Design teams and personality : effects of team composition on processes and effectiveness

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Effects of Team Composition on Processes and Effectiveness

Miranda Peeters

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Peeters-Baars, Maria Adriana Gerarda

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Miranda

Contents

Chapter 1

Introduction

'The ideal engineer is a composite ... He is not a scientist, he is not a mathematician, he is not a sociologist or a writer; but he may use the knowledge and techniques of any or all of these disciplines in solving engineering problems.'

N. W. Dougherty, 1955

'Teamwork is so important that it is virtually impossible for you to reach the heights of your capabilities or make the money that you want without becoming very good at it.'

Brian Tracy

Technology has considerably gained in complexity since the year Dougherty expressed his thought. Nowadays, it is hardly possible anymore for a single engineer to possess all relevant disciplinary knowledge and single-handedly integrate it to come up with successful technological designs. Organizations have acknowledged this and embraced the quotation made by Brian Tracy when extrapolating Dougherty's words to groups of engineers with the result that multidisciplinary design teams are common practice in technological organizations these days. In addition to their disciplinary knowledge and skills, design team members also bring other personal characteristics, such as personality, into the team. The diversity this creates in a design team is what sets the stage for interesting, but potentially

problematic design processes in design projects. So, the question arising from this development is:

> *What are desirable personality characteristics of engineers who need to function in multidisciplinary design teams in order for these teams to be effective?*

Or, put differently:

> *How should design teams be composed in terms of team member personality so that a process emerges that leads to a good design*?

This question is central to the research presented in this dissertation.

Relationships between design team member personality, design processes, and design team effectiveness were researched based on an input-process-output model of team effectiveness (Hackman, 1975). The input-process-output research model that underlies the research in this dissertation is presented in Figure 1.1. The model implies that team composition in terms of personality (inputs) affects design processes (processes), as well as design team effectiveness (outputs). Furthermore, design processes and design team effectiveness have a reciprocal effect on each other (Hackman, 1975). Considering the iterative character of the design process, in which sub results of the design process strongly determine the ultimate design team's effectiveness, this input-process-output model seems appropriate when researching relationships between design team composition in terms of personality, design team member process behaviors, and design team effectiveness.

The main contribution of this research lies in the fact that it studies relationships between team composition in terms of design team member personality, design processes, and design team effectiveness which has not been done integrally before. Additional contributions of the research presented in this dissertation are offered by means of sub research questions regarding specific parts or relationships in the research model. These are presented in the companion sections. The following topics are subsequently addressed. The type of teams studied is described in Section 1.1, (design) team composition in terms of

team member personality is discussed in Section 1.2, design processes are discussed in Section 1.3, and (design) team effectiveness is discussed in Section 1.4. In Section 1.5, an overview of the dissertation is presented by discussing the way in which relationships presented in the research model were researched.

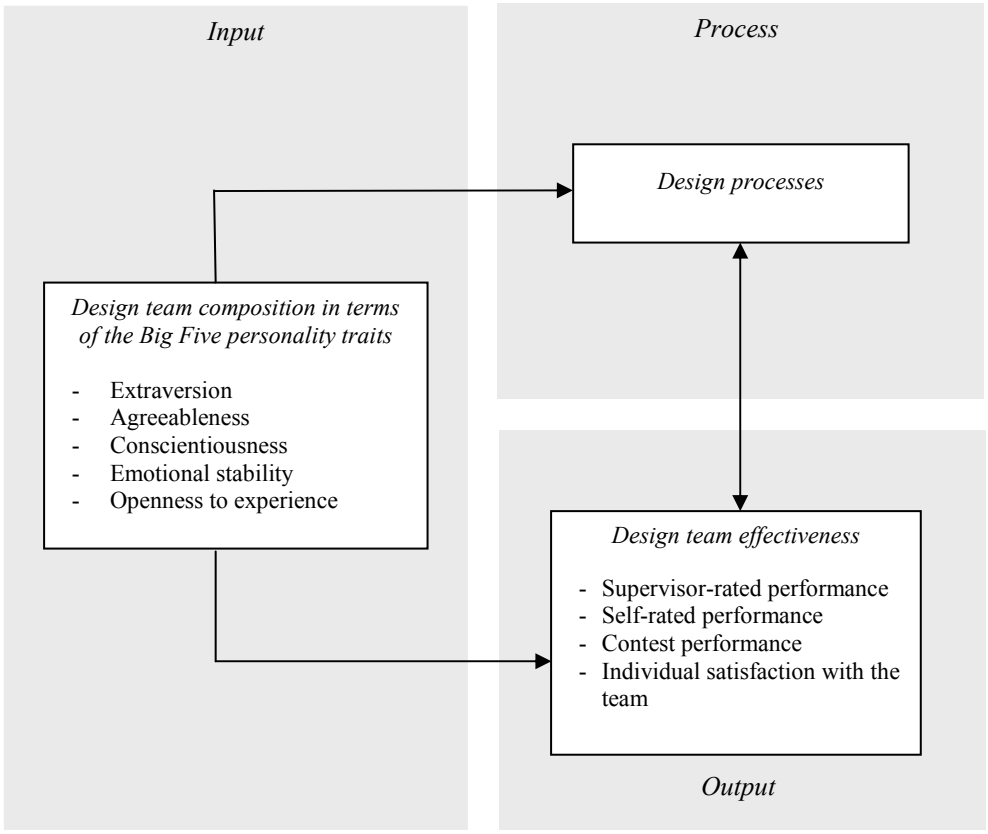

Figure 1.1 The Research Model

1.1 Type of Team studied

In the world around us, there are many types of team (f.i., hobby teams, sport teams), but in this research the focus is on (student and professional) work teams and in particular on (student and professional) multidisciplinary design teams. A work team is generally defined as 'a group of individuals who see themselves and are seen by others as a social entity, who are interdependent because of the task they perform as members of a group, who are embedded in one or more social systems, and who perform a task that affects others'

(Guzzo & Dickson, 1996; pp. 308-309). Both the professional and student teams that were included in this study fit this definition. Moreover, given the boundary conditions of their work, the design teams that were studied can be considered as a specific type of work team, namely a project team. The task project teams perform is complex and it requires a specific output by a certain deadline. Since the task is complex, it requires coordination of the team members: they work on multiple sub tasks the results of which need to be integrated, and the temporal flow of these sub task activities needs to be regulated in order to deliver the design on time. To do so, project teams typically have a high degree of autonomy (Janicik & Bartel, 2003). The definition of project teams applies to the (professional and student) design teams under study, but with minor deviations. These are addressed below.

Professional design teams under study were interdependent groups of engineers that were embedded within an organization and organizational sub structures (e.g., divisions, departments). They had to come up with innovative or incremental designs for the market their organization operates in. Given the teams' multidisciplinary composition, team members worked on disciplinary sub tasks with a substantial amount of autonomy. However, the coordination of task completion was often assigned to a project leader, who monitored progress and regulated it in mutual consultation with the team (members).

Student design teams under study were also interdependent groups of students of engineering, but they were mainly embedded within their education programs at the university, although a sub sample of these teams also did their design work within an organizational context. These teams had to come up with innovative or incremental designs for organizations or for contest purposes. Almost half of the student teams under study were multidisciplinary; in all teams team members worked on sub tasks. All student teams were self-managed, so they had complete autonomy over their design work.

1.2 Team Composition in Terms of Personality

The focus in this dissertation is on the effects of design team member personality and team composition in terms of personality. Nowadays, a well-accepted framework with which to describe personality is the Five-Factor Model of personality, also known as the Big Five (Digman, 1989, 1990; McCrae & Costa, 1989; McCrae & John, 1992). Within this framework a person's personality is described by the five factors *extraversion*,

agreeableness, *conscientiousness*, *emotional stability*, and *openness to experience*. Each of these factors predisposes a person to behave in a certain way (Robertson & Callinan, 1998) and research has shown that the factors remain relatively stable over time and situations (Costa & McCrae, 1992, 1988). The five factors, or traits, are described in behavioral terms (McCrae & Costa, 1985). Extraversion is associated with behaviors like being sociable, gregarious, assertive, and active. Agreeableness is associated with behaviors like being courteous, flexible, trusting, good-natured, forgiving, soft-hearted, and tolerant. Behaviors associated with conscientiousness are being careful, thorough, responsible, organized, planful, hardworking, achievement-oriented, and persevering. Emotional stability is related to behaviors like being calm, poised, and secure. The opposite of emotional stability, which is also frequently used by researchers, is known as neuroticism, and is associated with behaviors like being anxious, depressed, angry, embarrassed, emotional, worried, and insecure. Finally, behaviors related to openness to experience are being imaginative, curious, cultured, original, broad-minded, intelligent, and artistically sensitive.

Within team composition research, team member trait scores are aggregated (to team mean-, variance-, standard deviation-, minimum-, or maximum scores or proportions of high or low scoring team members) in order to represent team composition in terms of personality. In line with previous research, effects of team mean and variance scores were studied in this dissertation. However, these single-trait operationalizations may not be representative of the pattern of effects the combination of team member personalities can be expected to have. Scholars in the field of team composition research (McGrath, 1998; Kozlowski & Klein, 2000) recommend to use more refined and complete operationalizations to reflect team composition in terms of personality.

As the Big Five personality traits have been shown to be related to (a) individual performance (e.g., Hurtz & Donovan, 2002), and (b) team composition in terms of the Big Five personality traits to team performance (e.g., Barrick, Stewart, Neubert, & Mount, 1998), as well as to (c) design team performance (Kickuk, 1999), the Big Five personality traits were selected as team member characteristics to be studied.

The research questions that are addressed regarding effects of team composition in terms of the Big Five personality traits are:

Research question 1: What are the most important Big Five team composition variables to be studied with regard to team performance?
Research question 2: Can team composition measures be refined such that the effects of the patterns of personalities of team members on team outcomes can be studied?
Research question 3: How does design team composition in terms of the Big Five personality traits relate to design team member process behaviors?
Research question 4: Are relationships between team composition in terms of personality different for different outcomes of design team work?

1.3 Design Processes

Previous research has shown a number of relevant aspects of design processes that take place within (multidisciplinary) design teams (e.g., Cross & Clayburn-Cross, 1996; Eckert & Stacey, 2001; Stempfle & Badke-Schaub, 2002; Stumpf & McDonnell, 2002; Valkenburg, 2000). These studies may not have done complete justice to the complexity of designing in teams in the sense that only isolated aspects of the design process were studied. In our view, the design process has to be studied more integrally. To arrive at a more integrated perspective, a task analysis on designing in multidisciplinary teams was performed in order to determine the combined design team member behaviors that are important throughout the design process. The research question on which this task analysis was based was:

What specific design process behaviors of team members of multidisciplinary teams are critical in order to establish favorable dynamics during designing, thereby resulting in successful completion of the design task?

Using the results from this study, relationships addressed in the third research question presented in Section 1.2 can be researched.

1.4 Design Team Effectiveness

McGrath (1984) distinguished between performance-related and other (e.g., person-related) outcomes of teamwork. To arrive at a comprehensive picture of effects of how team members' personalities and their design process behaviors relate to design team effectiveness, both kinds of outcomes are considered in this dissertation. For the effectiveness of teams in general, *supervisor-rated performance* was researched (as is most commonly done in team effectiveness research (e.g., Barrick, Stewart, Neubert & Mount (1998)). This outcome was also researched for design team performance in particular. Additional design team performance outcomes varied from objective (*contest results*) to subjective (*self-rated performance*). A newly introduced personal outcome of the design teamwork that was researched is *individual satisfaction with the team*. These outcomes can be used to research relationships addressed in the fourth research question presented in Section 1.2.

1.5 Overview of this Dissertation

To study relationships in the research model (Figure 1.1), the following studies have been conducted. To delineate which team member personality traits affect the performance of teams in general, a meta-analysis on the relationship between team composition in terms of the Big Five personality traits and supervisor-rated team performance has been conducted in the study that is presented in Chapter 2. In the study presented in Chapter 3, the issue of different operationalizations of team composition in terms of personality was addressed. To be able to capture effects of patterns of personality within a team, team composition in terms of personality was operationalized in terms of differences between team members on personality traits. An individual team member's distance toward other team members on each of the Big Five traits was related to a personal outcome of design team work, namely, individual satisfaction with the team. This provides a first test of the input-output relationship depicted in the research model (Figure 1.1). To detail the design processes box, the two sub studies presented in Chapter 4 were conducted. In the first study, a task analysis was performed by interviewing professional multidisciplinary design team members and categorizing their responses according to the Critical Incident Technique (Flanagan, 1954). In the second study, a subset of the design behavior scales that resulted from the task

analysis, relevant to designing that takes place in innovative student design teams, was tested for content, structure, stability, and reliability.

Elements of studies presented in Chapters 2, 3, and 4 were integrated in the study presented in Chapter 5, as they were used to specify the research model. The inputs were limited to those that appeared relevant on the basis of the meta-analysis. Furthermore, team composition in terms of personality was operationalized by aggregating the individual operationalizations that resulted from the study presented in Chapter 3. The design process measurement scales that resulted from the studies presented in Chapter 4 were used to detail the process box of the research model. The research model was tested by relating specified inputs and processes to three types of outcome: supervisor-rated performance, self-rated performance, and contest results.

In the final chapter of this dissertation, I reflected upon (a) results regarding relationships between team composition in terms of personality and team outcomes and (b) results regarding relationships between team composition in terms of personality and design processes. Based on this reflection, I presented suggestions for future research of this type. In conclusion, I presented an answer to the research questions by discussing implications of the results presented in this dissertation for design team practice and education.

Chapter 2

Personality and Team Performance: A Meta-Analysis [*]

Using a meta-analytical procedure, the relationship between team composition in terms of the Big Five personality traits (trait elevation and variability) and team performance were researched. The number of teams upon which analyses were performed ranged from 106 to 527. For the total sample, significant effects were found for elevation in agreeableness (ρ=.24) and conscientiousness (ρ=.20), and for variability in agreeableness (ρ=-.12) and conscientiousness (ρ=-.24). Moderation by type of team was tested for professional teams versus student teams. Moderation results for agreeableness and conscientiousness were in line with the total sample results. However, student and professional teams differed in effects for emotional stability and openness to experience. Based on these results, suggestions for future team composition research are presented.

Teamwork appears to be the trend within many organizations (e.g., West, Borill & Unsworth, 1998; West, 1996a). The rationale behind structuring work into teams is that the combination of complementary employee skills, knowledge, attitudes, and other characteristics will result in optimal achievement of organizational goals. Scholars set out to find out whether this rationale actually holds true, focusing on teamwork and its effects.

[*] This chapter is based on: Peeters, M. A. G., Van Tuijl, H. F. J. M., Rutte, C. G., & Reymen, I. M. M. J. (*in press*). Personality and team performance: A meta-analysis. *European Journal of Personality.*

One of the research topics they addressed was, and still is, the relationship between team composition in terms of personality and team effectivity.

This line of research --along with other personality research-- substantially gained from the consensual attainment of the conceptual and measurement framework for the personality construct: the "Five-Factor Model" of personality, or the so-called "Big Five" (Digman, 1989, 1990; McCrae & Costa, 1989; McCrae & John, 1992). Since the origination of this framework (e.g., Goldberg, 1983; 1990), the number of studies dedicated to the relationship between team composition in terms of Big Five personality traits and team effectiveness has slowly mounted. Although each of the previously conducted studies provided a unique contribution to the scientific literature, future research in this respect would greatly benefit from a meta-analysis that systematically assesses and integrates results obtained so far. Not only would such a meta-analysis enlarge our understanding of how team composition in terms of team member personality influences team effectivity, it would also provide insight into what research questions will have to be addressed in the future (cf. De Fruyt & Salgado, 2003). Therefore, the aim of this study is (a) to provide a meta-analytical answer to the question: How is team composition in terms of personality related to team performance?, and (b) to signal directions for future research.

The structure of this chapter is as follows. First, the criterion measure team performance is discussed. Subsequently, the predictor measures are discussed: the Big Five personality traits are defined, the operationalization of team composition in terms of the Big Five personality traits is discussed, and for each operationalization of each of the five traits, expectations and results regarding their effect on team performance are discussed, always ending with the presentation of trait-specific expectations for the meta-analysis. Next, the expected moderation is discussed. In the method section, the literature search method, the criteria for inclusion of the studies, and the method via which we conducted the meta-analysis are explicated. Subsequently, results are presented, culminating in a discussion of what these results tell us about what future research is needed with respect to the relationship between team composition in terms of personality and team performance.

