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# The Big Five personality factors and team performance: implications for selecting successful product design teams

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**Abstract**

Big five vs. FFM!

In the pursuit of faster product development, product design teams are a growing phenomenon in many organizations. In order to be successful, these teams must be composed of people who work well together. However, despite the benefit of selecting the optimal combination of team members, this topic has received little attention. Personality has been identified as a potentially helpful selection variable in the determination of optimal team composition. This study examines the relationships between the 'Big Five' personality factors (Conscientiousness, Extraversion, Neuroticism, Agreeableness, and Openness to Experience) and objective team performance for three-member product design teams. In addition to this, the potential incremental contribution of personality to the variance in team performance over that accounted for by established selection measures such as general cognitive ability was investigated. In the short duration of the study, it became apparent that some teams were capable of success, and some were not. Successful teams were characterized by higher levels of general cognitive ability, higher extraversion, higher agreeableness, and lower neuroticism than their unsuccessful counterparts. In successful teams, the heterogeneity of conscientiousness was negatively related to increments in product performance. Implications for the selection of product design teams and future directions for research are discussed. © 1997 Elsevier Science B.V.

So the more diverse, the less performant product?

*Keywords:* Team; Selection; Personality; Performance; Product design teams

## 1. Introduction

In new product development, time is one of the biggest potential costs in the product development cycle. In fact, it has been suggested that products which meet their budget

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but are late coming to market generate substantially less profit than those going over budget but coming to market on time (Gupta and Wilemon, 1990). In light of the importance of product development timeliness to the ultimate success of the product, and hence the organization, there is a demand for faster and more efficient new product development (Maidique and Zirger, 1984; McDonough III and Barczak, 1992). Project organization, or more specifically, the use of cross-functional teams which are accountable for the project from beginning to end has been identified as one of the strongest determinants in project timeliness (Peters, 1987; Larson and Gobeli, 1988; Perry, 1990; Cooper and Kleinschmidt, 1993; Cooper, 1994; Cooper and Kleinschmidt, 1994).

One of the first logical steps in implementing product development teams is selecting the optimal members for the team. Selection, or manipulating the team's composition prior to the project, allows the team's probability of success to be maximized in a cost-effective manner. It has already been recognized by many organizations and researchers that a carefully selected team is vital to the success of the product, while a poorly chosen team invites chaos, disaster, and inferior technical performance (Rideout, 1986; Lane, 1987; Kezsbom, 1992). In order to use selection procedures in a responsible and effective manner, it is first necessary to determine the team member characteristics of the optimal development team.

Factors such as group cohesiveness (Keller, 1986) and 'cognitive problem-solving orientation' (McDonough III and Barczak, 1992) have been suggested to characterize successful product development teams. However, these factors are secondary factors. That is, they may be expressed as functions of individual characteristics or combinations of team member characteristics. Group cohesiveness is only possible if the behavioral tendencies of the team members are compatible at some minimal level that allows interpersonal interaction to occur without destructive interpersonal conflict. 'Cognitive problem-solving orientation' (CPSO) is simply a reflection of the propensity of a person to pursue the solution to a problem in a certain manner (e.g., searching for novel solutions versus adhering to commonly accepted ways of doing things). In other words, CPSO is an indicator as to how we can expect a certain person to behave when confronted with a problem or task.

The propensity of a person to behave in a certain manner, or to successfully interact with others, is a function of his or her personality (Hogan, 1991). Thus, if we can determine the personality combinations of team members that contribute to, or inhibit team performance, we can maximize our chance of product development success by simply administering a commercial personality test prior to team formation.

This study attempts to etch a starting place for future research in personality as a predictor of team success for a product design team and to provide some preliminary rules in the selection of product design teams. The 'Big Five' personality taxonomy, which summarizes all personality traits into five factors ('Conscientiousness', 'Extraversion', 'Agreeableness', 'Emotional Stability', and 'Openness to Experience'), will be used as a framework to organize the existing literature as well as the findings from this study.

## 2. Relevant literature and research hypotheses

### 2.1. Personality as a predictive measure

Personality traits are relatively enduring characteristics of individuals which are not easily changed by interventions such as behavioral training (Helmreich, 1984). Although there is multitudinous research on personality, most of it is in the clinical psychology literature and deals with the relationship of personality type with abnormal behavior. Until recently, there had been relatively little effort put forth to determine the personality factors associated with exceptional job performance (Driskell et al., 1987). This effort was also hampered because there was little consensus on the personality test/scale that should be used, making comparison across studies difficult. However, recently, there has been extensive work done in developing an overall classification system for personality traits which allows comparisons to be made across studies in a consistent manner. The 'Big Five' ('Extraversion', 'Emotional Stability', 'Agreeableness', 'Conscientiousness', and 'Openness to Experience') classification system which will be described in greater detail later in the paper, has received the most support (Tupes and Christal, 1961; Norman, 1963; Digman and Inouye, 1986; McCrae and Costa, 1987; Digman, 1990; Goldberg, 1990; Barrick and Mount, 1991) and will be the personality framework used in this study.

Several researchers have suggested that team member personalities may be useful as a predictive device for future performance (Cattell, 1951; Golembiewski, 1962; Hackman and Morris, 1975; Ridgeway, 1983). However, there are also many opponents to this notion (Whyte, 1941; Mann, 1959; Sorenson, 1973; Kahan et al., 1985). Those who are pessimistic about the usefulness of personality tend to refer to studies done in the 1950s which attempted to make sweeping generalizations about personality traits to a wide array of situations. Current reviews and meta-analyses, using more sophisticated analysis techniques, a consistent taxonomy of personality traits (e.g., the 'Big Five'), and specific performance criteria (George, 1992) suggest that there is potential to use personality measures in selection decisions (Schneider, 1996). Furthermore, some researchers have found that managers implicitly use personality factors in their hiring decisions (Dunn et al., 1995) and it is therefore prudent to conduct studies which investigate potential relationships between personality and performance so that managers may be given some guidance in the use (or potential misuse) of personality as a selection measure.

Research in the personnel selection literature indicates that if relevant personality factors are identified for a specific job or role, future performance can be predicted (Borman et al., 1980; Lord et al., 1986; Day and Silverman, 1989; Barrick and Mount, 1991; Tett et al., 1991). Extending this logic into the realm of teams, if relevant personality traits are identified for a specific team task, the personality profile of the team might be helpful in predicting future team performance (Driskell et al., 1987). The application of such knowledge would help organizations to maximize the effectiveness of the team simply by ensuring that the personality profile of the team (e.g., the combination of team member personality factors) matched the requirements of the task (Klimoski and Jones, 1994). After reviewing much of the team personality literature,

Driskell et al. (1987) proposed various hypotheses relating Hogan's six personality factors (Hogan uses four of the 'Big Five' factors: 'Agreeableness', 'Openness to Experience', 'Emotional Stability', and 'Conscientiousness' and splits 'Extraversion' into 'Sociability' and 'Ascendancy') to certain task types. The hypotheses that were proposed relating team member personality factors to team performance for optimizing tasks (those tasks where more than one possible solution exists and the team's mandate is to optimize the product/solution produced) are included below in the discussion under the appropriate personality factor. Although Driskell et al. (1987) did not directly propose how to operationalize the team's personality profile, they suggested that 'any single individual or composite of individuals can be described in terms of these dimensions [Hogan's six personality factors]' (Driskell et al., 1987; Driskell and Salas, 1992) suggesting that each personality factor should be considered separately and that a combination of scores on the factors may be used.

