and incentivize behavior using a financial reward tied to relative ranking in a design session. These features capture the essential components of a collaborative design task—exploration of a design space, coupled decisions with negotiation, and potentially-conflicting objectives—though in a highly simplified format.

6 CONCLUSION AND FUTURE WORK

This paper shows a statistically significant relationship between Big Five and LOC personality traits and individual outcomes in an abstract collaborative design task. An internal LOC personality trait positively affects individual values while high levels of aggregated Big Five traits (extraversion, agreeableness, conscientiousness, neuroticism, and intellect/imagination) negatively affects the individual values. These results show that individual personality traits are important factors when looking at collaborative engineering design tasks and further study is necessary for a deeper understanding.

Future work should conduct more focused experiments to strengthen the causal relationship between personality traits and outcomes of design activities and, specifically, interaction effects between pairings or groupings of individuals in teams. The ultimate goal of this research direction is to identify processes, methods, or tools tailored to best support diverse groups of engineering actors working effectively on collaborative design tasks.

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