2.1 Criterion Measure: Team Performance

Team performance is generally represented by a subjective rating of a team by their instructors (student teams) or supervisors (professional teams). These ratings are made at the team level for a number of task relevant dimensions (including quality, quantity, planning and timeliness of the work, and aspects of communication within the team) and are then combined in a composite score. The relationship between the team and the rater can be different. Some teams work closely together with the supervisor (English, Griffith & Steelman, 2004; Van Vianen & De Dreu, 2001), whereas other supervisors are more independent of the team (Kichuk, 1999). In an effort to diminish subjectivity, some researchers included supervisory ratings on objective aspects of the team product in their measure of team performance (Kichuk, 1999; Neuman, Wagner & Christiansen, 1999), or they had multiple raters with different backgrounds determine the team's performance (Kichuk, 1999; Mohammed & Angell, 2003; Neuman et al., 1999; Neuman & Wright, 1999). Only in experimental studies were objective measures used to describe the team's performance (Graziano, Hair & Finch, 1997; Le Pine, 2003).

Common to the majority of team performance ratings is that they are task specific and that they have been made by a supervisor or instructor at the team level. All studies with such a team performance rating will be included in our meta-analysis.

2.2 Predictor Measures

Definition of the Big Five Personality Traits

The Big Five framework of personality distinguishes five factors: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience (De Raad, 2000; McCrae & John, 1992; Wiggins, 1996). The premise of the framework is that the factors remain stable and consistent over time and situations, and that each factor predisposes a person to behave in a certain way (Robertson & Callinan, 1998). Each of these traits can be described by a number of behavioral terms. Here, only exemplary behavioral terms will be presented (for complete descriptions see e.g., Costa & McCrae, 1992; Hendriks, Hofstee & De Raad, 1999). Extraversion refers to the extent to which a person is social and talkative. Agreeableness refers to the extent to which a person is gentle and cooperative. Conscientiousness refers to the extent to which a person is self-disciplined

and organized. Emotional stability refers to the extent to which a person is calm and poised, and finally, openness to experience refers to the extent to which a person is imaginative and curious. Every person's personality can be described in terms of these five traits and, as presumed, a person's personality remains relatively stable over time and across situations (Hofstee, Kiers, De Raad, Goldberg & Ostendorf, 1997; John & Srivastava, 1999; McCrae & Costa, 1997). Furthermore, factor- and content analyses of differential measurements of the Big Five consistently replicate the underlying five-factor structure (John, 1990; Mount & Barrick, 1995).

Within each of the five traits a number of facets are distinguished. Saucier and Ostendorf (1999) delineated 18 of them in large English and German samples. Nevertheless, both the number and method of measurement of facets vary per instrument. To name two well-known instruments: the NEO-PI-R distinguishes six facets per trait (Costa & McCrae, 1992), each of which is measured by eight questions, whereas the Five-Factor Personality Inventory (Hendriks et al., 1999) distinguishes 81 blends of positive and negative poles of the primary factors in so-called circumplex models. Since there is a large number of facets and because of the differential measurement and definition of the facets, research into team composition in terms of personality is usually limited to the Big Five traits.

The implication of the foregoing for our meta-analysis is that we will only include studies that used the Big Five framework to measure personality. Furthermore, we will restrict ourselves to the effects of traits, since results of the facets within each trait are hardly available and difficult to compare.

The Operationalization of Team Composition in Terms of Personality

To be able to study the effects of personality within a team, researchers have to convert individual personality trait scores into a measure that represents team composition in terms of personality. Almost all researchers distinguish between two characteristics of the team composition in terms of personality: the *elevation* and the *variability* of a certain trait within a team (Barrick, Stewart, Neubert & Mount, 1998, Kichuk & Wiesner, 1998; Mohammed & Angell, 2003; Neuman et al., 1999; Van Vianen & De Dreu, 2001). Trait elevation is calculated by the averaged or summed individual scores for a trait, or by the

proportion of high scoring individuals on a trait. Trait variability is represented by a team's variance or standard deviation score for a certain trait. Trait elevation and trait variability are generally negatively correlated[1], but in the majority of studies, these correlations are only significant for agreeableness and conscientiousness. Barrick et al. (1998) cited that historically also the minimum and maximum scoring team members per trait were taken into consideration when studying the effects of team composition in terms of personality, but only few researchers used these operationalizations (Barrick et al., 1998; Le Pine, 2003; Van Vianen & De Dreu, 2001).

Given the fact that the predominant operationalizations of team composition in terms of personality used up till now are trait elevation and trait variability, we will perform our meta-analysis upon both of them.

2.3 Hypotheses

We built our hypotheses for trait elevation and variability on both expectations described in research so far, and on the extent to which there is empirical support for these expectations. It is remarkable that a lot of hypothesizing has been done so far, but only few results are available to empirically underscore these expectations. Per trait we discuss (a) expectations about elevation, (b) results about elevation, (c) expectations about variability, (d) results about variability, and we conclude each section with (e) the presentation of our hypotheses for the meta-analysis.

Extraversion

With regard to the elevation of extraversion, researchers acknowledge extraversion to be important for a smooth functioning of the social mechanisms within a team, since it is by description strongly linked to intra-team processes or contextual performance (i.e. performance regarding the social and motivational context in which a team operates (Borman & Motowidlo, 1993)). With regard to effects of elevation of extraversion,

[1] The correlation between trait elevation and trait variability was found for extraversion, agreeableness, conscientiousness and emotional stability in five studies, and for openness to experience in three. The weighted average correlations are: extraversion -.08, agreeableness -.36, conscientiousness -.22, emotional stability .01, and openness to experience -.26.

researchers propose different hypotheses. On the one hand, extraverts are talkative, outgoing, enthusiastic, energetic, optimistic, and assertive (Costa & McCrae, 1992), and researchers expect these characteristics to result in a positive attitude toward teamwork (Barrick et al., 1998; Barry & Stewart, 1997) and high performance expectations (Barry & Stewart, 1997). Furthermore, extraverts in a team are expected to stimulate discussion (Mohammed & Angell, 2003; Taggar, 2002) and their attitude should foster a climate in which team members feel free to express themselves (Barry & Stewart, 1997). This freedom of expression is critical for the quality of the decisions the team will have to make with regard to the task (Schultz, Ketrow & Urban, 1995). On the other hand, researchers also express caution over the inclusion of too many extraverts in a team, since this may harm the team's effectiveness. Extraverts may be expected to like to work within a team merely for the possibility of social interaction this offers them (Neuman et al., 1999). This focus on pleasurable social interaction is expected to distract their attention from task completion (Barry & Stewart, 1997; Mohammed & Angell, 2003). Furthermore, because of their talkativeness and assertiveness, extraverts tend to be dominant (Kichuk & Wiesner, 1998). Researchers expect that a team that is composed of too many dominant individuals will likely engage in conflict over team issues (Mazur, 1973), like, for instance, leadership (Barry & Stewart, 1997; Mohammed & Angell, 2003). So the expectations concerning elevation of extraversion are mixed, which leads researchers to expect a curvilinear effect of extraversion elevation on team effectiveness. Results of Barry and Stewart (1997) indeed showed that intermediate levels of the elevation of extraversion within a team lead to high team performance.

The emphasis of researchers on either positive or negative effects of the elevation of extraversion at the same time forms the basis for the expectation of a positive effect of variability in extraversion. This expectation is supported by findings by Neuman et al. (1999).

Since we cannot research curvilinear effects meta-analytically and since curvilinear elevation effects counterbalance each other, we only expect variability in extraversion to be related to team performance. Therefore we propose the following hypotheses:

Hypothesis 1a: Elevation of extraversion is not related to team performance.

Hypothesis 1b: Variability in extraversion is positively related to team performance.

Agreeableness

Elevation in agreeableness is, without exception, expected to be positively related to team effectiveness. As with extraversion, the effect of agreeableness is expected to manifest itself through its favorable effect on team processes or contextual performance. Team members high in agreeableness are friendly, tolerant, helpful, altruistic, modest, trusted, straightforward (Costa & McCrae, 1992), and non-competitive (Graziano, Hair & Finch, 1997). Researchers expect these characteristics to facilitate interpersonal attraction (Neuman & Wright, 1999) and thus cooperation (Barrick et al. 1998; Neuman & Wright, 1999; Mohammed, Mathieu & Bartlett, 2002; Taggar, 2002), smooth conflict resolution (Barrick et al., 1998; Neuman & Wright, 1999; Taggar, 2002), open communication (Neuman & Wright, 1999), information-seeking (Taggar, 2002), compliance with team goals, and task cohesion (Van Vianen & De Dreu, 2001), group cohesion (Barrick et al. 1998; Greene, 1989), and alignment (shared mental model) on the most effective way to work together as a team (Klimoski & Mohammed, 1994). Results of empirical studies confirm the expectation that higher levels of agreeableness lead to higher team performance (Barrick et al., 1998; Graziano et al., 1997; Neuman et al., 1999; Neuman & Wright, 1999; Van Vianen & De Dreu, 2001).

Variability in agreeableness (Mohammed & Angell, 2003), or even the presence of one single disagreeable team member is expected to disrupt cooperation (Barrick et al., 1998), which is costly in terms of social rewards (Thibaut & Kelly, 1959). So a negative relationship between variability in agreeableness and team performance is predicted. The few empirical results available so far support this hypothesis: performance (oral presentation) is better when teams have a lower variability in agreeableness (Mohammed & Angell, 2003). Considering these predictions and results, we expect for our meta-analysis that:

Hypothesis 2a: Elevation of agreeableness is positively related to team performance.

Hypothesis 2b: Variability in agreeableness is negatively related to team performance.

Conscientiousness

Since conscientiousness is the most consistent predictor of individual performance (Hurtz & Donovan, 2000; Salgado, 2003), researchers expect this propitious effect of the elevation of conscientiousness to present itself at the team level as well. Highly conscientious team members are thorough, hardworking, responsible, self-disciplined, organized, self-motivated, and achievement- and task-oriented (Barrick & Mount, 1993; Costa & McCrae, 1992; Goldberg, 1993). Researchers expect these characteristics to result in effort and perseverance toward team goal completion (LePine, 2003; Molleman, Nauta & Jehn, 2004; Mohammed & Angell, 2003; Neuman & Wright, 1999; Taggar, 2002; Van Vianen & De Dreu, 2001), a focus on and commitment to the task (Barry & Stewart, 1997; Taggar, 2002), cooperation (Molleman et al., 2004), and role adaptation in face of changes within the team or task (Le Pine, 2003). The lack of these characteristics, may lead to social loafing or free riding (Mohammed & Angell, 2003; Molleman et al., 2004; Neuman et al., 1999). Considering this, researchers expect a positive effect of the elevation of conscientiousness within a team. Results of several empirical studies support these expectations, as they show that higher elevation of conscientiousness within a team leads to higher team performance (Barrick et al., 1998; Neuman et al, 1999; Neuman & Wright, 1999; Van Vianen & De Dreu, 2001 (student sample and combined sample)), and more specifically to better team performance in writing reports (Mohammed & Angell, 2003) and making decisions (Neuman & Wright, 1999).

With respect to variability in conscientiousness, researchers hypothesise that similarity in conscientiousness will lead to cohesion (Van Vianen & De Dreu, 2001), whereas dissimilarity in conscientiousness may lead to conflict and diminish a team's effectiveness (Mohammed & Angell, 2003; Molleman et al., 2004). Thus, a negative effect of variability in team member conscientiousness on team performance is predicted. In the empirical studies that have been carried out, it has indeed been demonstrated that higher team performance is reached when teams have a lower variability in conscientiousness

among team members (Barrick et al., 1998; Kichuk, 1999). Based on these expectations and results, in our meta-analysis we expect to find that:

> *Hypothesis 3a: Elevation of conscientiousness is positively related to team performance.*
> *Hypothesis 3b: Variability in conscientiousness is negatively related to team performance.*

Emotional stability

Team members whose elevation in emotional stability is high are described as self-confident and secure about chosen goals and decisions (Molleman et al., 2004; Van Vianen & De Dreu, 2001). Researchers expect these qualities to foster cooperation, a relaxed team atmosphere (Barrick et al., 1998; Molleman et al., 2004), stability within the team and coordination of work behaviors (Neuman et al., 1999), and task cohesion (Van Vianen & De Dreu, 2001). Based on this and on previous findings of Haythorn (1953), Heslin (1964), and Thoms, Moore and Scott (1996), the elevation of emotional stability is expected to be positively related to team performance. Results of separate studies support this expectation (Barrick et al., 1998; Kichuk & Wiesner, 1998; Molleman et al., 2004).

Considering variability in emotional stability, researchers hypothesise that the presence of one single (Barrick et al., 1998; Neuman et al., 1999; Van Vianen & De Dreu, 2001) or just a few (Mohammed & Angell, 2003) unstable or neurotic team members will have an adverse effect on team effectiveness by disrupting the cooperation, the atmosphere, or the cohesion within a team. So, variability in emotional stability is expected to be negatively related to team performance. However, in studies conducted to test this hypothesis, results for variability were mixed (negative effect: Mohammed & Angell, 2003; positive effect: Neuman et al., 1999). Given the results obtained so far, for our meta-analysis we hypothesise that:

> *Hypothesis 4a: Elevation of emotional stability is positively related to team performance.*
> *Hypothesis 4b: Variability in emotional stability is not related to team performance.*

Openness to experience

Relatively few researchers include openness to experience in their research or hypothesise about effects of this trait. With regard to the elevation in openness to experience, researchers reckon team members high in openness to be creative, broadminded, and willing to experiment or to try new things (LePine, 2003; Molleman et al., 2004). Team members possessing these characteristics are expected to adapt easily to new situations, build upon each other's ideas, and look for alternative ways to solve problems they encounter (Le Pine, 2003). They are also expected to foster a creative atmosphere in which team members have opportunities to learn and to experience satisfaction (Molleman et al., 2004). Researchers expect positive relationships between elevation of openness to experience and team performance. Results with regard to openness obtained in individual studies using correlational analysis so far are mixed (positive: Neuman et al., 1999; negative Van Vianen & De Dreu, 2001 (student team sample)). Results of studies using regressional analysis, however, show that higher elevation of a team's openness results in better decision-making performance (Le Pine, 2003) and higher overall team performance (Neuman et al., 1999).

With respect to variability in openness, researchers hypothesise that if all team members are highly open to experience, this may result in conflict and lowered cohesion, because all team members want to get their way (Van Vianen & De Dreu, 2001); in short, they expect beneficial effects of variability in openness. However, none of the studies conducted so far has shown either positive or negative effects of variability in openness to experience on team performance.

Although expectations and results are somewhat mixed, in general they favour a positive effect of elevation of openness. Furthermore, the expected positive effect of variability in openness is not supported by results. Therefore our meta-analysis hypotheses are:

Hypothesis 5a: Elevation of openness to experience is positively related to team performance.

Hypothesis 5b: Variability in openness to experience is not related to team performance.

Moderation of the Main Effects

When studying the effects of personality trait elevation and variability on team performance, differences may be expected to occur in a comparison of student teams and professional teams. These differences may be due to a number of aspects.

First, professionals can generally be expected to have more experience with teamwork than students. Higher levels of teamwork experience can be expected to smoothen cooperation and thus lead to better (contextual) performance, especially when high levels of cooperation are required. Mohammed et al. (2002) included team experience in their study and found a negative effect of team experience on contextual performance and a considerable, though non-significant, positive effect on leadership performance. Since leadership effectiveness is positively related to all five personality traits (Judge, Bono, Ilies & Gerhardt, 2002), professional teams that are more experienced in teamwork may exhibit positive relationships between personality and leadership performance, but negative ones between contextual personality traits and contextual performance.

Second, professionals work together in teams for longer periods of time than students (professionals often work on a sequence of tasks within the same team (e.g., Barrick et al., 1998; English et al., 2004; Van Vianen & De Dreu, 2001)). The longer a team has to work together, the more team members will have to make an effort to be able to keep on functioning as a team. Contextual performance may become more important and personality traits related to it may thus exert a stronger impact on the overall performance.

Third, professional teams perform different types of tasks than student teams do. A number of researchers pointed to the fact that the type or complexity of the task performed by a team has to be considered as a potential moderating influence on the results they had found (e.g., Barry & Stewart, 1997; Graziano et al., 1997; Mohammed & Angell, 2003). English et al. (2004) tested the moderating effect of type of task and found that the relationship between the (aggregated) elevation of conscientiousness and team performance was strongest for additive tasks (that is, when added inputs of the team members determine a team's performance (Steiner, 1972)).

Fourth, the extent to which professional and student team members are interdependent in order to successfully complete their task may differ. Interdependency will be strongly related to the distribution of task relevant knowledge within a team or to its

multidisciplinarity. Most often, student teams are composed of members that study the same subject, and will thus be less interdependent than members of professional teams who often vary in skills and knowledge. The more interdependent team members are, the more attention they will have to pay to contextual performance in order to facilitate cooperation that is needed to integrate relevant knowledge as a result of which the task can be completed successfully. Therefore, personality traits related to contextual performance (agreeableness, extraversion, and emotional stability (Mohammed et al., 2002)) may have a stronger impact on overall performance in teams where the members are more highly interdependent.