The use of personality in the realm of team staffing is more complex than simply using it as a predictive device for a particular job. Not only must the personality profile of the team match the demands of the task, the people on the team (and hence, their personalities) must be compatible. Organizations are beginning to realize the importance of considering personality mixes when designing self-managed work teams. For example, at Eastman Kodak, teams were constructed using the best technical people available. However, despite the attention to ability level, sometimes the teams were successful and sometimes they were not. Once the company started to take personal compatibility into account when organizing teams, the teams have had a higher success rate (Moad, 1994). Thus, personality seems to make definite contribution in helping organizations to staff effective teams.

### 2.2. *Review of the 'Big Five' literature*

The studies relating team member personality to team performance is sparse. Most of the studies that do exist measure and relate specific personality traits (which compose a minute piece of one of the five factors) to team performance or team satisfaction. There is no replication of any of the results due to the task specificity and the situation nature of the experiments. There are therefore no specific conclusions relating personality, as classified within the 'Big Five' framework, to team performance. However, the preliminary results from the studies in existence indicate that some personality traits may affect performance for certain tasks in certain situations (Driskell et al., 1987). A brief overview of the findings to date for each factor is described below. [1]

#### 2.2.1. *Conscientiousness*

A person displaying the factor of 'Conscientiousness' has been described as being dependable, careful, thorough, responsible, organized, planful, hardworking, persever-

[1] It should be noted that the Big Five personality factors are not mutually exclusive. Some personality facets or traits are considered to load on more than one factor. Evidence involving personality traits for which more than one factor may be appropriate is provided under the factor for which the stronger case may be made (either in terms of precedent used in previous reviews, or in the context of the study).

ing, and achievement-oriented (Digman, 1990; Barrick and Mount, 1991). In the individual personnel selection research, the factor 'Conscientiousness' has been shown to be a valid predictor of future job performance for all occupational groups (Barrick and Mount, 1991; Tett et al., 1994). Given that each person in the team is performing his/her job by participating in the team task, it is logical that the factor of 'Conscientiousness' may also be related to the task performance of the group. This extension of logic is also supported by recent findings by Thoms et al. (1996) which show that 'Conscientiousness' is positively related to self-efficacy (which the authors contend is predictive of performance) for participation in self-managed work groups.

Other support for the contention that the level of 'Conscientiousness' of the members in the group may be related to group performance can be found by the studies that have related the groups' need for achievement with their subsequent performance on a task. Groups whose members showed a high need for achievement outperformed groups whose members had a low need for achievement (French, 1958; Schneider and Delaney, 1972; Zander and Forward, 1968) on a variety of tasks. Leadership orientation was also found to correlate positively with group performance (Shaw and Harkey, 1976). In addition to this, Driskell et al. (1987) proposed that 'ambition' (which includes 'need for achievement') may be predictive of team performance for a variety of tasks.

*Hypothesis 1*: The team's level of Conscientiousness (operationally defined as the sum of the scores received by each individual on the factor of Conscientiousness) will be positively related to the performance of the team.

### 2.2.2. *Extraversion*

'Extraversion' is exemplified by such traits as sociability, gregariousness, assertiveness, talkativeness, and activeness (Barrick and Mount, 1991; Digman, 1990). In the individual personnel selection literature, 'Extraversion' has been shown to have positive validity in predicting future individual job performance for those occupations that have a large social component (Barrick and Mount, 1991; Tett et al., 1994). Given that an optimizing task performed as a team requires frequent social interactions among the members, it may be argued that the factor of 'Extraversion' could be related to the team's performance for an optimizing task. The research that has been done with respect to components of 'Extraversion' in the realm of the team environment has been diverse.

Dominance, (which is closely related to the factor of 'Ambition'; Hogan, 1991), which in turn loads on the factor of 'Extraversion' (Hough, 1992) has been shown to be positively related to the performance of the group (Haythorn, 1953; Ghiselli and Lodahl, 1958; Smelser, 1961; Altman and Haythorn, 1967; Bouchard, 1969; Shaw and Harkey, 1976; Driskell et al., 1987; Williams and Sternberg, 1988) as well as the degree of participation within the group (Mann, 1959; Watson, 1971).

The level of 'Sociability' (which is part of 'Extraversion', according to Hogan, 1991) of group members has been shown to relate positively to team performance (Bouchard, 1969; Shaw, 1971). In addition, an early review of studies relating personality factors to team characteristics by Mann (1959) reported a positive relationship between the factor of 'Extroversion' (which consisted of 'Sociability' and 'Surgency') and the degree of group member task-related participation.

The degree of participation within the group is usually operationalized as the amount

of talking done by each group member. Williams and Sternberg (1988) found that both the average amount of talking done by members of the group and the maximum amount of talking done by any member of the group was positively correlated with the performance of the group.

The factor of 'Extraversion' as measured by the Eysenck Personality Questionnaire was not found to correlate significantly with team performance (Williams and Sternberg, 1988). However, Thoms et al. (1996) found that 'Extraversion' as measured by the NEO-FFI (Costa and McCrae, 1992) was positively correlated with self-efficacy (and, hence, performance, according to Thoms et al., 1996) for participation in self-managed work groups.

Most of the evidence seems to suggest that there should be a positive relationship between the factor of 'Extraversion' and team performance.

*Hypothesis 2*: The team's level of Extraversion (operationally defined as the sum of the scores received by each individual on the factor of Extraversion) will be positively related to the performance of the team.

### *2.2.3. Neuroticism*

The factor of 'Neuroticism' may also be thought of as a lack of 'Emotional Stability', or 'Adjustment' (which is the degree to which one exhibits 'Emotional Stability'). 'Neuroticism' is characterized by traits such as anxiety, depression, anger, embarrassment, emotionality, and insecurity (Digman, 1990; Barrick and Mount, 1991).

In the personnel selection research, 'Emotional Stability' was not found to be correlated with future performance. Barrick and Mount (1991) hypothesized that once a certain threshold of stability had been attained by the person tested, the degree of 'Emotional Stability' was no longer relevant in predicting performance.

However, in the realm of groups or teams, both Mann (1959) and Heslin (1964) claimed that 'Adjustment' was one of the best factors in predicting group performance. Others also noted that 'Emotional Stability' or lack of nervous tendencies was positively correlated with group effectiveness (Haythorn, 1953; Mann, 1959; Shaw, 1971) and distinguished leaders from nonleaders (Richardson and Hanawalt, 1952; Cattell and Stice, 1954). 'Neuroticism' was also found to be negatively correlated to self-efficacy (and hence performance, according to the authors) for participating in self-managed work groups (Thoms et al., 1996). Driskell et al. (1987) hypothesized that 'Emotional Stability' should be positively correlated with group performance for all tasks. In sum, the consensus seems to be that 'Emotional Stability' should be positively correlated with subsequent group performance, or, that 'Neuroticism' should be negatively correlated with subsequent group performance.