Summarizing, differences between professional and student teams are to be expected based on their team work experience, the duration, type and complexity of their task, and the interdependency among team members. Since these aspects are to a greater or lesser extent interrelated, it is difficult to formulate specific hypotheses for each of these aspects separately. That is why we explore the moderation for type of team (professional versus student teams) without specific hypotheses.

2.4 Method

Meta-Analysis Procedure

The meta-analysis was conducted using Hunter and Schmidt's (2004, p. 180-182) two stage procedure for meta-analysis of correlations using artifact distributions. In the first stage, correlations were collected according to the following steps and criteria: The meta-analysis has been conducted upon research that has been published in refereed journals. To obtain a complete set of publications, two search methods were used. First, a computer-based literature search was conducted in PsychInfo (all databases) and in ABI/INFORM global (current files, back files and deep back files). The key words used were *Big Five*, *personality*, *team performance*, and *team outcomes*. A second way in which articles were found was by executing a citations search in the reference sections of previously gathered articles. Studies that were included met the following criteria:

1. With regard to the variables under study (a) personality was described using the Big Five framework, (b) trait elevation was operationalized via aggregated mean or summed scores, or via the proportion of high scoring team members, and variability

was operationalized via variance or standard deviation scores, and (c) a team's task performance was rated at the team level by supervisors who used task specific rating dimensions.

2. Effect sizes that expressed a direct relationship between Big Five trait elevation within a team and team performance, or between Big Five trait variability within a team and team performance could be found in the article.[2]
3. If independent subgroups were included in an article, they had to be analysed separately (e.g., professional and student teams). If several effect sizes applying to the same effect category were presented, then these were averaged before inclusion (e.g., written and oral performance).

To conclude the first stage, the correlations were corrected for artifact information that was available for all studies: sampling error. This was done for the total sample, and for both samples of the moderator analysis: the professional teams and the student teams. The results of this stage of the analysis are the estimates of the mean and standard deviation of the population correlation for each of the correlations in each of the samples.

In the second stage, the estimates of the first stage were corrected for artifact information that is only sporadically available. For our analysis this was information on reliability in the predictor measures, reliability in de criterion measure and direct range restriction in the predictor measures. We discuss each of them separately.

Information on the reliability of the elevation of personality traits was only given in a few studies. Sometimes, authors referred to reliabilities given in personality inventory manuals. We therefore created artifact distributions using information presented in meta-analyses on individual personality and individual performance (Hurtz & Donovan 2000; Judge et al., 2002; Judge & Ilies, 2002; Salgado, 1997). The means and standard deviations of these distributions were: extraversion m = .91, SD = .01, agreeableness m = .89, SD = .01, conscientiousness m = .91, SD = .01, emotional stability m = .91, SD = .02, and openness to experience m = .90, SD = .01. These mean reliabilities were similar to those sporadically presented in the studies we included in our study.

[2] One exception has been made with regard to this criterion. Effects were described in Kichuk and Wiesner (1998), but no effect sizes were reported in this article. Therefore these have been obtained via the dissertation of Kichuk (1999).

Information on the reliability of the criterion measure was presented in three studies (Barrick et al., 1998; Neuman et al, 1999; Van Vianen & De Dreu, 2001). To derive an artifact distribution on the reliability of supervisory rated performance, we combined the reliabilities of team level supervisory ratings reported in the articles under study with those presented in meta-analyses on individual personality and supervisory rated performance (Hurtz & Donovan, 2000; Salgado, 1997, 2003) and that of Rothstein (1990) cited in Hunter and Schmidt (2004) and other individual level meta-analyses. The distribution had a mean of .83 and a standard deviation of .09.

Finally, distributions were created for the direct range restriction of each of the personality traits for the professional team sample. No information on range restriction was presented in the studies under analysis. Therefore we used information reported by Barrick and Mount (1991) and Hurtz and Donovan (2000). The mean and standard deviations of these distributions were .93 for all traits (agreeableness .94) and .01 (all traits), respectively.

Using these distributions the estimated population correlations and standard deviations were corrected. The trait elevation-performance correlations were corrected for reliability in the predictor and the criterion measure. The trait elevation-performance correlations of the professional teams were corrected for range restriction in the predictor as well, since selection of employees is known to impose restriction upon the predictor scores. Range restriction was not expected to occur in the student team sub sample. To our knowledge, students are not selected for their study based on their personality scores. Furthermore, effects of self-selection due to study subject were not expected to occur, since the subjects of the students in the studies included in the meta-analysis were quite diverse. However, to facilitate comparison between the total and sub sample correlations, the overall trait elevation-performance correlations were corrected separately for reliability with and without direct range restriction. The trait variability-performance correlations were only corrected for reliability in the criterion measure.

2.5 Results

Studies Included in the Meta-Analysis

Depending on the trait under study, six to nine studies fulfilled the criteria specified above, yielding six to ten independent samples reporting effect sizes. All effect sizes used were

expressed in terms of correlations. The studies included in the meta-analysis are presented in Table 2.1. For each study we described the team characteristics (type of team, number of teams studied, mean team size, and tenure of members within the team), the task characteristics (description and duration of the task), and the way team performance was rated.

The sample sizes in the studies ranged from 24 to 88 teams, with an average of 52.7 teams. We did not control for the size of the teams, since the range of the mean team size was, on average, quite restricted, although the teams sampled by Barrick et al. (1998) formed an exception to this rule: when excluding Barrick et al.'s teams, mean team size ranged from 3–4.8 with an overall mean team size of 3.9; when including their teams, mean team size ranged from 3-13, with an overall mean team size of 4.8.

The professional and student team sub samples can be described as follows. Five of the ten samples consisted of student teams, the other five of professional teams. The professional teams had functioned together for a longer period of time --from one up to three-and-a-half-years-- and performed an ongoing task, but the tasks performed by the professional teams differed substantially (Barrick et al., 1998; English et al., 2004; Neuman et al., 1999; Neuman & Wright, 1999; Van Vianen & De Dreu, 2001). The student teams had to complete study projects or a task for research purposes. The duration of their projects was fairly short: one hour up to about 13 weeks, and their tasks were very similar in nature: creative or problem solving (Barry & Stewart, 1997; Kichuk & Wiesner, 1998; Mohammed & Angell, 2003; Mohammed et al., 2002; Van Vianen & De Dreu, 2001). Due to the confoundedness of these aspects, which may each cause the moderation of the relationship between personality and team performance, it is not possible to attribute differences found in the moderation analysis to either type of task, or tenure with the team, or the duration of the task. In Table 2.2 the results of the meta-analysis are presented, starting with the number of studies (k), followed by the total sample size per category (*N*), the average weighted $\bar{r}$, the values of ρ (corrected $\bar{r}$), the standard deviation of ρ (SD_ρ), the 80% credibility interval (CV), and the 90% confidence interval around the weighted average (CI). In this table values between brackets have been corrected for direct range restriction. In Table 2.3 the results of the moderation analysis for type of team are presented. Rhos are considered to be significant if the CI does not include zero.

Table 2.1 *Studies into the Relationship between the Big Five Personality Traits and Team Outcomes included in the Meta-Analysis*

Authors[a]	*Team characteristics*	*Task characteristics*	*Team performance*
Barrick, Stewart, Neubert & Mount (1998)	▪ type: professional teams ▪ *n* = 51 ▪ mean size = 13 ▪ tenure with the team: on average 3.59 years	▪ description: manufacturing ▪ duration: ongoing	The supervisory ratings on eight dimensions of team effectiveness were summed
Barry & Stewart (1997)	▪ type: student teams ▪ *n* = 61 ▪ mean size = 4.7 ▪ tenure with the team: two semesters	▪ description: analytical, creative, problem-solving ▪ duration: one week for each of the three tasks	The instructor ratings of the quality of the performance on the three tasks were averaged. Instructors were unaware of the identities and predictor scores of team members
English, Griffith & Steelman (2004)	▪ type: professional teams ▪ *n* = 30 ▪ mean size = 3 ▪ tenure with the team: ?	▪ description: flying a plane ▪ duration: ?	Crews' captains/supervisors rated the crew's performance based on a specifically developed crew performance appraisal
Kichuk (1999), Kichuk & Wiesner (1998)[b]	▪ type: student teams ▪ *n* = 81-95[c] ▪ mean size = 3 ▪ tenure with the team: for the duration of the task	▪ description: designing and building a newspaper bridge ▪ duration: 45 minutes	An independent rater 'supervised' by a recorder scored each bridge on length, width, height and strength using a predefined scoring key
Mohammed & Angell (2003)	▪ type: student teams ▪ *n* = 59 ▪ mean size = 4.5 ▪ tenure with the team: 15 weeks	▪ description: process–improvement project ▪ duration: 12-13 weeks	Course instructors (unaware of the students' predictor scores) graded written reports based on various criteria using feedback of the project sponsors. An audience of course instructors, project sponsors, classmates and special guests rated the project presentation

Table 2.1 *continued*

Authors[a]	*Team characteristics*	*Task characteristics*	*Team performance*
Mohammed, Mathieu & Bartlett (2002)	▪ type: student teams ▪ *n* = 25 ▪ mean size = 4.8 ▪ tenure with the team: 15 weeks	▪ description: real-life laboratory exercise: cafetaria management ▪ duration: 15 weeks	An instructor (unaware of the teams' predictor scores) rated a team's performance on two meal days on a number of dimensions which are combined in a composite score
Neuman, Wagner & Christiansen (1999)	▪ type: professional teams ▪ *n* = 82 ▪ mean size = 4 ▪ tenure with the team: on average 3.5 years	▪ description: customer service ▪ duration: ongoing	The human resources staff rated customer service ratings, and team supervisors rated task completion ratings. Both ratings were combined in a composite score
Neuman & Wright (1999)	▪ type: professional teams ▪ *n* = 79 ▪ mean size = 4 ▪ tenure with the team: 3 years	▪ description: communication about and processing of employee claims ▪ duration: ongoing	Ratings made by three department supervisors (unaware of employees' predictor scores) on six performance dimensions were combined
Van Vianen & De Dreu (2001)	▪ type: professional teams ▪ *n* = 24 ▪ mean size = 3.6 ▪ tenure with the team: on average 13.4 months	▪ description: drilling or placing underground cables and pipes ▪ duration: ongoing	Supervisory ratings (supervisors worked closely together with their teams) on eight dimensions of team effectiveness were summed
Van Vianen & De Dreu (2001)	▪ type: student teams ▪ *n* = 28 ▪ mean size = 3.8 ▪ tenure with the team: three months	▪ description: research project ▪ duration: three months	Supervisory ratings (supervisors worked closely together with their teams) on eight dimensions of team effectiveness were summed

Note. [a] alphabetically ordered by first author; [b] details reported here were found in Kichuk (1999); $\bar{r}$ *s* are computed using the mean number of teams *n* = 88

Main Effects

The finding that elevation of extraversion was not related to team performance (ρ = .04, CI = -.05-.13) is in line with hypothesis 1a. However, although the effect of variability in extraversion was positive, as predicted in hypothesis 1b, this effect was not significant (ρ = .05, CI = -.06-.18). Elevation of agreeableness (ρ = .24, CI = .09-.39) was positively related to team performance, as predicted in hypothesis 2a. Variability in agreeableness (ρ = -.12, CI = -.16- -.07) was negatively related to team performance, which is in line with hypothesis 2b. Elevation of conscientiousness (ρ = .20, CI = .09-.31) was positively related to team performance, as predicted in hypothesis 3a. As stated in hypothesis 3b, variability in conscientiousness (ρ = -.24, CI = -.33- -.14) was negatively related to team performance. We predicted a positive relationship between the elevation of emotional stability (hypothesis 4a), but this effect was not found (ρ = .04, CI = -.06-.13); however, the prediction that variability in emotional stability is not related to team performance (hypotheses 4b) is supported by the data (ρ = .02, CI = -.13-.16). Elevation of openness to experience was not positively related to team performance (ρ = .03, CI = -.14-.20) as stated in hypothesis 5a, but findings that variability in openness to experience was not related to team performance (ρ = -.01, CI = -.15-.12) are in line with hypothesis 5b.

So, the higher the average level of agreeableness and conscientiousness within teams, and the more similar team members are with respect to agreeableness and conscientiousness, the better their team performs.

Moderation of the Main Effects

When testing for moderation of the effects of trait elevation, we found significant rhos for agreeableness of professional teams (ρ = .51, CI = .42-.61), but not for agreeableness of student teams (ρ = .02, CI = -.11-.15). A significant rho was found for conscientiousness of professional teams (ρ = .42, CI = .33-.51), but not for conscientiousness of student teams (ρ = .00, CI = -.07-.07). Furthermore, we found significant rhos for emotional stability of student teams (ρ = -.04, CI = -.07- -.01), but not for that of professional teams (ρ = .14, CI = -.05-.32). So, the higher the average level of agreeableness and conscientiousness within professional teams and the lower the level of emotional stability within student teams, the higher the team performance.

Table 2.2 *Relationships between Big Five Trait Elevation, Big Five Trait Variability, and Team Performance*

Trait	*k*	*N*	$\bar{r}$	*ρ*	SD_ρ	*80% CV lower*	*80% CV upper*	*90% CI lower*	*90% CI upper*
Elevation [a]									
Extraversion	9	497	.03	.04 (.04)	.00 (.00)	.04 (.04)	.04 (.04)	-.05 (-.05)	.13 (.14)
Agreeableness	9	497	.17	.24 (.25)	.20 (.22)	-.02 (-.02)	.50(.53)	.09 (.09)	.39 (.41)
Conscientiousness	10	527	.15	.20 (.21)	.12 (.13)	.04 (.04)	.36 (.38)	.09 (.09)	.31 (.34)
Emotional Stability	9	497	.03	.04 (.04)	.00 (.00)	.04 (.04)	.04 (.04)	-.06 (-.07)	.13 (.14)
Openness to Experience	6	362	.02	.03 (.03)	.19 (.21)	-.21(-.23)	.27 (.30)	-.14 (-.16)	.20 (.22)
Variability [b]									
Extraversion	6	332	.05	.06	.00	.06	.06	-.06	.18
Agreeableness	6	332	-.09	-.12	.00	-.12	-.12	-.16	-.07
Conscientiousness	6	332	-.17	-.24	.00	-.24	-.24	-.33	-.14
Emotional Stability	6	332	.01	.02	.08	-.09	.12	-.13	.16
Openness to Experience	4	222	-.01	-.01	.00	-.01	-.01	-.15	.12

Note. [a] *ρ*s are corrected for unreliability in predictor and criterion measures, *ρ*s between brackets are corrected for unreliability in predictor and criterion measures and direct range restriction; [b] *ρ*s are corrected for unreliability in the criterion measure; CV = Credibility interval; CI = Confidence interval

Table 2.3 *Relationships between Big Five Trait Elevation, Big Five Trait Variability, and Team Performance for Professional Teams and Student Teams*

Trait	*k*	*N*	$\bar{r}$	ρ	SD_ρ	80% CV lower	80% CV upper	90% CI lower	90% CI upper
Professional teams									
Elevation[a]									
Extraversion	4	236	.11	.15	.34	-.28	.59	-.17	.47
Agreeableness	4	236	.35	.51	.00	.51	.51	.42	.61
Conscientiousness	5	266	.29	.42	.00	.42	.42	.33	.51
Emotional Stability	4	236	.09	.14	.12	-.02	.29	-.05	.32
Openness to Experience	3	185	.13	.19	.14	.00	.37	-.03	.41
Variability[b]									
Extraversion	3	157	.13	.16	.00	.16	.16	-.01	.33
Agreeableness	3	157	-.11	-.13	.00	-.13	-.13	-.16	-.11
Conscientiousness	3	157	-.17	-.21	.00	-.21	-.21	-.34	-.08
Emotional Stability	3	157	.13	.16	.00	.16	.16	-.01	.33
Openness to Experience	2	106	-.09	-.11	.00	-.11	-.11	-.14	-.08

Table 2.3 *continued*

Trait	*k*	*N*	$\bar{r}$	ρ	SD_ρ	80% CV lower	80% CV upper	90% CI lower	90% CI upper
Student teams									
Elevation [c]									
Extraversion	5	261	-.04	-.05	.00	-.05	-.05	-.16	.06
Agreeableness	5	261	.01	.02	.00	.02	.02	-.11	.15
Conscientiousness	5	261	.00	.00	.00	.00	.00	-.07	.07
Emotional Stability	5	261	-.03	-.04	.00	-.04	-.04	-.07	-.01
Openness to Experience	3	177	-.09	-.12	.19	-.37	.13	-.32	.09
Variability [b]									
Extraversion	3	175	-.03	-.03	.00	-.03	-.03	-.10	.04
Agreeableness	3	175	-.06	-.08	.00	-.08	-.08	-.15	-.01
Conscientiousness	3	175	-.18	-.22	.00	-.22	-.22	-.36	-.08
Emotional Stability	3	175	-.09	-.11	.00	-.11	-.11	-.20	-.02
Openness to Experience	2	116	.06	.08	.00	.08	.08	-.11	.26

Note. [a] ρs are corrected for unreliability in predictor and criterion measures and direct range restriction; [b] ρs are corrected for unreliability in the criterion measure; [c] ρs are corrected for unreliability in predictor and criterion measures; CV = Credibility interval; CI = Confidence interval

When testing for moderation of the effects of trait variability, we found significant rhos for agreeableness of both professional teams (ρ = -.13, CI = -.16- -.11) and student teams (ρ = -.08, CI = -.15- -.01). Significant rhos were also found for the variability in conscientiousness of professional teams (ρ = -.21, CI = -.34- -.08) and student teams (ρ = -.22, CI = -.36- -.08). However, we found significant rhos for variability in emotional stability of student teams (ρ = -.11, CI = -.20- -.02), but not for that of professional teams (ρ = .16, CI = -.01-.33), and significant rhos for openness to experience of professional teams (ρ = -.11, CI = -.14- -.08), but not for that of student teams (ρ = .08, CI = -.11-.26). This means that findings of main effects of variability in the total sample are replicated in the sub samples for both agreeableness and conscientiousness. However, professional teams and student teams differ with respect to the effect of variability in emotional stability and openness to experience on team performance. The more similar student team members are in emotional stability and the more similar professional team members are in openness to experience, the better their teams perform.

2.6 Discussion

Using meta-analytical procedures, we aimed at providing a more comprehensive answer than offered in previous studies to the question: How is team composition in terms of personality related to team performance? To answer this question, we discuss our findings and conclusions per trait. The second aim of this study was to signal directions for future research. These are presented throughout the discussion.

Extraversion

Neither elevation nor variability in extraversion influences team performance. For elevation this is in line with what we expected. For variability we expected a positive relationship with team performance, but although results were in the predicted direction (especially in the professional team sample), they were not significant. Based on our results we can only conclude that both elevation and variability in extraversion are not related to team performance.

Agreeableness

The higher the elevation of agreeableness in teams, the higher their performance. This finding is in line with a number of separate studies on the relationship between agreeableness and team performance (Barrick et al., 1998; Graziano et al. 1997; Neuman et al., 1999; Neuman & Wright, 1999; Van Vianen & De Dreu, 2001), but differs from individual level meta-analyses in which no relationship was found between agreeableness and performance (Hurtz & Donovan, 2000). It seems that agreeableness does not come into play until people have to work together. Results by Hurtz and Donovan (2000), who showed a positive relationship between individual agreeableness and individual interpersonal facilitation, are consonant with this expectation. So perhaps agreeableness asserts its effect on team performance through interpersonal facilitation within the team. This is a topic that should be addressed in future research. The fact that the effect of elevation in agreeableness was stronger in professional teams and virtually absent in student teams may have to do with the fact that professional teams cooperate over a longer period of time and members are more interdependent. As we speculated this requires more interpersonal facilitation (contextual performance), and thus the effect of elevation of agreeableness on team performance will be more salient in professional teams. The effect of variability in agreeableness was as expected. For all samples we found that the more similar team members are in this respect, the better their teams perform. In general, we can conclude that teams whose members score both highly (except for student teams) and similarly on agreeableness are the teams that perform best.

Conscientiousness

For conscientiousness we found that the higher the average levels of conscientiousness of teams are, the higher their performance is. This finding is in line with findings on the relationship between individual conscientiousness and individual performance (Hurtz & Donovan, 2000; Salgado, 2003), and with results of a number of individual studies on the relationship between conscientiousness and team performance (Barrick et al., 1998; Mohammed & Angell, 2003; Neuman et al, 1999; Neuman & Wright, 1999; Van Vianen & De Dreu, 2001). Moderation analysis shows that this effect is absent in student teams. Again this might be explained by the fairly short period of time task completion takes and

the low levels of team member interdependency. Short project periods require little planning or systematic working towards goal completion, behaviors typical of people low in conscientiousness. Furthermore, similarity in background of students would make it possible for one --highly conscientious-- team member to complete the task. Than, the maximum team score (Barrick et al., 1998) for conscientiousness would be the better operationalization to study when researching the effect of conscientiousness in student teams. With respect to effects of variability of conscientiousness within a team, the results indicate that --for all samples-- the more similar team members are, the better their teams perform. The general conclusion for this trait is that the best performing teams are those whose members score both highly (except for student teams) and similarly on conscientiousness.

Emotional Stability

Contrary to expectations, elevation in emotional stability is not positively related to team performance. Maybe this relationship was not found because emotional stability is a too broad concept. Perhaps researchers should have tested for effects of facets within this trait. It may be that the self-confidence needed for effective teamwork (as hypothesised by Molleman et al. (2004) and Van Vianen and De Dreu (2001)) is better captured by the facets ‘self-consciousness’ (which pertains to a person’s social confidence) or ‘vulnerability’ or 'insecurity' (Saucier & Ostendorf, 1999) (which pertains to a person’s self-confidence) (Costa & McCrae, 1992), instead of by the complete trait of emotional stability. As expected, variability in emotional stability is not related to team performance in the total sample. However, when comparing the professional and student team samples, opposite effects occur, of which only those of the student team sample are significant. For student teams there is a negative effect of both elevation and variability on team performance, but it has to be noted that the upper bound of the CIs of both effects is very close to zero. For professional teams both effects tend in a positive direction. These results may alter when meta-analyses are conducted with larger sample sizes. Given the small magnitude of effects at the general level and the opposing effects at the sub sample level, we restrain ourselves from drawing general conclusions for this trait.

Openness to Experience

Elevation in openness to experience is not positively related to team performance, like we expected it to be. Elevation effects for both types of teams are in opposite directions (positive for professional teams and negative for student teams) but not significant. In line with expectations, variability in openness to experience is not related to team performance, although it is negatively related to team performance in the professional team sample. We think that the main explanation for the fact that these relationships are not as expected and different per sub sample for this trait is of a methodological nature: All effects found are based on relatively small sample sizes. It is not improbable that additional data may change these preliminary results. Therefore, we feel it is unjustifiable to draw general conclusions regarding openness to experience on the basis of the present results.

Limitations and Directions for Future Research

The main limitation of this meta-analysis is the small number of correlations from which population correlations were computed for some of the traits, especially in the moderator analysis. Hunter and Schmidt (2004) indicated that small samples in meta-analysis may lead to a second-order sampling error. This means that meta-analytical estimates of the standard deviations are affected (more than estimates of the mean) (p. 399). To avoid this kind of error, more research on this topic is needed to be able to perform meta-analysis on larger samples.

Another limitation might be that two studies used slightly different operationalizations of elevation and variability. For elevation, Barry and Stewart (1997) used proportions of high scoring team members, whereas the other studies used means or sums. For variability, Mohammed and Angell (2003) used standard deviation scores whereas the other studies used variance scores. This may have had an influence on the results of the total sample. It is, therefore, important that in future studies researchers use similar operationalizations of team composition in terms of personality. Bedeian and Mossholder (2000) proposed to use mean and standard deviation scores to test for variability effects (cf. Mohammed & Angell, 2003).

A final limitation was our inability to determine the exact cause of the moderating effects for professional- and student teams, because explanatory variables covaried in the

sub samples included in the moderator analysis. We present our conclusions with reticence, but even so, our inability to test for moderator variables separately may have led us to draw oversimplified conclusions. This limitation brings us to another important suggestion for future research: the effect of possible moderators should be tested independently. Given our preliminary explanation for the differences found, unravelling effects of the period of time team members cooperate and interdependency among team members may be given priority when studying moderator variables in professional and student teams.

These limitations notwithstanding, the integration of the results we offer holds important information about the relationship between team composition in terms of personality and team performance. The substantial main effects of the elevation and variability of conscientiousness and agreeableness, and the absence of such effects for other traits (elevation in extraversion, and variability in emotional stability and openness to experience) hold important consequences for team composition in practice. Preferably, teams should be composed of members that are highly and similarly agreeable and conscientious. This means that in the selection process of future team workers personality should be considered as one of the selection criteria. Furthermore, future team composition researchers should be aware of the differences between professional and student teams and the covariation of multiple moderator variables in both types of team. This knowledge should make them select the teams they intend to study with extra care.

Chapter 3

The Big Five Personality Traits and Individual Satisfaction with the Team [*]

Relationships between team composition in terms of team members' Big Five personality traits and individual satisfaction with the team after project completion were researched. Questionnaires were filled out by 310 undergraduate students (n=68 teams) working on an engineering design assignment. Individual satisfaction with the team was regressed onto individual-, dissimilarity- and interaction scores. A positive main effect was found for individual agreeableness and emotional stability, and for dissimilarity in conscientiousness. A moderation of the main effect of dissimilarity was found for extraversion: satisfaction with the team is only negatively related to dissimilarity to the other team members for members low in extraversion.

It is important for researchers and managers to know how satisfied team members are with their team, since knowing this holds important consequences for the team member's future work in that specific team, or for his/her future teamwork in general. One can imagine, for example, that dissatisfying experiences with teamwork negatively influence a person's attitude towards teamwork, resulting in e.g. decreased effort when employed in future teams. In their study on group potency, Lester, Meglino, and Korsgaard (2002) reported

[*] This chapter is based on: Peeters, M. A. G., Rutte, C. G., Van Tuijl, H. F. J. M., & Reymen, I. M. M. J. (*in press*). The Big Five personality traits and individual satisfaction with the team. *Small Group Research*.

significant correlations between group satisfaction and group effort (r = .63), and between group effort and the final performance rating (r = .61). Considering this in light of the fact that teamwork becomes increasingly dominant in organizations and education, team member satisfaction with a team presents itself as an important variable to study. If team member satisfaction with a team were to be determined by personality, it would hold important consequences for team composition. Satisfaction with the team, however, is an outcome variable that has largely been ignored in team personality research so far (Milliken & Martins, 1996, p. 409). Therefore, the objective of this study is to answer the research question: *How does team composition in terms of personalities of the team members influence the satisfaction individual team members feel about working in their particular team?*

The emergence of the Five-Factor Model of personality (Norman, 1963), or the 'Big Five' (Goldberg, 1990) provided a clear conceptual and measurement framework for research into personality (Robertson & Callinan, 1998). Its five factors extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience have been found to consistently describe personality for various samples (Hofstee, Kiers, De Raad, Goldberg & Ostendorf, 1997; McCrae & Costa, 1997). Geared with this common frame of reference and measurement, work and organizational psychologists set out to discover the predictive validity of personality for various outcome variables (e.g., job performance, job satisfaction, turnover) in various contexts. To study effects of personality on outcome variables, (a) *individual personality* has been related to *individual outcomes* (for meta-analyses, see: Barrick & Mount, 1991; Hurtz & Donovan, 2000; Judge, Heller & Mount, 2002; Judge & Ilies, 2002; Salgado, 1997, 2003; Tett, Jackson & Rothstein, 1991; Tett, Jackson, Rothstein & Reddon, 1999); and to study the effects of team composition in terms of personality, (b) *aggregated* or *team personality* variables have been related to *team outcomes* (Barrick, Stewart, Neubert & Mount, 1998; Barry & Stewart, 1997; Graziano, Hair & Finch, 1997; Kichuk & Wiesner, 1998; Mohammed & Angell, 2003; Mohammed, Mathieu & Bartlett, 2002; Neuman, Wagner & Christiansen, 1999; Van Vianen & De Dreu, 2001).

Based on the team context of our study, one might be inclined to expect our analytical approach to personality to be similar to the one described under (b), but we

propose, in fact, another way to study the relationship between team composition in terms of personality and individual satisfaction with the team. By aggregating individual team-member personality scores to the team level, the differences between individual team members are lost and the team itself actually becomes the entity of study. Hence the use of the term 'team personality'. However, working in a team is all about the interaction between individual team members with their more or less similar personal characteristics. So, when the effect of team composition in terms of personality on individual outcomes is to be studied, we believe one should focus on the personality of the individual team member and the degree of (dis)similarity between his/her personality and that of the other team members. Therefore, in this study we investigate the relationship between on the one hand *individual team member personality* and *the dissimilarity between individual team member personality and co-team members' personality,* and on the other hand *individual team member satisfaction with the team*. This makes the contribution of this study to the scientific literature on the effects of team composition in terms of personality twofold. Firstly, we look at an important yet underexposed outcome variable of teamwork: individual team member satisfaction with the team. Secondly, we operationalize team composition in terms of personality at the individual level which is a novel approach to studying the effects of the Big Five personality traits in a team context.

In the remainder of this introduction, we first discuss the variables in our study: individual satisfaction with the team and the Big Five personality traits. Thereafter we discuss the analysis of the effect of team composition in terms of personality on outcomes in previous research and present the perspective we adopt in this study based on the *Personality Trait-Based Interactionist Model* (Tett & Burnett, 2003). Finally, we present the study hypotheses.

3.1 Individual Satisfaction with the Team

Individual satisfaction with the team has not been subject of study before and that is why we present a definition of it. The satisfaction felt with the team can relate to either the team members or the team's composition, or to the way team members worked together during the project. Both parts of satisfaction with the team are reflected in the extent to which team members are willing to work in the same team again (which resembles team viability

(Barrick et al., 1998; Hackman, 1987)). If both the team (mates) and the cooperation within the team have been experienced as pleasant, team members will be satisfied and willing to work with the same team on similar projects in the future. However, if one of the two is experienced as less pleasant, the situation in which the team work takes place will determine whether a team member is willing to work with that same team again; e.g., in a hobby team, satisfaction will likely be much more determined by having a good time with likeminded people, whereas in a work team effective work processes leading to a good performance may be more important in determining a team member's satisfaction. As a result, individual satisfaction with the team will be captured most completely when it encompasses an aspect that relates to the team members, an aspect that relates to the work process, and an aspect that relates to the team's viability. Although satisfaction with the team can be assessed during any stage of the team work, the most complete assessment of it can only be given in hindsight, after a team has finished its work. Thus defined, individual satisfaction with the team becomes a particularized aspect of job satisfaction that regards the coworkers (cf. Bischop & Scott, 2000; Locke, 1976).

To position our research it is important to make a distinction between several constructs from the team literature and individual satisfaction with the team. One can think of group potency (Shea & Guzzo, 1987), team efficacy (Lindsey, Brass & Thomas, 1995), group cohesion (Mullen & Copper, 1994), team commitment (Bischop & Scott, 2000), and team viability (Hackman, 1987). Team efficacy, group potency, group cohesion, and team commitment are related to motivational processes in team work, while individual satisfaction with the team is a state-like outcome of working in a team. Furthermore, team viability exclusively concerns the team's capability to function together as a team in the future, which is only one aspect of satisfaction with the team**.** So, individual satisfaction with the team differs conceptually from group potency, team efficacy, group cohesion, and team commitment in that it is an outcome instead of a process-related characteristic of teamwork, and from team viability in that it is a broader concept.

3.2 The Big Five Personality Traits

Based on factor analysis, the Five-Factor Model of personality distinguishes five factors that together describe a person’s personality. The premise of the model is that the factors

remain stable and consistent over time and situations, and that each factor predisposes a person to behave in a certain way (Robertson & Callinan, 1998). These so-called Big Five personality traits can be described as follows. *Extraversion* refers to the extent to which a person is outgoing and talkative and is associated with behaviors like being sociable, gregarious, assertive, and active (McCrae & Costa, 1985). Highly extravert people are often perceived as being dominant and therefore as leaders (Barry & Stewart, 1997). *Agreeableness* refers to the extent to which a person is cooperative and friendly. Highly agreeable persons display behaviors like being courteous, flexible, trusting, good-natured, forgiving, soft-hearted, and tolerant (McCrae & Costa, 1985). *Conscientiousness* refers to the extent to which a person is self-disciplined and organized. Associated behaviors are being careful, thorough, responsible, organized, planful, hardworking, achievement-oriented, and persevering (McCrae & Costa, 1985). *Emotional stability* refers to the extent to which a person is calm, poised, and secure. The opposite is known as *neuroticism,* which is associated with behaviors like being anxious, depressed, angry, embarrassed, emotional, worried, and insecure (McCrae & Costa, 1985). Finally, *openness to experience* describes the extent to which a person is imaginative and curious. Highly open people can be described as being cultured, original, broad-minded, intelligent, and artistically sensitive (McCrae & Costa, 1985). Measurement of the Big Five can be accomplished using specially developed scales (Costa & McCrae, 1992; Hendriks, Hofstee & De Raad, 1999), or using (a combination of) scales from other well-known personality measures (e.g., Gough, 1988). Despite some differences in factor labeling, factor analysis and content analysis consistently replicate the underlying five-factor structure (John, 1990; Mount & Barrick, 1995).