*Hypothesis 3*: The team's level of Neuroticism (operationally defined as the sum of the scores received by each individual on the team on the factor of Neuroticism) will be negatively related to the team's performance.

### *2.2.4. Agreeableness (likability)*

A person exhibiting traits included in the 'Agreeableness' factor is courteous, flexible, trusting, good natured, cooperative, forgiving, soft-hearted, and tolerant. The results linking 'Likability' with group performance are not consistent across studies.

Most studies did not find a significant relationship between group member likability and performance or productivity (Haythorn, 1953; Berkowitz, 1959; McGrath, 1962; Terborg et al., 1976; Tziner and Vardi, 1982), while some found a negative correlation between likability and performance (Adams, 1953; Bass, 1954; Weick and Penner, 1969). Positive relationships between social insight and group performance (Bouchard, 1969), 'Agreeableness' and self-efficacy for working in self-managed work groups (Thoms et al., 1996) and the person-orientation of the team leader and team satisfaction (Stogdill, 1974) have been found. From these results, Driskell et al. (1987) hypothesized that 'Likability' would only be positively related to performance on social (e.g., training, assisting, or serving others) and manipulative/persuasive (e.g., organization or motivation of others) tasks. Given the intellectual nature of the optimizing task, it is not known if the factor of 'Agreeableness' will be related to team performance and thus no hypotheses are proposed.

*2.2.5. Openness to experience*

This factor of the 'Big Five' is also commonly referred to as 'Intellect'. Of the five factors, 'Openness to Experience' is the least well defined. Traits associated with this factor include imagination, culture, curiosity, originality, broad-mindedness, intelligence, and 'artisticness' (Barrick and Mount, 1991).

The personnel selection literature proposes that the factor 'Openness to Experience' is predictive of a person's training proficiency (Barrick and Mount, 1991), however, it was not found to be predictive of job performance. It is not clear whether the 'Openness to Experience' displayed by the team members has any relationship to team performance. The relationship between 'Openness to Experience' and team performance will be investigated in an exploratory manner.

*2.3. Heterogeneity of personalities*

Relationships between the 'team level' (composite score, or sum of all team member scores) of a personality construct and team performance implicitly assumes that there is a compensatory relationship between the personality factor being tested and subsequent team performance. That is, if a factor is positively correlated with the task demands, that low scores of some individuals on the factor can be compensated for by high scores on the same factor by other team members. This may prove to be an extremely limited and simplified view of personalities. In a team, the productivity of the group is contingent on the compatibility of the team members' personalities (Moos and Speisman, 1962). Compatibility has traditionally been operationalized as the heterogeneity of the team members' personalities on each team.

The studies that have considered heterogeneity of team member personalities in terms of subsequent team performance have produced conflicting results.

One line of thinking is that a mix of personality types is necessary to optimize the performance of the team (Pitcher, 1993) especially when the task characteristics are diverse (Nieva et al., 1978 (as reviewed by Goodman et al., 1986); Pearce and Ravlin, 1987). A few studies have looked at the interaction of team member personalities in relation to team performance. Teams (tetrads) composed of members with heterogeneous

personality profiles outperformed those with members who had homogeneous personalities on several optimizing tasks (Hoffman, 1958; Hoffman and Maier, 1961).

In the alternative, heterogeneity of individual characteristics offers breeding grounds for interpersonal conflict detrimental to team performance (Hoffman and Maier, 1961). Similarity theory supports this stance. Similarity theory argues that homogeneity of group members is desirable since it evokes positive forms of mutual attraction while heterogeneity introduces divisive tensions (Tziner, 1985). The implications of such an outlook is that workers placed in dissimilar groups in terms of members' personality orientations may have shorter tenure in the group and may ask to be transferred to a more compatible group (George, 1990), thus, interrupting the productivity of the group.

The fact that completely opposite views have been generated with respect to the relationship between heterogeneity and team performance may be explained by the team's task and the personality factors studied. That is, heterogeneity on some factors may be beneficial to team performance (e.g., to promote creativity), while homogeneity on other factors may be necessary to ensure team harmony and productivity (Belbin, 1981). Since this evidence does not provide enough support by itself to propose hypotheses, the relationship between the heterogeneity of team member scores on the personality dimensions and the team's performance will be investigated in an exploratory manner.

### *2.4. The potential incremental value of personality*

The true value of personality as a selection measure for many organizations lies in its potential to contribute incremental validity to the prediction of performance over that already possible using existing selection measures. One of the most commonly used, and most valid selection measures is general cognitive ability (Campbell, 1990; McHenry et al., 1990). Since personality is not thought to covary with general cognitive ability (Barrick and Mount, 1991), personality has the potential to make a unique contribution of information to the selection process.

*Hypothesis 4*: The personality of the team members will provide incremental validity over that provided by general cognitive ability in the prediction of team performance.

## 3. Research design and measures

This experimental study required the subjects to complete an Engineering Design task in a laboratory setting within a specified time limit. The subjects were administered a standardized general ability test, a personality test, and a demographic profile (gender and age only). A laboratory design was chosen in this case to control for extraneous factors (e.g., organizational politics, status differences) so that effects attributable to the personality variables under investigation would be more obvious (Driskell and Salas, 1992). However, it is acknowledged that laboratory designs have several disadvantages. The major disadvantage in this case is the limitation of the applicability of the study results to the general population.

### 3.1. Subjects

The subjects were 419 first year undergraduate Engineering Students enrolled in a problem-solving course. Twenty percent of the subjects were female. The subjects ranged in age from 16 to 32 years of age with the median age being 19 years.

The students were assigned to one of eight sections consisting of approximately fifty to sixty students each based on scheduling constraints. Within these sections, students were randomly assigned to teams of three for the design exercise. Completion of the design exercise and the self-analysis measures were a mandatory part of the course. However, participation in the study was contingent on the students voluntarily providing the researcher with demographic information. Of the 139 groups theoretically possible, the number of usable groups ranged from 99 to 116. [2]

### 3.2. Engineering product design task

The task which the teams were asked to perform was to design and build a bridge from a limited amount of newspaper and tape which were provided. The bridge was required to span the space between two chairs or tables (standing upright) which had to be at least two feet apart. The bridge could not be affixed in any way to the tables or chairs. It was to rest on top of these surfaces only. The students had 45 min to complete the task. Points were awarded based on the bridge's span, uniform width, height (as measured from two points on the base of the bridge) and strength. Bonus points were awarded for teams who finished under the time limit. Bridge dimensions were scored prior to the strength test. The strength of the bridge was determined by its ability to support a two pound book being placed on it and dropped from various heights. Once strength testing commenced, the team was not allowed to touch the bridge. Points were awarded for each drop the bridge withstood. Each team was given the scoring key before the task began. The overall objective of the task was to maximize the points obtained. Each team received an identical amount of resources with which to build the bridge.