3.3 Analyzing the Effects of Team Composition in Terms of Personality

Recently, team personality researchers (Mohammed & Angell, 2003) and other theorists (McGrath, 1998; Kozlowski & Klein, 2000) have begun to acknowledge the inadequacy of the present team personality research to capture the complete range of effects team composition in terms of personality has on team outcomes. They attribute this failure to incomplete methods of analysis: conclusions are based either on correlational results or on tests of effects of specific personality trait variables *without* controlling for the effects of

personality variables for which no effect was predicted. The inadequacy lies in the fact that looking at isolated traits does not reflect effects of personality as a whole. As improvement, it was recommended that all five traits should be considered *simultaneously* when testing for effects of specific traits on team outcomes (McGrath, 1998; Kozlowski & Klein, 2000). As we agree with this recommendation we include all five personality traits in our analyses.

Although considering all traits simultaneously is analytically already one step forward, we think that it will still be insufficient to capture the complex pattern of interactions taking place between the different personalities of team members when this is done using aggregated elevation and/or variability team personality scores. As stated earlier, we think a more comprehensive solution lies in operationalizing personality in teams on the individual level by placing the individual team member in the context of the team, which is what we do in this study. Such an approach is in line with Tett and Burnett's (2003) Personality Trait-Based Interactionist Model, which is meant to be a comprehensive model that aims to capture the effects of individual personality on job performance. Although job performance is not the outcome variable of interest in this study, we think that the model can also be applied to study satisfaction with the team. Concerning job performance, Tett and Burnett (2003) stated that job performance is *the valued part of the work behavior* and this value is determined by e.g. the organizational goals or the manager. However, employees themselves also evaluate their work behavior and its outcomes. Since the degree of satisfaction is a specific outcome of such an individual evaluation, we think the model can be applied equally well to study individual satisfaction with the team as an outcome.

The Tett and Burnett (2003) model posits that individual personality traits have a main effect on work behavior, which in turn has a main effect on job performance, in our study individual satisfaction with the team. Tett and Burnett (2003) expected these main effects to be moderated by five situational features (three of which are work-related and two of which are reward-related), which evoke differential levels of personality trait activation. For our study, the work-related *social* situational feature they proposed as a moderator is particularly of interest. It encompasses the social environment a person has to work in and the "trait-relevant cues" (p. 503) arising from it. Clearly, when working in a team, the social environment a person has to work in and from which trait-relevant cues

arise is created by the other team members. So, based on the Tett and Burnett (2003) model, we expect that individual team member personality predicts individual satisfaction with the team, but this relationship may be moderated by the social environment. In this study the social environment is operationalized as: personality trait dissimilarity between an individual team member and the other team members.

3.4 Hypotheses

The lack of studies that reported on the relationship between the Big Five and individual satisfaction with the team prompts us to take an exploratory approach to hypothesizing on these relationship. We elaborate on relationships we expect to exist between individual satisfaction with the team and (a) individual personality traits, (b) trait dissimilarity between an individual team member and the other team members, and (c) the interaction between both, each time ending with trait specific hypotheses.

It is easily conceivable that an individual's personality predisposes him/her to like or dislike teamwork. People high on extraversion, agreeableness, and emotional stability can generally be expected to like working in a team. A team offers extraverts the means to be assertive, to talk, and to socialize (Neuman et al., 1999). Agreeable persons can cooperate, be courteous, and friendly in a team. Emotionally unstable people will feel insecure in a team environment. In addition, they are high on negative affectivity (Judge et al., 2002) which in general makes them judge things more negatively. Influences like those described above will probably increase individual satisfaction with the team for team members high on extraversion, agreeableness, and emotional stability. Molleman, Nauta, and Jehn (2004) indeed found that individual team member emotional stability was positively related to individual team member's task satisfaction. Furthermore, Judge and his colleagues (2002) found significant positive relationships between extraversion (.25), agreeableness (.17), neuroticism (-.29) and job satisfaction (the negative relationship found between neuroticism and job satisfaction would have been positive if emotional stability were used) in their meta-analysis on a group of 163 independent samples.

Although Judge et al. (2002) found a positive relationship between individual conscientiousness and job satisfaction (.26), we do not expect to find such a relationship with regard to satisfaction with the team. Individual conscientiousness is consistently

positively related to individual performance (see e.g., Barrick & Mount (1991); Salgado (2003)), but in a project team performance is dependent on the team, not the individual team member. This is supported by the finding that in teams the team level of conscientiousness is a positive predictor of team performance (see Chapter 2). The effect of individual conscientiousness on satisfaction will therefore most likely be dependent on the team someone works with, perhaps through the team's effectivity. Indeed Molleman et al. (2004) found that the individual level of conscientiousness did not predict individual team member task satisfaction, but the team level of conscientiousness did.

In speculating about effects of openness to experience on individual satisfaction with the team, opposite effects can be expected. On the one hand imagination, curiosity, originality, and broad-mindedness may aid the team in arriving at a high quality concept for their design. On the other hand, team members that are highly open may remain curious, original, and broad-minded throughout the project, resulting in ever new suggestions on how to build the design, which in fact hampers the completion of the selected design in the end phase of the design project. The satisfaction open team members may experience in the conceptual phase of the project may be negated by their negative experiences (regarding not being able to keep implementing new conceptual ideas) in the finalizing stages of the project. This line of reasoning is supported by results from Molleman et al. (2004), who found no relationship between individual team member openness and individual task satisfaction, and by results from Judge et al. (2002), who found no significant relationship between openness and job satisfaction (.01) in their meta analysis. This makes our first hypothesis:

> *Hypothesis 1: Individual extraversion, agreeableness, and emotional stability are positively related to individual satisfaction with the team.*

With regard to effects of dissimilarity between an individual team member and the other team members (cf. Tsui, Egan, & O'Reilly, 1992) on team outcomes, scholars discern between (a) *complementary fit*, and (b) *similarity fit* (e.g., Neuman et al., 1999; Tett & Burnett, 2003). Complementary fit occurs when each team member brings in his/her unique qualities, the combination of which leads to positive outcomes (e.g., Belbin's (2004) team

role theory). Similarity fit occurs when team members possess characteristics that are similar and --through reduction of uncertainty because of comparison with similar others in the social environment (Festinger, 1954)-- this similarity leads to positive outcomes (Byrne, 1971). Both types of fit received scientific support (for an overview, see Byrne, 1997; Milliken & Martins, 1996).

Although effects of similarity on a number of personality characteristics have been researched, this has not been done for the relationship between individual Big Five traits on individual outcomes of teamwork. We think that for the relationship between the Big Five personality traits and individual satisfaction with the team a similarity fit expectation may hold best. If team members are dissimilar in personality, they will join the team with different --possibly even conflicting-- expectations or goals. Team members will act on their individual expectations and/or goals and if team members are dissimilar, they will thus display differential behavior regarding e.g., effort, goal setting, scheduling, and communication. For instance, one might expect highly extravert team members to devote a lot of time to social interaction, whereas more introverted team members may prefer to diminish this kind of interaction to a necessary minimum. If differences in personality traits lead to such implicit or explicit differences in individual goals or to the unsharedness of approaches followed within the team, this may pose a threat to a team's effectiveness. The detrimental effect of conflicting individual goals within a team on team effectiveness has already been demonstrated in previous research (e.g., Alper, Tjosvold, & Law, 1998; Van Vijfeijken, Kleingeld, Van Tuijl, Algera, & Thierry, 2002). This negative effect may easily translate into dissatisfaction with the team. Therefore, we generally expect to find a negative effect of dissimilarity in personality on satisfaction with the team.

More specifically, we expect these effects of dissimilarity in personality to be more salient for traits that relate to behavior that will frequently be displayed in order to complete the project (extraversion and conscientiousness), since the reason work teams are assembled is to complete the team task. We elaborate this expectation for both traits separately. To be able to finish their project, team members often are highly interdependent (Guzzo & Dickson, 1996), among other things because of distributed expertise (Salas, Dickinson, Converse & Tannenbaum, 1992; Sundstrom, De Meuse, & Futrell, 1990). This makes interaction of vital importance: team members have to communicate about ideas,

work approaches, individual contributions, progress, and problems that are encountered. They have to be assertive in taking actions toward project completion (cf. Van Vianen & De Dreu, 2001). In view of the fact that these are all behaviors that are related to extraversion, dissimilarity in extraversion may be expected to negatively affect team effectiveness and as a consequence team members' satisfaction with the team. Furthermore, as projects usually have a hard, fixed deadline it is equally important for project teams to set goals, schedule time, and assert effort towards timely completion of the team task. These are all behaviors typically associated with conscientiousness, so dissimilarity in conscientiousness may also have a negative effect on project team effectiveness (cf. Chapter 2) and likewise on team member's satisfaction with the team.

Openness to experience may also have been important with regard to task completion of the project teams under study. But, as with individual openness, effects can work either way. Dissimilarity in openness may be expected to be beneficial, as this may foster team effectiveness and thus satisfaction with the team (as highly open team members may come up with many conceptual ideas, whereas lowly open team members may stick to the selected idea in the end phase of the project). But these differences may also result in disagreement or conflict amongst team members over work approaches and thus lower satisfaction with the team. The fact that these effects may outbalance each other is to some extent supported by Molleman et al. (2004) who did not find an effect of team level openness to experience on individual team member task satisfaction. This makes our second hypothesis:

> *Hypothesis 2: Dissimilarity in extraversion and conscientiousness between an individual team member and the other team members is negatively related to individual satisfaction with the team*.

For traits for which dissimilarity is of influence on individual satisfaction with the team (extraversion and conscientiousness), a moderation of effects by the individual level of that trait may be expected to occur. To start with extraversion, we expected dissimilarity in extraversion to be negatively, and individual extraversion to be positively related to satisfaction with the team. This would mean that the most satisfied team members would be

those who are highly and similarly extravert. However, in a team with such members socializing may gain the upper hand over completing the task (Barry & Stewart, 1997; Mohammed & Angell, 2003). Furthermore, in a team composed of too many highly extravert and thus dominant individuals, members may likely engage in conflict over team issues (Mazur, 1973), like, for instance, leadership (Barry & Stewart, 1997; Mohammed & Angell, 2003). This expectation is partly empirically supported by Barry and Stewart (1997) who showed that intermediate levels of extraversion within a team lead to high team performance. We therefore propose the following hypothesis:

> *Hypothesis 3a: Dissimilarity in extraversion has a negative effect on individual satisfaction with the team for members low in extraversion, but not for members high in extraversion.*

The moderation for conscientiousness may be different. As we elaborated in the preamble to our first hypothesis, individual conscientiousness has been found to be a positive predictor of individual performance, and the team level of conscientiousness is a positive predictor of team performance. Moreover, Molleman et al. (2004) found that the team level of conscientiousness is positively related to individual team member task satisfaction. Combining this with our expectation that dissimilarity to other team member's conscientiousness is negatively related to satisfaction with the team, high individual conscientiousness may be --probably partly through team effectiveness-- positively related to satisfaction in teams in which team members are similarly conscientious. This makes our final hypothesis:

> *Hypothesis 3b: Dissimilarity in conscientiousness has a negative effect on individual satisfaction with the team for members high in conscientiousness, but not for members low in conscientiousness.*

3.5 Method

Participants and Procedure

All participants were members of student project teams (Sundstrom, 1999) that completed an engineering design assignment over a one-, six-, or 13-week-period at a Dutch university of technology. The student teams completing the one- or six-week period assignment were multidisciplinary teams that had to design and build a robot that had to perform a specific task. They faced similar constraints in that the resources were predefined and the deadline was hard. The student teams completing the 13-week assignment were teams composed of students of engineering that had to redesign a specific part of an organization and give precise instructions for the implementation of the proposed changes. These teams also faced a hard deadline. All teams had to report to their instructors on similar parts of their project: the results of their problem analysis, (selection of) concept ideas, and the elaboration of the selected concept. The research was introduced to them via a presentation in which they were told that we were interested in how design processes and outcomes in teams varied as a function of the team's composition, since team members differ in various ways (teamwork approach, personal goals, subject of study, willingness to invest effort). At the end of the presentation the students were asked to volunteer as participants in our research. They could indicate whether they appreciated feedback about their personality scores and the results of the study. If appreciated, this information was sent to them after completion of the research.

In total 68 teams were included in the research (n_{team} 1-week assignment = 11, n_{team} 6-week assignment = 14, and n_{team} 13-week assignment = 43). Team size ranged from 3 to 7 members, mean team size was 5.33. The respondents filled out a personality questionnaire before they started working on their assignment. The team members indicated their individual satisfaction with the team in a questionnaire they filled out at the end of the assignment, before their project was evaluated and graded. So, for the majority of teams, satisfaction with the team was rated after working together from one and a half up to three months. The written instruction on the questionnaire stressed the importance of filling it out individually. The research leader repeated this instruction orally. She stayed with the respondents during the filling out of the questionnaire and saw to it that instructions were actually followed. 310 respondents filled out both questionnaires, 257 (82.9%) of whom

were male and 53 (17.1%) female. Teams were only included if the personality questionnaire was filled out by all (n_{team} = 58), or by all minus one team member (n_{team} = 10). 11 teams (13.9%) did not meet our criteria for inclusion. Of the teams included 33 (48.5%) were all male, of the remaining 35 (51.5%) of the teams on average 66.6% of the members was male.

Measures

The Big Five personality traits were measured using a self-report of the extensively validated Five-Factor Personality Inventory (Hendriks et al., 1999). Each trait was measured by 20 items (ten positively and ten negatively formulated), which were scored on a 5-point scale varying from *not at all* (1) to *completely* (5). Examples of items on the Big Five dimensions measured are: *extraversion* 'Makes friends easily' (positive), *agreeableness* 'Orders people around' (negative), *conscientiousness* 'Does unexpected things' (negative), *emotional stability* 'Keeps a cool head' (positive), and *openness to experience* 'Is full of ideas' (positive).

Satisfaction with the team was measured by 3 newly formulated items, which were based on the definition of satisfaction with the team we presented in the introduction (Table 3.1). All items were scored on a 5-point Likert scale varying from *strongly disagree* (1) to *strongly agree* (5). As we constructed a new scale, confirmatory factor analysis was performed on these three items (Principal Axis Factoring). As expected, all items loaded on the same factor, with a common variance of 82.72% and an eigen value of 2.48.

Table 3.1 *Items of the Satisfaction with the Team Scale*

To what extent do you agree with the following statements?
1. Taken as a whole, I was satisfied with the composition of our design team.
2. Taken as a whole, things went pleasantly within our design team.
3. If I ever had to participate in a similar project again, I would like to do it with this team.

Operationalizing Individual Personality in a Team Context

As we study effects of team composition at the individual level, our operationalizations differ from those used in previous team composition research with analyses conducted at the team level. In the latter, individual trait scores are usually aggregated to elevation and diversity or variability scores at the team level to assess the effects of trait elevation (team mean scores (e.g., Barrick et al., 1998), or proportions high scoring team members (e.g., Neuman et al., 1999)) and trait diversity (team variance scores (e.g., Van Vianen & De Dreu, 2001)) or standard deviation scores (e.g., Mohammed & Angell, 2003)). The way we operationalize elevation and diversity on the individual level is discussed below.

The operationalization of individual team member personality is straightforward: It is the score of a team member on each of the five traits. The higher this *individual trait* score, the more the trait presents itself in that person.

In order to operationalize dissimilarity between an individual team member and the other team members, a person's personality has to be positioned in relationship to that of his/her team colleagues. It has to be what Kozlowski and Klein (2000) call a 'configural' concept. It is derived from attributes of the individual team members, but it has meaning on the level of the team. Since the focus of our study is on effects of personality, in our case the configural concept has to reflect the differences in personality traits between team members. To express these differences or dissimilarity in personality we deploy a demographic similarity equation, previously used by Wagner, Pfeffer and O'Reilly (1984) and Zenger and Lawrence (1989), to establish (dis)similarity for age and tenure between a single team member and each of the other team members. We think the use of such an equation for our study purposes is mathematically justified, because the assumptions underlying the age and tenure measures (ratio scales) are more restrictive than the ones underlying personality measures (ordinal/interval scales). Translating the demographic similarity equation used by Zenger and Lawrence (1989) to measure personality dissimilarity in teams, personality trait dissimilarity within a team is defined as:

$$trait\ D_i^G = \left[1/\text{n-1} \sum_{j \neq i \in G} (x_i - x_j)^2\right]^{1/2},$$

where the *trait* D_i^G is the extent to which a team member *i* within team G differs from his/her team mates *j* with respect to the trait in question, *n* is the number of members within team G, and *x* is the score on the personality trait in question. For each team member the trait D_i^G is computed for each of the five traits. Zero trait D_i^G scores indicate perfect similarity, whereas high trait D_i^G scores (maximum ≈ 4.0) indicate dissimilarity.

Finally, the interaction terms are computed by standardizing both the individual trait scores and trait D_i^G scores and by multiplying these per trait. We labeled these interaction terms 'individual trait scores * trait D_i^G scores'.

Data-analysis

The descriptive statistics (range, mean, standard deviation, and coefficients alpha) of the variables are presented in Table 3.2. At item level, the respondents used the full answer range (1–5) for each of the individual measures, so no range restriction occurred. As can be seen, the coefficients alpha of all scales are well above satisfactory levels. The correlations between all study variables are presented in Table 3.3.

To test our hypotheses, hierarchical linear modeling was applied and significance of outcomes was determined one-tailed with an alpha of .05. In model 1, the team members' individual trait scores for each of the five personality traits were entered. In model 2, the trait D_i^G scores for each of the five personality traits were added. Finally, the interaction terms individual trait scores * trait D_i^G scores for each of the five personality traits were added in model 3. The significance of model 1 was tested against the empty model, the significance of model 2 and 3 was tested against the previous model. To control for effects of team size, gender, and duration of the assignment their effect on individual satisfaction with the team was tested separately and models 1 through 3 were also tested controlling for these variables. Neither of these variables did uniquely add to the variance explained norsignificantly predict individual satisfaction with the team. For reasons of parsimony we therefore only report results without the control variables here. To conclude the tests, significant interactions were plotted following Aiken and West's (1991) simple slope procedure. Using centered scores for the predictor variables, the regression equations were rearranged into simple slopes of individual satisfaction with the team on the individual level

Table 3.2 *Descriptive Statistics for all Research Variables (N=310)*

Variable	*range*	*mean*	*s.d.*	*α*
Individual				
extraversion	1.90 - 4.90	3.81	0.51	.90
agreeableness	2.45 - 4.95	3.70	0.41	.84
conscientiousness	1.95 - 4.55	3.42	0.52	.89
emotional stability	2.50 - 4.90	3.97	0.46	.88
openness to experience	2.55 - 4.70	3.74	0.40	.86
Dissimilarity				
extraversion D_i^G	0.10 - 2.07	0.66	0.32	--
agreeableness $D_i^G{}_i$	0.08 - 1.48	0.52	0.25	--
conscientiousness D_i^G	0.09 - 1.77	0.63	0.31	--
emotional stability D_i^G	0.07 - 1.53	0.57	0.27	--
openness to experience D_i^G	0.06 - 1.36	0.52	0.26	--
Individual satisfaction with the team	1.00 - 5.00	3.96	0.91	.88

of a personality trait (M + 1 SD; M - 1 SD), given the conditional values of the trait D_i^G scores for that personality trait (M + 1 SD; M - 1 SD).

3.6 Results

Table 3.4 shows the results of the hierarchical linear modeling of individual satisfaction with the team. Entering the individual trait scores (model 1) resulted in a marginally significant model ($\chi^2(5) = 9.58$, $p \leq .10$, $\Delta R^2_{ind} = .03$, $\Delta R^2_{team} = .02$). Adding the trait D_i^G scores (model 2) added significantly to the variance explained ($\chi^2(5) = 12.60$, $p \leq .05$, $\Delta R^2_{ind} = .03$, $\Delta R^2_{team} = .03$). Adding the individual traits score * trait D_i^G score interaction terms (model 3) also resulted in a significant increase of the variance explained ($\chi^2(5) = 11.32$, $p \leq .05$, $\Delta R^2_{ind} = .05$, $\Delta R^2_{team} = .05$). Since model 3 is the full model, we limit our discussion of the results to this model.

In model 3, 11.0% of the variance in individual satisfaction with the team is explained at the individual level and 10.0% of the variance is explained at the team level. With respect to H1 the results show that as expected individual agreeableness ($b = .27$; $p = .03$), and individual emotional stability ($b = .36$; $p = .01$) are significantly and positively

Table 3.3 *Correlations between all Study Variables (N=310)*

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1.	Team size	--												
2.	Gender	-.10	--											
3.	Assignment period	.08	-.01	--										
4.	Individual extraversion	-.07	.05	.09	--									
5.	Individual agreeableness	.01	.03	-.05	-.02	--								
6.	Individual conscientiousness	.04	.23	.19	.00	.25	--							
7.	Individual emotional stability	-.02	-.28	-.05	.43	.21	.03	--						
8.	Individual openness to experience	-.04	-.04	.03	.44	-.16	.05	.45	--					
9.	Extraversion D_i^G	-.02	-.03	-.02	-.24	.03	.04	-.05	.03	--				
10.	Agreeableness D_i^G	.14	-.07	.02	-.06	-.20	-.05	-.01	.13*	.17	--			
11.	Conscientiousness D_i^G	.00	.02	-.15	.04	.00	-.12	.06	.02	.06	.25	--		
12.	Emotional stability D_i^G	.07	.06	.15	-.14	-.05	.00	-.24	-.03	.17	.00	-.08	--	
13.	Openness to experience D_i^G	.01	-.08	-.05	-.04	-.03	-.03	.02	-.07	.36	.07	-.02	.07	--
14.	Individual satisfaction with the team	.07	-.10	-.03	.07	.15	.09	.17	.07	-.09	-.11	-.16	.00	.00

Note. All correlations above .10 are significant at $p \leq .05$ (one-tailed); All correlations above .14 are significant at $p \leq .01$ (one-tailed)

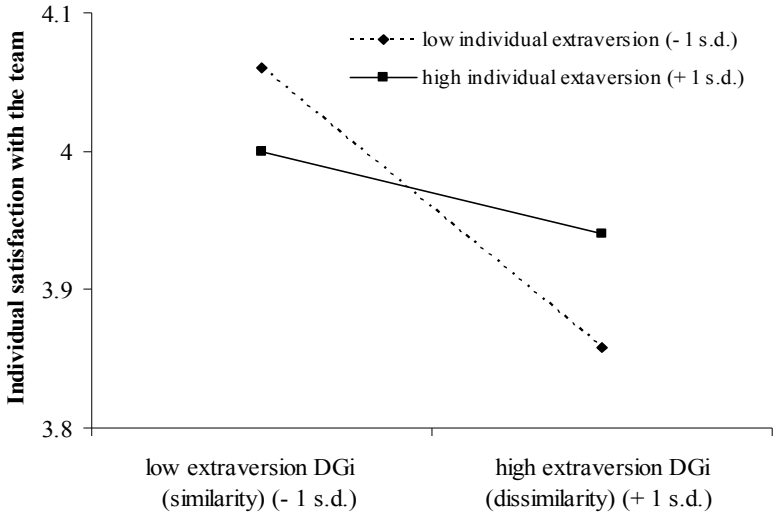

Figure 3.1 Interaction between individual extraversion*extraversion D_i^G

predicting individual satisfaction with the team. We also expected to find a positive main effect of extraversion, but this is not supported by our results (b = -.09; n.s.). So, the more agreeable and emotionally stable team members are, the more satisfied they are with their team.

With respect to H2 the results show that conscientiousness D_i^G (b = -.58; p = .001) is a significant negative predictor of individual satisfaction with the team, but, although results tend in the predicted direction, extraversion D_i^G (b = -.27; p = .08) is not. So, the more dissimilar team members are from their team mates with respect to conscientiousness, the less satisfied they are with their team.

When testing the moderation of effect for dissimilarity in extraversion (H3a) and conscientiousness (H3b), we only find a significant interaction for individual extraversion * extraversion D_i^G (b = .07; p = .01), and not for individual conscientiousness * conscientiousness D_i^G (b = -.05; p = .09). We plotted this interaction for extraversion in Figure 3.1. In line with H3a, extraversion D_i^G has a stronger negative relationship with individual satisfaction with the team for individuals low on individual extraversion (represented by the dotted line) than for those high in extraversion (represented by the solid

Table 3.4 *Hierarchical Linear Modeling of the Individual Trait Scores, the Trait D_i^G Scores, and the Interaction between Individual Trait Scores * Trait D_i^G Scores with Dependent Variable Individual Satisfaction with the Team (N = 310)*

Variables	*model 1*	*model 2*	*model 3*
Individual			
extraversion	.09	.05	-.09
agreeableness	.15	.16	.27*
conscientiousness	-.01	-.04	.05
emotional stability	.19*	.21*	.36**
openness to experience	-.15	-.13	-.01
Trait D^G_i			
extraversion		-.39**	-.27
agreeableness		.04	-.08
conscientiousness		-.52**	-.58**
emotional stability		.22	.14
openness to experience		.13	.11
Individual * Trait D_i^G			
extraversion			.07*
agreeableness			-.04
conscientiousness			-.05
emotional stability			-.05
openness to experience			-.05
-2*loglikelihood	*717.98*	*705.38*	*694.06*
χ^2	*9.58*	*12.60**	*11.32**
df	*5*	*5*	*5*
$\sum R^2_{ind}$	*.03*	*.06*	*.11*
$\sum R^2_{team}$	*.02*	*.05*	*.10*

Note. Intra class correlation = .48; unstandardized beta coefficients are shown for all variables;
* $p \leq .05$ (one-tailed); ** $p \leq .01$ (one-tailed); each model was tested against the previous model

line). So, the negative effect of dissimilarity in extraversion is moderated by individual extraversion: the negative effect of dissimilarity in extraversion on individual satisfaction with the team is the strongest for team members low in individual extraversion.

3.7 Discussion

We set out to answer the research question: How does team composition in terms of the personalities of the team members influence the satisfaction individual team members feel about working in their particular team? In answer to this question we found effects for individual personality, dissimilarity to other team members' personality, and for the interaction between both. Results show that team member's satisfaction with their team increases if they are more agreeable and emotionally stable, more similarly conscientious, and similarly and lowly extravert. We expected similarly and highly conscientious individuals to be most satisfied with their team, but results did not support this expectation. Apparently dissimilarity to other team members' conscientiousness has such a disruptive effect on satisfaction with the team that the individual level of conscientiousness is only of minor influence.

It is interesting to note that the differences in effects for specific traits generally coincide with a distinction between the so-called task-related traits (that aid in completing the team task) and the team-related personality traits (traits that facilitate smooth team functioning) (Halfhill, Sundstrom, Lahner, Calderone, & Nielsen, 2005; Mohammed et al., 2002). Mohammed et al. (2002) label conscientiousness task-related, and agreeableness, extraversion, and emotional stability team-related (based on Costa & McCrae, 1992; Hough, 1992; McCrae & Costa, 1989; Mount, Barrick & Stewart, 1998). In their study, Mohammed and colleagues found different effects of these sets of traits on team performance. In our study, the team-related traits agreeableness and emotional stability have a main effect on satisfaction with the team. The task-related personality trait conscientiousness affects satisfaction with the team through the similarity to other team members. Such a differential effect of cues coming from the task and from the team was indeed proposed by Tett and Burnett (2003). Our findings thus provide additional support for the differentiation between task- and team-related personality traits.

The only trait for which findings somewhat deviated from this categorization is extraversion. There was no positive main effect of individual extraversion, but the interaction shows that highly extravert team members are about equally satisfied with their team, whether they are similar or dissimilar to others. This finding is somewhat in line with effects found for the other team-related traits. The fact that we find an effect of dissimilarity

for this trait as well may be ascribed to the fact that extraversion may not merely be important for smooth team functioning. It may also be vital for task completion, as we argued in the introduction.

Limitations, Implications, and Future Research

With regard to our conclusions, we have to point out some limitations. First of all, our research was conducted among student project teams completing a design assignment. Results may be different for professional design or project teams. Secondly, personality scores were established using self-report. One might argue that all team members should rate the personality of their teammates in order to establish convergence between their impressions of all team members' personalities. Since much research evidence has already established this convergence (e.g., Albright, Kenny & Malloy, 1988; Bernieri, Zuckerman, Koestner & Rosenthal, 1994; Funder, Kolar & Blackman, 1995), we do not expect such an extension of personality measurement to change our results dramatically. Thirdly, the effects we found are generally somewhat small. We think this may be attributed to the fact that individual perceptions of satisfaction with the team are influenced by other factors than the individual's personality**,** for instance, by implicit or explicit expressions of team evaluations made by the other team members (cf. Molleman et al., 2004; Salancik & Pfeffer, 1977; Umphress, Labianca, Brass, Kass, & Scholten, 2003). Although the way an individual deals with this influence may be affected by his or her personality, the effect of others on perceptions of satisfaction may largely present itself independent from personality. Finally, we focused our research on the average dissimilarity between a team member and his/her team mates on a single personality trait. Of course, other forms of dissimilarity could be thought of too, for instance, the team member that differs most from the other team members (cf. Barrick et al. (1998); Neuman & Wright (1999)). Looking at effects of this kind may offer an interesting direction for future research. It may also be interesting to study effects of cross-trait interactions on individual satisfaction with the team (cf. Witt, Burke, Barrick, & Mount, 2002).

In spite of these limitations, our results hold theoretical, analytical, and practical implications. Theoretically, the application of the Personality Trait-Based Interactionist

Model (Tett & Burnet, 2003) proved to be worthwhile in this instance of team composition research, which is a first step toward an enlargement of the model.

Analytically, we have used an individual operationalization of team composition in terms of personality. This allowed us to look at the effect of dissimilarity between individual team members for a specific trait and at the interaction effect of an individual personality trait score and a trait D_i^G score for each of the Big Five traits, which both have not been considered in earlier team composition personality research. We consider this to be an important strength of our study. Another analytical advantage is the fact that we have tested the effects of all personality trait operationalizations simultaneously, and thus considered personality as a whole. This strengthens the credibility of the pattern of effects that we have found. The pattern that has emerged suggests that the inclusion of an individual trait dissimilarity operationalization is especially fruitful with respect to effects of personality traits that are important for task completion. In future research, it might be interesting to find out whether such a pattern also emerges for other outcome variables of teamwork. At this point we have to emphasize the fact that we focused on project teams that performed a specific kind of task. For other kinds of teams, however, the relationships between personality and satisfaction with the team might be quite different, depending on the objective of those teams (e.g., in hobby teams completing a task may be subordinate to having a good time together). If so, other personality traits may become important during the interaction between team members. Mohammed et al. (2002) demonstrated that team-related personality traits predict contextual performance, which concerns interpersonally oriented behaviors that support the social and motivational context in which a team operates (Borman & Motowidlo, 1993), and emphasizes moral and showing personal concern (Conway, 1999). If the objective of a team were of a more contextual nature, one might expect to find interaction effects for the team-related personality traits. Additional research is needed to be able to support this expectation.

Practically, if people have to work in teams the members of which have to work together repeatedly, one would like them to hold a positive attitude towards teamwork. Therefore, being satisfied with the team one works in might be an important condition. Based on our results the personality of team members can be used as a criterion for team composition in order to have members satisfied with their team. But considering the fact

that this study is the first in its kind, we feel more research is necessary in this respect to be able to propose recommendations in this direction. Moreover, in common day practice, work or project teams often do not remain stable in their composition due to a number of causes. A more feasible alternative to manipulating team composition is therefore to train members to become aware of each other's personality and to deal with the negative effects dissimilarities in team member personality have on teamwork.

To end where we started, we feel it is important to stress the value of individual satisfaction with the team as a variable in team effectiveness research. Seen from an organizational effectiveness perspective, individual satisfaction with the team is important because it is related to the effort and performance of team members (Lester et al., 2002). Seen from a more human perspective, for a large number of people work is nowadays an important determinant of life fulfillment. Therefore, employees become more demanding of their work environment, which includes people they have to work with. Satisfaction outcomes are important indicators of how employees perceive their work environment. Considering both reasons in light of the fact that work is increasingly performed within teams, highly satisfied team members may provide organizations with happy, hardworking employees (Fisher, 2003).

Chapter 4

Design Behavior in Teams: The Construction of Measurement Scales and a Practical Application [*]

In two studies a questionnaire to measure the behavior of members of multidisciplinary design teams was constructed. In study 1 the Critical Incident Technique was used to interview 13 professional multidisciplinary design team members with various backgrounds to collect behaviors that are critical for successful design task completion. These behaviors were structured into the Design Behavior Scales for Teams (DBST). In study 2 data from 25 multidisciplinary student design teams were collected and used to test the structure, content, reliability, and stability of the DBST. The resulting Design Behavior Questionnaire for Teams consists of 55 items divided into three main categories ('design creation', 'design planning', and 'design cooperation').