### 3.3. Procedure

The students were randomly assigned to teams of three within classes whose composition was based on scheduling constraints. This was done in the first week of the semester of the first year. It is therefore unlikely that any of the students knew their teammates well or had any experience working in a team with the other students (thus, mitigating the effect of previous social relationships on the team's process and performance).

Teams consisted of three members for this exercise because of the difficulty of the task and the time allotted. Many authors have claimed that groups need to be large enough to accomplish the work assigned to them, but when too large, groups may be dysfunctional due to heightened coordination rules (Steiner, 1972; O'Reilly and Roberts,

[2] There was a range in the number of usable groups because of missing data.

1977; Gladstein, 1984; Campion et al., 1993). A previous study (Kichuk, 1996) determined that teams of three would be able to accomplish the task in the 45 min allotted.

The students were administered the ability and personality tests as well as the demographic profile during class time.

At the beginning of the period, each team was given a description of the task, the material required to construct the bridge, and the scoring key. The students had 45 min from this point to construct the bridge. The scoring key was designed so that there were competing constraints on the bridge. The teammates had to strategize how to build the bridge to maximize the points. There was no one superior strategy. However, significant planning was required to maximize the points attained. After the time was up or the team had finished the bridge, the bridge was scored by specially trained research assistants.

Although measures of inter-rater reliabilities are traditionally provided when products are evaluated by external 'experts', the nature of this task did not require such a precaution for several reasons. First, the bridge was evaluated in terms of a pre-set scoring guide that assigns points as a function of the length, width, height, and strength of the bridge. These dimension measures (e.g., length, width, and height) were taken with measuring tapes that are accurate to within 1/16th of an inch. Points were assigned in 1-ft increments. Thus, there were no 'judgment calls' in assigning points to the measures taken. Second, there were two people on each measuring team. One person measured while the other watched and recorded the measurements. Thus, any mistakes in the measurements made by the Measurer were likely to be caught by the Recorder. In addition to the watchful eye of the Recorder, spectators from both the team whose bridge was being measured and from rival teams were likely to catch any mistakes made by the Measurer. The most subjective part of the point assignment was the strength test. The multiple spectators were likely to catch any inconsistencies made by the Measurer, however, in this case, multiple tests (as would be required for inter-rater reliabilities to be calculated) were not possible since the bridge's integrity was diminished with each weight dropped on it.

### *3.4. Measures*

Team performance was measured by the team's actual score obtained on their bridge in accordance with the scoring scheme shared with the teams prior to the task.

Team member personality was measured using the NEO–Five Factor Inventory (or 'NEO-FFI' which is a shortened version of the NEO–Personality Inventory, or 'NEO-PI') personality test (Costa and McCrae, 1992). The NEO-PI has been recommended by Hogan (1991) as a good measure of the Big Five personality dimensions. In a review of this test for the Eleventh Annual Measurements Yearbook, Widiger concluded that 'any study that purports to be addressing fundamental dimensions of personality should include the NEO-PI as a measure' (p. 606). The NEO-PI has reported alpha coefficients across the facets measured ranging from 0.61 to 0.79 for men and 0.60 to 0.82 for women (Hess, 1992). Both Hess (1992) and Widiger (1992) referred to the NEO-PI as having 'impressive' validity. The NEO-FFI was developed by taking the 12 items with

the highest absolute factor loadings on each of the five factors (Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness) from the NEO-PI (Costa and McCrae, 1992; Schmit and Ryan, 1993). Although the NEO-FFI provides less detail than the NEO-PI, it is still recommended for assessing the 'Big Five' personality factors (Briggs, 1989). Correlations between the NEO-FFI scales and the NEO-PI factors range from 0.75 to 0.89 (Costa and McCrae, 1992; Schmit and Ryan, 1993). Alpha coefficients in this sample for each of the 12-item scales were found to be 0.85 (N), 0.78 (E), 0.75 (E), 0.76 (A), and 0.83 (C) which was in accordance with previous reports (0.89, 0.79, 0.76, 0.74 and 0.84, respectively; Costa and McCrae, 1992; Schmit and Ryan, 1993). [3]

General cognitive ability was measured using Form IV of the Wonderlic Personnel Test. This short (12 min) test of general cognitive ability includes items in vocabulary, 'commonsense' reasoning, formal syllogisms, arithmetic reasoning and computation, analogies, perceptual skill, spatial relations, numerical series, scrambled sentences, and knowledge of proverbs. The primary factors measured are verbal comprehension, deduction, and numerical fluency (Foley, 1972; Wonderlic Personnel Test, 1992; Gatewood and Feild, 1994). The advantage of using the Wonderlic Personnel test is that it is short and has been normed on various populations over a long period of time (since 1938) and has been extensively tested in terms of validity and reliability.

The gender type of the team was coded as the number of females on the team. There were four possible gender combinations: zero females, 1 female, 2 females, and 3 females.

The overall team level of a variable, or 'composite', was determined by the simple addition of the team members' scores on the measure of interest (James, 1982; Keller, 1986; Driskell et al., 1987). Post-hoc analyses which proposed a relationship between the heterogeneity of a variable and the performance of the team were measured using the coefficient of variation of the team members' scores. The coefficient of variation (calculated as the standard deviation divided by the mean) is the appropriate measure of heterogeneity when looking at continuous data (Allison, 1978).

### *3.5. Analyses*

The frequency distribution of the group performance scores indicated that two distinct subsamples could be derived from the overall sample distribution. The first subsample ($N = 17$) was a cluster of 'zero scores' (ZS). The teams that received a score of zero (ZS) on their product did so because they violated fundamental constraints that were clearly stated in the problem. That is, ZS teams failed in the design task—they were not able to produce a minimally acceptable product that could be evaluated. The second subsample ($N = 100$) consisted of a normally distributed curve of non-zero scores (NZS). The fundamental difference between these two sample subsets was that the NZS teams could function as a team at some minimal level, whereas, the ZS teams were total failures on the design task.

[3] Schmit and Ryan (1993) also address the applicability and the factor structure of the NEO-FFI test in a college-age sample.

The existence of two such distinct subgroups within the sample indicated that the relationships between the independent variables and the performance measure should be analyzed in two stages.

*3.5.1. Analysis A: Differences between successful and unsuccessful teams*

In the first analysis, comparisons were made between the teams in the NZS subset and the teams in the ZS subset for each independent variable (e.g., group gender type, and the composites and coefficients of variation for ability and personality) using a combination of MANOVAs and univariate ANOVAs (if warranted from the results of the MANOVA). These comparisons were made in order to determine if there were characteristics that distinguished successful teams (e.g., those in the NZS subset) from unsuccessful teams (e.g., those in the ZS subset). In addition, because of the high inter-correlations among the independent variables, a stepwise logistic regression (via SPSS software; Norusis, 1990a,b,c) was employed in order to ascertain the primary differentiating variables and the incremental value of personality over that of general cognitive ability in predicting the success of the teams.