For many people the word 'design' automatically brings to mind images of luxurious and fashionably styled commodities designed by well-known designers. However, the larger part of designing happening nowadays results in the less eye-catching interiors of high-tech objects that modern society could not be imagined without. Think, for instance, of mobile phones, computers, medical equipment, or audio-visual media. The technological development of these objects has taken flight and keeping up with this pace is one of the

[*] This chapter is based on: Peeters, M. A. G., Van Tuijl, H. F. J. M., Reymen, I. M. M. J., & Rutte, C. G. *Design behavior in teams: The construction of measurement scales and a practical application.* Manuscript submitted for publication.

challenges technological organizations and their designers face. The advanced state of the technology that is to be used during designing as well as the technology that is to be designed calls for designers with increasingly diverse and specialised knowledge and skills. Since it is hardly possible for any single designer to answer this call, designing is ever more done by multidisciplinary teams (e.g., collaborative design, new product development teams, research and development teams). These multidisciplinary design teams, in which specialised designers combine their knowledge, skills, and effort to come up with designs for high-tech products (Carroll, 2000; King & Anderson, 1990; Valkenburg, 2000), are the ones we concentrate on in this study.

As straightforward as this combining of resources in a team may sound, successfully completing a design task within a multidisciplinary design team is an intricate matter given the complex force field in which it has to be completed (e.g., Dorst, 2003). The tight deadlines, high technological standard, management of a team of 'self'-willed designers (Cross & Clayburn-Cross, 1996; Dorst, 2003; Hales, 1993), and problems arising during interaction between designers with different knowledge (Busby, 2001) are all potential threats to the effectiveness of multidisciplinary design teams in terms of design processes. To gain insight into behavioral aspects of design processes, a number of them have been studied so far: communication (Eckert & Stacey, 2001; Stempfle & Badke-Schaub, 2002), negotiation (Stumpf & McDonnell, 2002), reflection (Valkenburg, 2000), and social processes (Cross & Clayburn-Cross, 1996). Each of these aspects was studied separately, but clearly they are not independent. The force field in which designing takes place not only owes its complexity to those many aspects, but even more so to their intertwinedness. In order to do justice to this complexity, studies into factors contributing to design team effectiveness should take a more integrative approach, which is also noted by some of the researchers mentioned above. Our aim in this study is to use such an integrative approach in order to develop an instrument to measure those factors, the *Design Behavior Questionnaire for Teams* (DBQT). With the DBQT behavior directed at successful design task completion within multidisciplinary design teams can be measured. It is aimed to provide a generic reflection of the behavioral aspects of the design process that support or hinder successful design task completion as fully as possible.

The approach we adopted to establishing the DBQT is analysing the task of multidisciplinary design team members. Using task analysis, researchers and practitioners (e.g., HRM) aim to provide a complete description of behavior that is critical for successful completion of a specific job, function, or task. To our knowledge, designing in multidisciplinary teams has not been subjected to a task analysis before. Doing so may not only aid in establishing the criticality of the behavioral aspects with regard to successful design task completion, it may also turn out to be a worthwhile procedure for integrating separate behavioral aspects of the design process of multidisciplinary design teams that were objects of study so far.

When studying design activities, some well-accepted concepts are those of Dorst (1997) and Roozenburg and Dorst (1991), who distinguish between the *design task*, *design process dynamics*, and *designers*. In the remainder of this introduction we discuss all three concepts. First, we discuss the design task in terms of successful completion. Second, we present our research question and specify the dynamics of the design process we concentrated upon when studying successful design task completion. Third, having delineated the former two dimensions within the scope of our research, we discuss how the designers relate to both processes and outcomes.

With respect to the first concept, the design task, it is important to define successful design task completion, because this is the criterion against which the criticality of design team member behavior has to be judged. Generally, irrespective of the background or multidisciplinary composition of a design team, successful design task completion adheres to the same three criteria (cf. Frankenberger & Badke-Schaub, 2002): (1) the final design solves the problem it was intended to solve, given the demands of the stakeholders (clients, users) and additional requirements and restrictions that originated during the design process, (2) the final design is delivered within predefined costs limits, and (3) the final design is delivered within predefined time limits. Everyday practice learns that quite often not all of these criteria can be fully met. Naturally, a final design has to solve the problem for which it was designed, but with regard to specifications, costs, and deadlines, parties involved often have to settle for less in mutual agreement. For which criteria parties decide to mitigate demands may vary per project. It is therefore crucial to know what design team members from various backgrounds mean when they speak of successful design task

completion, before they can be asked to specify behavior directed at it. Following our line of reasoning, it seems logical to assume that quality will be the prime criterion by which successful design task completion is judged. This assumption has to be corroborated for any new sample under study, as is the assumption that quality, costs, and time are the main outcome criteria.

The second concept, the design process dynamics, more specifically the behaviors of the designers when involved in designing, are the actual object of our study. The question we research is: *What specific design team member behaviors are critical in order to establish favorable dynamics during designing, thereby resulting in successful completion of the design task of multidisciplinary design teams?* We focus on *behaviors* (cf. Günther & Erhlenspiel, 1999), because behavior is an observable design process characteristic, that can be discussed or affected in order to manage effectiveness. Naturally, for effectiveness only *critical* behaviors are of interest. In addition, we focus on *specific* behaviors, since the more specific behaviors are described, the more information they provide for actions to be taken. We acknowledge that cognitive processes may also be critical for designing (Cross, 1990, 1999). However, cognitive processes are difficult to influence, because they cannot be observed directly. Moreover, behavior can be considered the resultant of the cognitions that preceded it. Therefore, cognitions fall outside the scope of our study.

Having established what information we need in order to answer our research question, we can now specify where to obtain this information. This is where the third concept distinguished above, the designers, comes in. Designers are a central element in this study, because we consider them to possess expert knowledge on (a) the behavior they display during the course of the design process, and (b) how in their experience this behavior relates to successful design task completion. We draw upon this rich source of designers' expert knowledge for our task analysis. The behavior of designers who collaborate within multidisciplinary teams has been the object of study before. Up till now, design team member behavior has been studied in protocol studies in both lab (e.g., Cross, Christiaans & Dorst, 1996) and field settings (e.g., Badke-Schaub & Frankenberger, 2002), in ethnographic (field) studies (e.g., Baird, Moore & Jagodzinsky, 2000; Bucciarelli, 1988; Eckert & Stacey, 2001), in case studies (e.g., Peng, 1994; Sonnenwald, 1996), and in interviews (e.g., Denton, 1997; Lawson, 2004; Reid, Culverhouse, Jagodzinski, Parsons, &

Burningham, 2000; Tomes, Oates & Armstrong, 1998). As stated before, the majority of these studies have focussed in depth only on a single behavioral aspect of the design process. By making exhaustive use of the knowledge of designers, we are able to look at designing in multidisciplinary teams with a broader view.

In order to convert designers' knowledge into a valid and reliable questionnaire, a particular method is required. The construction of the instrument has been done in two steps, which are subsequently described in study 1 'Task analysis on designing in multidisciplinary teams', and in study 2 'Constructing the Design Behavior Questionnaire for Teams'.

4.1 Study 1 Task Analysis on Designing in Multidisciplinary Teams

Method

To perform our task analysis of designing in multidisciplinary teams, we used the Critical Incident Technique (CIT) (Flanagan, 1954). The CIT "consists of a set of procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles" (p. 327). Flanagan defines an incident as "any observable human activity that is sufficiently complete in itself to permit inferences and predictions to be made about the person performing the act" (p. 327). Furthermore, he states that critical incidents that are collected should have "special significance" and should meet "systematically defined criteria". Over the years the CIT has proven its worth: entering 'critical incident technique' in the PsycInfo database provides well over 200 hits of studies in which the CIT has been used. Given its definition, this technique is very useful for our purposes, since we aim to solve the practical problem of developing an instrument that maps critical behavior displayed by designers during design work in multidisciplinary teams. To construct the *Design Behavior Scales for Teams* (DBST), we followed the five steps described for the CIT (Flanagan, 1954). Here we shortly present each step as applied in our study. For a more detailed discourse on each of these steps, we refer to Flanagan (1954, pp. 336-346).

In step 1 'General aims', the goal of designing in a multidisciplinary team was described. The goal of this activity is successfully completing the design task. As we discussed in the introduction, the prefix 'successfully' might adhere to the quality of the

design, its timely delivery, or the costs involved. We presumed that the quality of the design would be the most important criterion when determining successful design task completion and that timeliness and costs might take a second place. However, we acknowledged that the order of these outcomes might be different, or that the list of outcome criteria may be considered incomplete by the interviewees or the companies for which they design. We therefore checked this early on in our interviews by asking respondents how they and their organization define a successful design.

In step 2 'Plans and specifications', we defined what situations are of interest and what persons are to be interviewed on these situations. We considered all situations regarding the actual designing within multidisciplinary teams of relevance. Since multidisciplinary design team members and team leaders experience these situations on a daily basis, we considered them to be the most appropriate persons to be interviewed. We contacted candidates for the interviews via the institute that provides eight 2-year post-master's design programs leading to a Professional Doctorate in Engineering (PdEng) at the Technische Universiteit Eindhoven. During these programs attention is specifically focussed on cooperation within multidisciplinary teams. Since the research was partly performed on the authority of the institute that provides the PdEng-programs, we were granted access to their alumni database. A short (11 item) questionnaire was sent to all traceable alumni (about 400) of the PdEng-programs. In the questionnaire the alumni could indicate whether they were currently working in a multidisciplinary design team, whether they worked on an incremental (improve upon an existing design) or innovative (create a new design) design project, whether they were project leader or not, within which branch their design team operated, and whether they were willing to participate in an interview on designing in multidisciplinary teams. The alumni were given two weeks to respond to the questionnaire. After this period, 132 questionnaires (about 30%) had been returned, 20 of which came from multidisciplinary design team members who indicated that they were willing to participate in an interview. To end up with a representative sample, we used the branch the designers reported to be designing in as a selection criterion. These branches overlapped with the major engineering disciplines taught at a university of technology. Since these major disciplines can be distinguished within the majority of multidisciplinary design teams, we considered a sample to be representative if all branches were present. Our

sample met this criterion (see below for the composition of the sample). Selected candidates were contacted and appointments for an interview were made. We conducted 12 interviews with 13 interviewees (one was a duo-interview; one of the interviewees was female). Five of the interviewees were project leader, eight were designer or process engineer. Eight of the interviewees qualified the designing their team(s) did as innovative, four as incremental and one as a combination of both. All 13 interviewees were employed in well-known technological companies in the southeast of the Netherlands. The branches their teams operated in were (a) architecture (n = 1), (b) chemical engineering (n = 3), (c) industrial design (n = 2), (d) information and communication technology (n = 3), (e) mechanical engineering (n = 2), and (f) megatronics (n = 2).

In step 3 'Collecting the data', the interviews were conducted. We constructed an interview scheme in order to guard fulfillment of the interview criteria[3] specified by Flanagan (1954). The first five questions on the interview scheme concerned the description of the interviewee's team(s) in terms of (a) the interviewee's task and roles in the team(s), (b) team composition characteristics (composition criteria and process, size, and disciplines involved), (c) task division and coordination within the team, (d) team contacts (frequency, (in)formality, and content), and (e) other things the interviewee deemed important that had not yet been addressed. The next question on the interview scheme concerned the definition of successful design project completion. We presented our description of it and asked the interviewee to respond[4]. The main part of the interview concerned questions about the critical incidents. The interviewees were asked the following questions: "How do team members contribute to the degree to which the design project is successful? Can you give me concrete examples (preferably not older than six months) of behavior of team members that were critical for the success or failure of the design project? Would you describe per example: (1) What the situation was like, (2) What the team members did in the given

[3] During the interview the interviewer should watch carefully whether the incidents reported (a) relate to the actual behavior that was (b) observed by the interviewee, (c) whether all relevant factors concerning the situation were reported, and whether the interviewee clearly (d) judged and (e) founded the criticalness of the behavior.

[4] A successful design project might be described in terms of quality (or innovativeness for innovative design teams), delivery time, and costs of the partial and end results of the project. How do you describe a successful design project?

situation, and (3) What the effect of their behavior was." The answers to these three questions together formed a critical incident. The interviewees were asked to come up with as many critical incidents as possible.

To be able to prepare themselves, interviewees received this interview scheme a week before the interview took place. All interviews were conducted by the same interviewer, in order to standardize the execution. When an interview started, interviewees were first informed about how the anonymity of the data would be ensured (no names -- personal or organizational-- would be used when transcribing and reporting on this data), about the goal and duration of the interview (one hour), and they were asked to give permission to tape the interview (which all respondents did). Thereafter, the questions on the interview scheme were addressed. If an answer was unclear or less specific than desired, the interviewer would ask for clarification. Only when interviewees could not come up with additional incidents from their own experience, would the interviewer ask about the behavior of team colleagues. When no more incidents could be thought of before the hour had passed, the interview was completed. In conclusion of the interviews, the interviewees were asked if they could be contacted for additional information and if they were interested in a summary of this study. The tapes of the interviews were transcribed and a list of detailed descriptions of all critical incidents was compiled from these transcriptions.

Step 4 ‘Analyzing the data’ and step 5 ‘Interpreting and reporting’ were performed following the detailed description of how to proceed with the categorization offered by Latham and Wexley (1994). Below, we describe how we implemented Latham and Wexley's steps within this study. A more detailed discourse on each of these steps can be found in Latham and Wexley (1994, pp. 56-61).

First, the critical incidents had to be transformed into behavioral items. This was necessary since the literal transcriptions of the critical incidents reported in our interviews did not always provide us with useful phrasings of behavioral items (see Latham and Wexley, 1994, p. 51), or because the critical incidents contained multiple behavioral items. This additional step was not described as such by either Flanagan (1954) or Latham and Wexley (1994).

After having taken out the behavioral items of the critical incidents, we took identically phrased behavioral items together. We used this set of behavioral items as input for the categorization process. Next, 10% of items were taken randomly out of the set (Latham & Wexley, 1994). These items had to be used later on in order to establish content validity. To ensure random selection of the 10% of behavioral items, we used a random number table.

The remaining behavioral items were categorised. According to Latham and Wexley (1994) this categorization is preferably performed by function analysts. For our study, three independent raters performed the categorization. All three raters were well informed on design processes but their background varied: one had a background in engineering and two in work and organizational psychology. The categorization was performed in two sub steps. In the first sub step, the raters used the behavioral items to compose a categorization framework. Each rater used the behavioral items to individually formulate a framework that fitted the data. Then, the raters compared the three individually derived frameworks and discussed and reconciled differences in order to end up with a framework they all agreed upon. Before proceeding to the second sub step, this final framework was checked against the criteria formulated by Flanagan (1954, p. 345) that relate to the transparency of the framework, the organization and magnitude of levels within the framework, and the clarity and applicability of the headings within the framework. In the second sub step, the behavioral items were actually categorised within the framework that resulted from the first sub step. Latham and Wexley (1994) advised that this next step of the categorization should be performed by different raters. However, as we tested the categorization within the framework statistically (in study 2), the need for a new set of raters was not as pressing as it would have been without this test of the framework structure and content. Therefore, the same three raters performed this second sub step of the categorization as well.

After completing the categorization of behavioral items within the framework, its overall interrater reliability was computed by dividing the number of items raters agreed upon by the total number of items within the categorization. The interrater reliability should equal or exceed 0.8. For this study, it was decided that, if the interrater reliability of the categorization should be below 0.8, the raters would engage in discussion to reconcile differences of opinion on the interpretation of the category labels and/or behavioral items.

Subsequently, they would recategorise the items that they disagreed upon independently and the interrater reliability would be computed again for this new categorization.

Finally, the content validity of the categorization was checked using the 10% of the behavioral items that had been left out initially. These were categorised by a fourth rater to ensure independence of ratings. If, based on this categorization, a category had to be added to the framework, or if two or more behavioral items had to be added to a category, content validity would not yet be attained and more incidents would have to be collected.

Results

With regard to alignment on the general aim of designing in multidisciplinary teams (step 1), all interviewees agreed upon the three criteria by which we defined successful design project completion. For the majority, the quality/innovativeness of the design (named first by nine designers, second by two) and timely delivery (named first by three designers, second by seven) were the most important criteria. With regard to costs, only one interviewee named it as primary criterion; most interviewees indicated that costs were predefined in the project plan. Since designers had a similar conception of successful design project completion, their responses could be combined for further analysis.