*3.5.2. Analysis B: The relationship among the independent variables and team performance for successful teams*

Once the characteristics that differentiated the successful teams from the unsuccessful teams were established from the first analysis, the hypothesized relationships and the exploratory analyses proposed earlier between the independent variables (e.g., ability, personality, attitude and gender) and the team's performance were investigated for the successful teams.

Hypotheses 1–3 proposed the effect of a continuous independent variable (e.g., personality) on the continuous dependent variable (e.g., team performance). These hypotheses were tested using multiple regression.

Hypothesis 4 proposed that personality would provide incremental validity to the prediction of performance over that provided by ability. Stepwise regression analyses were done entering general cognitive ability on the first step followed by several combinations of personality variables (e.g., each composite personality factor by itself, each coefficient of variation by itself, the composite and coefficient of variation together for each of the five factors, the composites of the five factors together, the coefficients of variation for the five factors together, all composite and coefficients of variation).

Given the relatively new focus on selection criteria for team performance, a variety of exploratory correlation analyses were done investigating the relationships between the independent variables for which hypotheses were not offered (e.g., the heterogeneity of the team's general ability level; the personality factors of Agreeableness, Openness to Experience, and Neuroticism; and the heterogeneity of each of the 'Big Five' personality factors) and team performance.

## 4. Results

The means, standard deviations and inter-correlations for the independent variable composites and coefficients of variation are given in Table 1. Most of the personality

Table 1
Descriptives and inter-correlations for the independent variables

| | *N* | Mean | Coefficient of variation | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Conscientiousness | 88 | 101.7 | 0.19 | – | 0.06 | 0.32** | −0.02 | −0.07 | 0.03 | −0.29** |
| 2. Extraversion | 88 | 94.3 | 0.15 | 0.22* | – | 0.10 | 0.40** | −0.10 | 0.07 | 0.13 |
| 3. Neuroticism | 88 | 55.7 | 0.33 | −0.24* | −0.39** | – | 0.15 | 0.06 | −0.14 | −0.14 |
| 4. Agreeableness | 88 | 98.4 | 0.14 | 0.37** | 0.44** | −0.37** | – | −0.00 | 0.03 | 0.14 |
| 5. Openness to experience | 88 | 85.5 | 0.17 | 0.13 | 0.29** | −0.24** | 0.19 | – | −0.02 | 0.10 |
| 6. Cognitive ability | 87 | 67.7 | 0.13 | 0.13 | 0.12 | −0.26** | 0.25* | 0.25* | – | −0.11 |
| 7. Gender[a] | 99 | 0.62 | – | 0.24* | −0.13 | 0.17 | 0.13 | 0.18 | 0.11 | – |

Notes: Data are provided for teams in the NZS subset only. Inter-correlations among the independent variables' composites are presented in the lower triangle. Inter-correlations among the independent variables' coefficients of variation are presented in the upper triangle. Significance is reported using a two-tailed test.
[a]Gender is operationalized as the number of females on the team; $N_{x\ \text{females}}$ = number of teams with $x$ females on the team; $N_{0\ \text{females}} = 52$; $N_{1\ \text{female}} = 34$; $N_{2\ \text{females}} = 12$; $N_{3\ \text{females}} = 1$.
*$P < 0.05$; **$P < 0.01$.

Table 2
Descriptives for the independent variables

| | Mean | | Mean coefficient of variation | |
|---|---|---|---|---|
| | NZS subset | ZS subset | NZS subset | ZS subset |
| Conscientiousness | 101.7 | 96.5 | 0.14 | 0.18 |
| Extraversion | 94.3 *[a] | 86.5 *[a] | 0.14 | 0.16 |
| Neuroticism | 55.8 **[b] | 68.6 **[b] | 0.34 | 0.27 |
| Agreeableness | 98.4 **[c] | 89.7 **[c] | 0.13 | 0.13 |
| Openness to experience | 85.5 | 82.6 | 0.17 | 0.15 |
| Cognitive ability | 67.7 ** | 57.2 ** | 0.19 | 0.22 |

Notes: Variables for which the means differ between the NZS and ZS subsets are marked with the appropriate level of significance. NZS subset = non-zero scoring subset (e.g., successful subset). ZS subset = zero scoring subset (e.g., failing subset). Mean coefficient of variation = mean of the coefficients of variation in the corresponding subset. $N_{NZS} = 88–100$ and $N_{ZS} = 13–17$. The range of $N$s occurred because the variables differed in the number of missing values.

[a]The difference between the means of the NZS and ZS subsets are significant at the $P < 0.05$ level when general cognitive ability is controlled.

[b]The difference between the means of the NZS and ZS subsets are significant at the $P < 0.01$ level when general cognitive ability is controlled.

[c]The difference between the means of the NZS and ZS subsets are significant at the $P < 0.10$ level when general cognitive ability is controlled.

*$P < 0.05$; **$P < 0.01$.

composites are significantly inter-correlated ($r$'s up to 0.39). [4] Contrary to expectations, general cognitive ability is significantly correlated with three of the five personality factors (i.e., Neuroticism, Agreeableness and Openness to Experience).

### *4.1. Analysis A: Differences between successful and unsuccessful teams*

The differences between successful and unsuccessful teams on the independent variables are displayed in Table 2.

There was no significant difference between successful and unsuccessful teams with respect to the number of females on the team ($F(1, 114) = 1.74$; $P > 0.05$). Gender was therefore excluded from consideration in the remainder of Analysis A.

The results from a MANOVA ($F(8, 89) = 2.93$; $P < 0.01$) entering all of the independent variable composites suggested that there were significant differences between the NZS and ZS subgroups. More specifically, successful teams were characterized by higher composite levels of cognitive ability ($M_S = 67.7$ versus $M_U = 57.2$; $F(1, 96) = 12.9$; $P < 0.01$), higher Extraversion scores ($M_S = 94.3$ versus $M_U = 86.5$; $F(1, 96) = 6.2$; $P < 0.05$), higher Agreeableness scores ($M_S = 98.4$ versus $M_U = 89.7$; $F(1, 96) = 7.4$; $P < 0.01$), and lower Neuroticism scores ($M_S = 55.8$ versus $M_U = 68.6$; $F(1, 96) = 12.2$; $P < 0.01$) than their unsuccessful counterparts.

[4] Correlations among the five personality factors may be expected since some factors include facets with similar characterisitcs; see Appendix A for the facets associated with each factor.

Table 3
Correlations between the independent variables and performance for the NZS subset

| Composites | Group score | Coefficient of variation | Group score |
|---|---|---|---|
| Conscientiousness | 0.07 | Conscientiousness | −0.22* |
| Extraversion | 0.07 | Extraversion | −0.06 |
| Neuroticism | 0.01 | Neuroticism | −0.12 |
| Agreeableness | −0.02 | Agreeableness | −0.02 |
| Openness to experience | 0.03 | Openness to experience | −0.01 |
| Cognitive ability | −0.07 | Cognitive ability | −0.11 |

Notes: $N$ ranged from 81–95 teams for the correlations with group performance. There was a range of $N$s because the independent variables differed in the number of missing values.
* $P < 0.05$; * * $P < 0.01$.

Upon first glance, it seems as if there are many differences between the two subsets. However, these differences must be interpreted with caution because many of these variables are inter-correlated (Table 1). Given the high degree of inter-correlation ($r$'s up to 0.56) among the variables cited above (e.g., general cognitive ability, Agreeableness, Extraversion, and Neuroticism), a logistic regression was done in order to determine if there was a smaller subset of predictor variables that distinguished the successful from the unsuccessful teams. The composites and coefficients of variation of the independent variables were entered into a forward-stepwise logistic regression equation. After the stepwise regression, two variables were found to be the primary differentiating variables between successful and unsuccessful teams: the composite of general cognitive ability ($\chi^2 = 11.7$; $P < 0.01$), and the composite of Neuroticism ($\chi^2 = 7.3$; $P < 0.01$).

The MANOVA results for the heterogeneity measures of the independent variables were not significant. Therefore, these variables did not warrant further investigation in this analysis.

### *4.2. Analysis B: The relationships among the independent variables and team performance for successful teams*

The bivariate correlations between the independent variables and the performance criterion are given in Table 3. The gender composition was not significantly related to the team's performance score. Therefore, it was not necessary to control for the gender composition of the group in subsequent analyses.

Hypothesis 1, which postulated that the team's composite level of Conscientiousness would be positively related to the team's performance, was not supported ($\Delta R^2 = 0.02$; $P > 0.05$). However, in the exploratory analysis, the heterogeneity of Conscientiousness was found to be negatively and significantly correlated with the team's performance ($r = -0.22$; $P < 0.05$). [5] Furthermore, when all of the independent variables (e.g., both

[5] Previous arguments suggested that bivariate correlations should be interpreted with caution due to the high inter-correlations among the composites of the independent variables. However, the inter-correlations among the coefficients of variation (e.g., the heterogeneity measures) were not as strong as those found among the composites.

the composites and the coefficients of variation for all of the ability, personality and attitude variables) were entered into a stepwise regression equation with the group's performance score as the dependent variable, the heterogeneity of Conscientiousness was the only variable to share significant variance with the performance scores ($\Delta R^2 = 0.05$; $P < 0.05$). [6] However, a post-hoc regression analysis entering both the composite and the level of heterogeneity of Conscientiousness simultaneously as independent variables did not produce significant shared variance with performance ($\Delta R^2 = 0.05$; $P > 0.05$).

Hypothesis 2, which postulated that the composite level of Extraversion would be positively related to the actual performance of the team was not supported ($\Delta R^2 = 0.01$; $P > 0.05$). The heterogeneity of the team on the factor of Extraversion was also not significantly related to the team's subsequent performance ($r = -0.06$; $P > 0.05$). A post-hoc regression investigating the potential effect of the composite and heterogeneity measure of Extraversion on performance did not produce significant results.

Hypothesis 3, which predicted that the team's composite of Neuroticism would be negatively related to the team's performance was not supported ($\Delta R^2 = 0.00$; $P > 0.05$). In addition, the heterogeneity of team member scores on the factor of Neuroticism was not significantly related to performance ($r = -0.12$; $P > 0.05$). There was also no significant result obtained when both the composite and heterogeneity of Neuroticism were entered as independent variables.

Hypothesis 4, which proposed that personality would add incremental validity to the prediction of performance over that of cognitive ability was problematic. The composite of general cognitive ability was not found to be significantly related to the performance of successful teams ($\Delta R^2 = 0.02$; $P > 0.05$). Furthermore, no significant relationship was found between the teams' heterogeneity of ability scores and the team's subsequent performance ($r = -0.11$; $P > 0.05$). There was also no significant relationship between the teams' ability characteristics and the teams' performance when both the composite and the heterogeneity scores were considered together (e.g., simultaneously) in a regression equation. None of the composite measures of the personality variables in isolation, together with the other composites, or combined with the coefficients of variation added significant incremental validity to the prediction of performance. The only variable which contributed (and added significant incremental validity to the nonsignificant validity which cognitive ability provided) to the prediction of performance was the coefficient of variation on the factor of Conscientiousness ($\Delta R^2 = 0.05$; $P < 0.05$).

There were no significant relationships found between any measure of Agreeableness (e.g., the composite or the heterogeneity measure) and actual performance. The team members' levels of Openness to Experience was not found to relate to the actual performance of the team in any way.

[6] Incremental variance of $R = 0.05$ (when statistically significant) is also considered meaningful when discussing the use of personality as a potential predictor of performance.

## 5. Discussion

### 5.1. Personality as a selection measure

#### 5.1.1. Conscientiousness

The level of Conscientiousness a person possesses (e.g., the degree to which a person is dependable, purposeful and strong-willed) has been associated with increased task performance in the individual personnel selection literature (Barrick and Mount, 1991; Tett et al., 1994). It was therefore expected that the group's level of Conscientiousness would be related to the group's product performance. The lack of relationship between the composite of Conscientiousness and the team's performance was therefore surprising. One possible explanation for the apparent lack of relationship between the Conscientiousness composite and the team's performance may be that the subjects under investigation in this study were new students and that the result of the task was part of each student's mark in the course. The relative novelty of being a university student and the perceived consequences of not performing well may have caused most students to behave conscientiously while doing the task regardless of how they scored on the personality profile. Studies which follow design teams over a longer period of time need to be done in order to establish the long-term impact of Conscientiousness on performance.

The heterogeneity of Conscientiousness was found to be negatively and significantly related to the actual performance of the team. This finding is not surprising. People who score high on the Conscientiousness factor tend to be focused and achievement-oriented, while those scoring low on the factor may be more relaxed in applying the work ethic (Costa and McCrae, 1992). Thus, the negative relationship between the level of heterogeneity in the Consciousness factor and team performance might be attributable to conflict that arises among the team members with respect to the urgency or importance of the task at hand. For example, team members with a high-achievement orientation may have become frustrated with other team members who were more relaxed in the execution of the exercise. The differences in outlooks could have become apparent in a short time and may have distracted the team members from focusing on the task, or, prevented some members from cooperating with others. These feelings of frustration, or hostility towards other members, might have detracted from the team's ability to perform at an optimal level. This contention has received anecdotal evidence. In one company's experience with teams, the stress level of the team members significantly increased when there were members on the team who were reluctant to accept sufficient responsibility to complete the assigned task to the other team members' satisfaction. This, in turn, negatively affected performance (Flynn et al., 1990).

#### 5.1.2. Extraversion

Successful teams were found to score higher on the composite of Extraversion than were unsuccessful teams. This provides support for the earlier contention that the team's composite level of Extraversion is positively related to performance (e.g., teams must have some minimum level composite of Extraversion to be successful as a design team). However, in terms of potential predictive value, once the composite of Neuroticism is

considered, Extraversion does not add any value in differentiating successful from unsuccessful teams.

The composite of Extraversion was not found to be significantly related to the performance of successful teams. This finding is in direct contravention to the individual personnel selection literature which suggests that a person's level of Extraversion positively impacts performance in jobs where there is a large social component (e.g., Barrick and Mount, 1991), and from the small group literature which proposes that the team's level of Extraversion (or some facet of Extraversion such as dominance or sociability) should be positively related to the performance of the team. However, there are several possible reasons why the relationship between Extraversion and team performance was not observed.

First, although the design task in this study closely paralleled many aspects of 'real world' design processes, the time frame over which the exercise took place did not. It is therefore possible that the relationship expected between Extraversion and performance was not found because of the short duration of the exercise. That is, the teams' levels of Extraversion did not have a chance to be manifested in performance differences.

Second, the expectation derived from the individual personnel literature and the small group literature that Extraversion would affect team performance may not have been warranted. The bridge-building exercise used in this study was classified as an 'optimizing' task because the mandate of the team was to maximize the value of their product (e.g., build a bridge that would attain the maximum number of points when evaluated in terms of a pre-defined scoring guide). Although the overall task was to build an optimal bridge, this required the team to engage in a series of different subtasks. First, the team had to define a design strategy that would accomplish their mandate. This initial phase required frequent social interaction in order to evaluate alternate design ideas. The first part of the process was therefore akin to both an 'optimizing' task as defined in the small group literature, and a 'social' occupation as defined by the personnel selection literature. Similar to a 'real life' design process where prototypes are built in order to assess the feasibility of the final design, the design teams in this exercise were required to build the bridge they designed. This prototype building may be thought of as a 'mechanical' task (as defined by Driskell et al., 1987). Thus, although the product of the design process (e.g., the 'optimal' product) would suggest that the design process should be classified as an 'optimizing' task, the design process is really best described as an optimizing process which consists of a combination of task types (e.g., optimizing, social and mechanical). Much of the literature in the small group studies used tasks which could be neatly classified into a single task category (e.g., 'optimizing', 'social', etc.). Thus, the application of these results to the design process are somewhat problematic. Driskell et al. (1987) hypothesized that 'sociability' (which is part of Extraversion) is positively correlated with team performance on social tasks, negatively correlated with team performance on mechanical tasks, and has no significant relationship with the performance of optimizing tasks in a team setting. Further, they contend that 'ambition' (which they also contend to be part of Extraversion) is positively related to team performance on optimizing and mechanical tasks, but has no relationship to social tasks. It becomes apparent that when the design process is artificially factored into the traditional task categories used in the small group literature that the information

available relating personality to team performance becomes very confusing and of questionable usefulness. Future research should therefore focus on commonly performed tasks/processes (such as design processes) that occur in the workplace, or realistic approximations of these tasks (such as the one used in this study).

A third possibility is that the relationship between Extraversion and the performance of successful teams is more complex (e.g., not linear) than the one investigated in this study. The effect of Extraversion on performance may also depend on the combination of the team members' levels on this factor, although a regression equation entering both the composite and standard deviation of the groups' Extraversion scores as a function of actual performance did not show any significant relationships.

*5.1.3. Neuroticism*

Successful and unsuccessful teams differed substantially on the factor of Neuroticism. The composite of Neuroticism was the only factor to add incremental validity to the prediction of team success (e.g., ZS versus NZS status) over that provided by the composite of general cognitive ability. However, neither the composite nor the heterogeneity measure of Neuroticism was found to be predictive of team performance in teams capable of minimal performance (e.g., the NZS subset).

The above findings are in line with the 'threshold' hypothesis proposed by researchers in the individual personnel selection literature (Barrick and Mount, 1991). That is, there is a minimal level of Emotional Stability (e.g., low scores on the Neuroticism factor) that is necessary for adequate functioning on the job, however, after this minimum level is attained, there is no relationship between incremental amounts of Emotional Stability over and above this threshold and performance.

The results from this study are also somewhat supportive of the proposition from some early studies in the small group literature that a high level of Neuroticism is associated with poor performance.

*5.1.4. Agreeableness*

The composite of Agreeableness was found to be significantly higher in the NZS subset than the ZS subset, however, once the effects of Neuroticism and cognitive ability were considered, the significance of this difference disappeared.

The lack of relationship between any measure of Agreeableness and the outcome variables for the groups in the NZS subset is in keeping with the lack of previous substantive evidence in both the small group and individual personnel selection literature linking this variable with task/job performance. Thus, the factor of Agreeableness does not seem to be related to team performance for teams that are capable of adequate performance.

*5.1.5. Openness to experience*

No relationship was found between the factor of Openness to Experience and team performance. This lack of relationship may be characteristic of this task which was very focused (e.g., the problem was already identified and the performance criteria already discerned). Openness to Experience may be more influential on performance if the task requires creativity or tackling an abstract problem (Driskell et al., 1987).

### 5.2. The potential incremental validity of personality as a selection measure

The personality factor of Neuroticism provided incremental validity over that provided by ability in differentiating successful from unsuccessful teams which provided partial support for the contention that personality might have value as an incremental predictor of team performance over established measures such as general cognitive ability. However, in successful teams, this contention was problematic to test. The composite of general cognitive ability appeared to have a 'threshold' relationship with team performance. That is, some minimum level of general cognitive ability was necessary in order for a team to be minimally successful (e.g., satisfy the basic constraints of the task), however, once a team had the composite ability necessary to achieve success, general cognitive ability was not related to increments in the team's performance. As was found previously in this study, the heterogeneity of Conscientiousness (i.e., the coefficient of variation of Conscientiousness) was the only personality variable found to contribute to the variance in team performance.

The lack of relationship between general cognitive ability and performance in successful teams was surprising, however, there is a logical explanation for this result. According to Jensen (1993), the substantial variance in performance accounted for by general cognitive ability in higher level occupations may manifest itself in terms of a threshold variable for entry. In other words, if the design task used in this study was a 'higher level task' (e.g., representative of higher level occupations), a threshold relationship, instead of a linear relationship between general cognitive ability and team performance should have been expected. The classification of the bridge building exercise as a 'higher level task' receives some support from the data in this study. The mean score of the successful teams' average level of ability (e.g., composite ability divided by the number of members) was higher than the population average on the factor of general cognitive ability. [7] It could therefore be argued that the bridge building exercise was a complex task requiring above average ability levels to complete, and as such, the threshold relationship found in this study between cognitive ability and performance is exactly what should have been expected. [8]

### 5.3. Summary: Groundwork for a model

The task that the teams were asked to perform was of a very short duration. As mentioned above, some of the relationships that may exist between team member

[7] In order to compare the 'level' of cognitive ability that successful and unsuccessful teams exhibited with the population norms provided in the Wonderlic Personnel Test (1992), the teams' average scores were used (e.g., the team's composite of cognitive ability divided by the number of team members). The mean of the teams' scores for the successful team subset was 22.6. The population average score on the factor of general cognitive ability was 21.

[8] The composite of general cognitive ability accounted for approximately 11% of the variance in the classification of teams into 'successful' and 'unsuccessful' status.

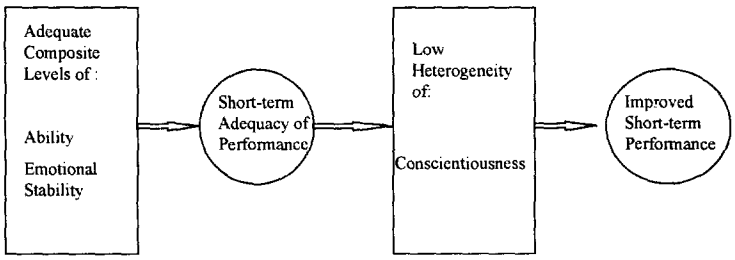


Fig. 1. Preliminary model relating group-level ability and personality to team performance.

personalities and the performance of the team may not have had a chance to emerge. However, even in this very short time period, it became apparent that some teams were not able to function at a minimally acceptable level (e.g., those teams in the ZS subset). The differences in personality and ability that were found between the successful and unsuccessful teams may indicate that there are certain characteristics that the team must exhibit in order to surpass a critical period at the beginning of the team's life in which immediate failure is possible.

As diagrammed in Fig. 1, it is proposed that the survival of the team depends on the team's ability to overcome short-term obstacles in order to function adequately. In order to attain short-term adequacy, the team members together (e.g., the composite of individual team member scores) must have an adequate level of ability to do the task, and must display adequately low levels of Neuroticism to function as a team. Of course 'adequate levels' must be further defined. Once the team has achieved short-term adequacy, the heterogeneity of the team on the factor of Conscientiousness seems to be negatively related to increments in successful performance.

## 6. Implications and directions for future research

Given the exploratory nature of this study, it is premature to suggest rules for selecting successful teams. However, the findings from this study do suggest that the ability and personality tests currently used in individual personnel selection may have some applicability to the selection of teams. It is possible that a combination of ability and personality factors may be useful in selecting the appropriate combination of team members in order to avert failure. Furthermore, it is possible that some personality characteristics (e.g., heterogeneity of Conscientiousness) may relate to decrements in performance for teams that achieve initial success. Although the current results are promising, future research is required to address some of the limitations of the present study.

First, the variables of ability and personality should be examined as predictors of performance for design teams that are engaged in projects over a longer time period. The short duration of the task used here may not have provided adequate time for some personality combinations to be manifested in performance differences. It is therefore recommended that more involved design projects that require the team to exist over an extended time period be used to verify the results obtained.

The advantage of using a laboratory design for exploratory team research minimizes the effect of other potentially confounding variables (e.g., status differences, organizational politics) so that any relationship between the independent and dependent variables may be isolated to a greater degree than is possible in a field environment (Driskell and Salas, 1992). However, there are also arguments that may be made with respect to limitations in the generalizability of the results as a result of the simplification of the situation, including the characteristics of the task. The 'bridge-building' task that was used in this study, although not as complex as many design problems found in organizational settings, was of sufficient difficulty to differentiate between successful and unsuccessful teams. The design task also had many characteristics similar to a design situation in the workplace. Specifically, in order to be successful at this task, the team had to satisfy many constraints, strategize how to maximize performance (i.e., points), allocate resources, and perform under time pressure. Although the results suggest some relationships for future research, in order for these preliminary results to generalize to organizational design teams, studies need to be taken from the laboratory environment into actual organizations where other 'real life' variables (e.g., organizational politics, reward systems, status differences, experience differences) impact on the team's ability to succeed in addition to personality. This will allow us to determine if the team's personality combination is still a major factor in determining the team's success when other factors are present.

There are several potential limitations with respect to the generalizability of the results from this research which stem from the fact that a student sample was used. The first concern relates to the suitability of Engineering students as proxies for actual Engineers. However, this is not thought to be a big limitation. The focus of this research was on Engineering Design teams which were responsible for the design of a product. The use of Engineering students is an acceptable proxy for actual Engineers because these students are the future Engineers to which organizations may apply the results found in this and similar studies examining the effect of personal characteristics on the performance of Engineering Design teams.

Another concern about using a university student sample is potential restriction of range on the factor of ability. However, surprisingly, the sample used in this study did not differ from the population norms to the extent that might have been expected. The student sample scored slightly higher, on average than the population norm (e.g., student ability score average = 22.3 versus population norm = 21.1), however, the distribution of scores in the student sample were not different enough from the population norms (e.g., student sample: Q1 = 18, Median = 22, Q3 = 26; Population norm: Q1 = 16, Median = 21, Q3 = 26) to warrant much concern with respect to restriction of range.

Another potential problem with using a student sample is that the students may not take the exercise seriously, or may try to influence the results of the experiment. However, neither concern was thought to play a large role in the results obtained. This study took place in the first week of classes in the first year of university. The design exercise was also mandatory as part of the course and worth a substantial (i.e., 10%) part of their mark. Therefore, it is likely that students were motivated to perform the task to the best of their abilities. Although it is possible that the students did not take the ability and/or personality testing seriously, or tried to influence the results of the experiment,

this is not thought to be likely. There was widespread interest in the results from the ability and personality tests—most notably, students were very concerned how they scored on the ability test relative to their classmates and wanted to learn about strategies to improve their scores in the future. There was also widespread interest in the interpretation of the personality test results. As well, participation in writing the ability and personality tests was completely voluntary. If students did not want to 'waste their time' they were not required to do so. It is also not likely that the students tried to influence the results of the experiment since they were not privy to the research questions prior to the design exercise.

Although the limitations to the generalizability of the results from the use of a student sample were thought to be minimal, future research should be done using actual Engineers to ensure the applicability of the results.

The applicability of the results obtained in this study may be limited to design tasks or to similar optimizing tasks. As mentioned previously, personality combinations that affect team success may be dependent on the team's task (Driskell et al., 1987). Therefore, in order to develop a 'personality map' for team success, team personality combinations need to be investigated for other types of tasks.

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## Appendix A

| The Big Five personality factors | Facets associated with each factor |
|---|---|
| Neuroticism | Anxiety |
| | Angry hostility |
| | Depression |
| | Self-consciousness |
| | Impulsiveness |
| | Vulnerability |
| Extraversion | Warmth |
| | Gregariousness |
| | Assertiveness |
| | Activity |
| | Excitement-seeking |
| | Positive emotions |
| Openness to experience | Fantasy |
| | Aesthetics |
| | Feelings |
| | Actions |
| | Ideas |
| | Values |

| | |
|---|---|
| Agreeableness | Trust |
| | Straightforwardness |
| | Altruism |
| | Compliance |
| | Modesty |
| | Tender-mindedness |
| Conscientiousness | Competence |
| | Order |
| | Dutifulness |
| | Achievement striving |
| | Self-discipline |
| | Deliberation |

Note: Facets for each factor are defined as per Costa and McCrae, 1992.

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