In total 120 critical incidents (in each of which antecedent, behavior, and consequence were described) were reported by the interviewees (step 3); the majority of the interviewees reported between eight and 12 critical incidents, with one exception of 15 reported incidents (average = 10). This indicates that the responses were evenly spread over the respondents and none of them was overrepresented. From these 120 critical incidents 299 behavioral items regarding team member behavior were extracted. From these behavioral items seven were identical to another item and were therefore taken together as one behavioral item. This left us with 292 behavioral items.

After taking out 10% of the items, the remaining behavioral items were first used to establish a categorization framework (first sub step). When comparing their three individually derived frameworks with each other, all raters agreed upon a distinction of three main categories: ‘design creation’, ‘design planning’, and ‘design cooperation’. The first main category contained items on the actual creation of the design. The second main category contained items that concerned the use of time during the design process. The

third main category contained items on social processes going on between the design team members and between the design team members and their external environment. The raters all grouped the same items under these main categories. However, the categorization of the items within these three main categories of the framework had been done somewhat differently by each of the raters. They therefore discussed the content of their sub categories and reached agreement on a sub division of the main categories. The final framework met all criteria formulated by Flanagan (1954, p. 345), so the framework was adopted to continue the categorization of the behavioral items with. The headings of the main and sub categories of the categorization framework are presented in Table 4.1.

Next, each of the raters categorised all 292 behavioral items within the framework (second sub step). They agreed upon the categorization of 187 of the 266 behavioral items, which resulted in an interrater reliability of .70. After discussion and recategorization of the items that had been disagreed upon, agreement was reached upon the categorization of 243 behavioral items, resulting in an interrater reliability of .92**,** which was satisfactory to continue.

Thereafter, the content validity was checked by categorizing the 10% of the behavioral items that had been left out initially. All items were categorised in accordance with the framework developed by the three raters, only one item was categorised differently. Since this categorization did not result in the need to add a new category or to add two or more behavioral items to an existing category, it was concluded that the content validity of the category structure and classification of behavioral items within it was ensured. In the resulting DBST we included only items that had been agreed upon by all three raters. So, the DBST consists of 243 items divided into 19 categories[5].

4.2 Study 2 Constructing the Design Behavior Questionnaire for Teams

In study 2 we provide an elaborated example of how the DBST obtained in study 1can be used for further instrument development. We added a 5-point rating scale to a selection of the DBST items and used ratings from a sample of multidisciplinary student design teams

[5] The complete list of behavioral items is available upon request from the author.

Table 4.1 *Category Framework for Design Behavior Scales for Teams*

Main category	*Sub category*
Design creation	Establishing the design goal
	Gathering information, generating ideas and solutions
	Restricting/combining solutions, establishing the concept
	Elaborating the design
	Phase transition
	Reflecting on the design
	Adjusting based on reflection
Design planning	Planning time
	Establishing responsibilities per discipline
	Keeping schedule
	Evaluating the schedule, use of time, or meeting of responsibilities
	Adjusting the schedule, use of time, or responsibilities based on evaluation
Design cooperation	Making arrangements about the cooperation within the team
	Cooperation
	Evaluating the cooperation
	Adjusting the cooperation based on evaluation
	Communication
	Making decisions
	Documenting decisions

to statistically test the validity, reliability, and stability of that selection. As a result of these analyses, the *Design Behavior Questionnaire for Teams* (DBQT) can be presented.

Method

Data for this study were obtained from self-managing student design teams that competed in design contests that were held at each of the three universities of technology in the

Netherlands in the autumn of 2003. All competing teams had to design and build from scratch a robot that had to perform a specific task (which differed per university). At the university in Eindhoven the design period was spread out over six weeks. In this period the teams could work on the design project in the time they had available next to the activities on their regular course schedule. At the other two universities (Delft and Enschede) the design period was condensed into a week that was dedicated to this project only (Monday till Sunday). At all three universities the teams could work during the day and during the evening until 22.00h (and 24.00h on the final night). Although the period in which the designing took place differed between universities, the actual designing and building time was roughly similar at each of the universities.

In total 33 teams competed in the contests (N = 158) and on 25 of these teams sufficiently complete data were collected (n = 100-106). The teams were multidisciplinary, ranging from two to up to four disciplinary backgrounds and the average team size was 5.2 members. Of the respondents 85% was male and 15% female.

The selection of teams that were studied had implications for the part DBST that could be tested. All items regarding behavior relating to interaction with a client (dispersed over the design creation and design planning categories) could be left out, since there were no actual clients with whom they had to interact in these design projects. The number of items that remained after taking out these questions was still rather large, which might be expected to influence the response negatively. We therefore wanted the questionnaire to be as tapered as possible and took two additional steps to trim it. First, scales were condensed by combining items into one item if their content allowed us to do so. Second, scales were inspected for their relevance for this selection of teams by asking experienced course leaders (n = 8) of the robot design contest to judge the applicability of each of the sub categories to the teams in their course. A category was retained in the questionnaire if 75% or more of the judges ($n \geq 6$) deemed it important. The categories ‘establishing responsibilities per discipline’, ‘evaluating the schedule, use of time, and meeting responsibilities’, ‘adjusting the schedule, use of time, and responsibilities based on evaluation’, ‘making arrangements about the cooperation within the team’, ‘evaluating the cooperation’, ‘adjusting the cooperation based on evaluation’, and ‘documenting decisions’ did not meet this criterion and were therefore not included in the questionnaire. The

relatively short time span in which these projects took place may have been the most important reason why most of these categories were judged inapplicable. The questionnaire that was presented to the student designers contained 12 DBST categories with a total of 85 items. Each of the items was formulated as a statement that applied to the team. For each statement we asked respondents to indicate to what extent they agreed with it, which they could indicate on a 5-point Likert scale (1= *highly disagree*, 5 = *highly agree*). Given the fact that project teams go through different phases in which behavior may be displayed differently (Gersick, 1988; King & Anderson, 1990), the questionnaire was filled out twice during the design period; the first time during the project's concept phase and the second time during its elaboration phase. Testing the selected part of the instrument proceeded along guidelines described by Latham and Wexley (1994). These guidelines encompass the testing of both the structure and the criterion-related validity of the instrument.

Latham and Wexley (1994) state that factor analysis can be used to group the items if three to five times as many people have filled out the instrument as there are items within it. Ideally, all items within the instrument should be analysed together, but the limited number of respondents ($n_{\text{concept phase}}$ = 100-106) did not allow us to do so. We were, however, able to perform factor analysis separately on the items in each of the three main categories 'design creation', **'**design planning', and 'design cooperation'. On the items in each of these categories we performed a confirmatory (Stevens, 1996) factor analysis (Principal Axis Factoring, Varimax Rotation with Kaiser Normalization), thereby testing the hypotheses that (a) the number of sub categories defined in study 1 was correct, and (b) that the content of the items in the sub categories was in line with the category labels used. Especially for the 'design creation' category, the ratio between respondents and items was somewhat unfavourable (37 items and 104 respondents). To account for this ratio, we employed guidelines presented by Stevens (1996) for factor analysis on data from small samples. Stevens advised to adjust the acceptable factor loadings to the size of sample under analysis by doubling their standard error when samples are small. Considering the different numbers of respondents per main category (n = 104, n = 106, n = 100, respectively) we computed this minimal factor loading for each of them separately, and this value turned out to be .40 for each main category (minimal factor loading: 2*standard error; standard error ($p \leq .05$) = 1.96*[1/√ (N-1)]).

Factors with an eigen value of <1.00 were not taken into consideration. An item was considered as belonging to a factor if (a) it had a factor loading of ≥.40, (b) it did not have a loading of ≥.40 on another factor, and (c) its highest loading differed ≥.20 with its loading(s) on the other factor(s). To test the resulting scale's internal consistency, Crohnbach's alpha was computed for each of the scales (in case of only two items, the correlation between both items was computed). Crohnbach's alphas ranging from .60 to <.70 are considered to reflect a moderate, .70 to <.80 a good, .80 to <.90 a very good, and .90 to <.95 an excellent internal consistency (Hair, Babin, Money, Samouel, 2003, p. 172). Items that lowered Crohnbach's alpha (or correlated negatively with the other items) were removed from the scale. Finally, the results of the factor analyses were tested for consistency over time, using the data collected during the elaboration phase. To test the resulting scales' stability over time, for each scale its correlation at both measurement points was computed ($n_{\text{concept-} \cap \text{ elaboration phase}}$ = 98-106). A satisfactory value for this stability correlation is difficult to provide, since this statistic is influenced by the time that elapsed between both points of measurement, and this interval differed somewhat for our respondents.

Next, Latham and Wexley (1994) propose to conduct an item analysis in order to identify and remove items that do not differentiate between good or bad performance. Since in our study items were already grouped using factor analysis in the previous step, we performed this step on the scales that resulted from the factor analyses. In the study presented in chapter 5 we tested the hypothesis $Y = f(X)$ for each scale: scoring high on scale X means doing well on design activity Y (Landy, 1986, p. 1186).

Results

The results of the factor analyses are presented in Tables 4.2 through 4.4. For each item the DBST category label, the item content, and the factor loading(s) are given. In Table 4.5 we present the old DBST category label, the new DBQT scale label, the Crohnbach's alpha at both points of measurement, and the stability of each new DBQT scale. We discuss the results separately for each of the factor analyses conducted on the items of the main category 'design creation', 'design planning' and 'design cooperation'.

On the 37 items of the first main category ‘design creation’, a seven-factor confirmatory factor analysis was performed on the answers of 104 respondents. Items that met the specified criteria for this category are listed in Table 4.2 (n_{items} = 24). Seven factors fitted the data structure well, and together they explained 59.67% of the variance in 'design creation’. The first factor items stem from two DBST categories ‘elaboration’ and ‘information’. Closer inspection of the item content reveals that all items pertain to collecting information or making use thereof when elaborating the design, so the scale was relabeled ‘information-based designing’. The second and sixth factor items both stem from the DBST category ‘solutions’. Inspection of the item content showed that the second factor pertains to 'confining the solution space', and the sixth to 'building the solution space'. The factors were relabeled as such, in order to reflect this refinement. The fourth factor items all stem from the DBST category ‘phase transition’, but the third item in this scale lowered the alpha in the concept phase from .87 to .82. We decided to retain this item in the scale for three reasons: (a) the scale’s alpha can be qualified as very good with or without the item in it, (b) deleting this item makes the phase transition scale incomplete, and (c) a scale of two items would remain after deleting this item, which is undesirable. Finally, the seventh factor contained items that related to the organization of the design task *after* the design goal had been established. The sub category 'establishing the design goal' was therefore relabeled 'design task organization'. The other factors in this analysis were in line with what was expected based upon the DBST categorization, although some items had to be deleted from the scales. With exception of the ‘design goals’ scale, all consistency measures were well above satisfactory levels. Summarizing the results for the ‘design creation’ category, we can conclude that the hypothesised number of categories fit our data well, that the category labels and content for three of the seven scales are in line with what was proposed in the DBST categorization, but that the content and labeling of the four other scales had to be revised.

On the 16 items of the second main category ‘design planning’, a two-factor confirmatory factor analysis was performed on the answers of 106 respondents. Items that met the specified criteria for this category are listed in Table 4.3 (n_{items} = 12). Two factors fitted the data structure well, and together they explained 50.48% of the variance in ‘design planning’. The scale labels were as proposed in the DBST categorization and only from the

'keeping schedule' category items had to be deleted. All consistency measures for both scales are well above satisfactory levels. Summarizing the results for the ‘design planning’ category, we can conclude that the hypothesised number of categories, the category labels and --to a large extent-- the category content are in line with what was proposed in the DBST categorization.

On the 32 items of the third main category ‘design cooperation’, a three-factor confirmatory factor analysis was performed on the answers of 100 respondents. Items that met the specified criteria for this category are listed in Table 4.4 (n_{items} = 19). Three factors fitted the data structure well, together they explained 42.62% of the variance in ‘design cooperation’. The results show that the DBST 'cooperation' category can be divided into two sub categories ‘cooperation’ and ‘reflection on team functioning’, of which the latter is a more specifically described form of cooperation. The items of the third factor stem from two DBST categories ‘making decisions’ and ‘communication’. Closer inspection of the item content reveals that one of the two communication items also deals with decisions and the other with the frequency of the contact. Since regular contact would support the other behaviors regarding the decision-making process, we labeled the new scale ‘making decisions’. All consistency measures for the resulting scales are well above satisfactory levels. Summarizing the results for the ‘design cooperation’ category, we can conclude that the hypothesised number of categories fits the structure of this main category and so do two of the three category labels. The category content deviated somewhat from the one proposed in the DBST categorization: almost none of the 'communication' items fitted the structure, and the 'cooperation' sub category could be refined by splitting it into two scales.

3.3 Discussion

Based on the responses of professional multidisciplinary design team members, we constructed a preliminary version of the DBST (study 1) and we tested its structure, content, reliability, and stability using responses of students that created an innovative design within multidisciplinary design teams (study 2). As a result we presented the DBQT, which consists of 55 items divided into three main categories and 12 sub categories. With this instrument multidisciplinary design team member behavior that is critical to successful design task completion can be measured. We discuss our results per main category, point

Table 4.2 *Factor Loadings for Design Creation Items (n=104)*

DBST category label	*Item*	*Factor*						
		1	*2*	*3*	*4*	*5*	*6*	*7*
Information	Used all available information	.71						
Elaboration	Developed design thoroughly	.54						
Information	Gathered all relevant information	.49						
Elaboration	Gathered necessary additional external information	.48						
Elaboration	Kept overall design in mind during elaboration	.43						
Solutions	Experimented with new solutions		-.56					
Solutions	Restricted number of solutions		-.43					
Adjusting	Went flexibly with unexpected circumstances within project			-.76				
Adjusting	Adjusted sub designs to overall design			-.74				
Adjusting	Adjusted our activities to each other			-.67				
Adjusting	Considered overall design decisions when adjusting sub designs			-.67				
Phase transition	Conscious transition determining concept - elaborating design				-.83			
Phase transition	Conscious transition generating solutions - determining concept				-.79			
Phase transition	Conscious transition setting goals - generating solutions[a]				-.45			

Table 4.2 *continued*

DBST category label	*Item*	*Factor*						
		1	*2*	*3*	*4*	*5*	*6*	*7*
Reflecting	Constantly deliberated connection between sub designs					.62		
Reflecting	Signalled and reported inconsistencies between sub designs					.49		
Reflecting	Signalled and reported need for additional information					.48		
Reflecting	Timely notified team when encountering design problems					.45		
Reflecting	Constantly deliberated to accentuate design goal					.43		
Solutions	Taken all solutions into consideration						-.82	
Solutions	Came up with as many solutions as possible						-.70	
Establishing goal	Determined individual contributions in mutual consideration							.63
Establishing goal	Determined sub division of design problem in mutual consideration							.51
Establishing goal	Determined professional requirements in mutual consideration							.51
Eigen value		*10.28*	*3.00*	*2.48*	*1.97*	*1.72*	*1.36*	*1.26*
Variance explained		*27.79*	*8.12*	*6.69*	*5.34*	*4.66*	*3.68*	*3.40*
Cumulative variance explained		*27.79*	*35.91*	*42.60*	*47.94*	*52.59*	*56.27*	*59.67*

Note. Principal Axis Factoring, Varimax Rotation with Kaiser Normalization; Factor loadings below .30 are not shown in the table; [a] Item lowered Crohnbach's alpha from .87 to .82

Table 4.3 *Factor Loadings for Design Planning Items (n=106)*

DBST category label	*Item*	*Factor*	
		1	*2*
Keeping schedule	Adjusted individual time planning to decisions made	.81	
Keeping schedule	Fitted additional activities into individual time planning	.77	
Keeping schedule	Reminded each other of timely delivery of sub results	.76	
Keeping schedule	Revised individual time planning if necessary	.71	
Keeping schedule	Signalled divergence of sub designs	.70	
Keeping schedule	Systematically checked whether schedule was kept	.59	
Keeping schedule	Discussed whether time planning would be made	.55	
Planning time	Translated overall time planning into sub design time planning in mutual consideration		.85
Planning time	Made individual time planning in mutual consideration		.76
Planning time	Made realistic overall time planning		.70
Planning time	Determined time required to deliver desired quality in mutual consideration		.62
Planning time	Determined deadline for delivery of the design in mutual consideration		.44
Eigen value		*7.29*	*1.66*
Variance explained		*42.74*	*7.74*
Cumulative variance explained		*42.74*	*50.48*

Note. Principal Axis Factoring, Varimax Rotation with Kaiser Normalization; Factor loadings below .30 are not shown in the table

out weaknesses and strengths of our findings, and present practical applications and suggestions for future research regarding both the DBST and DBQT. Structuring the interview data led to the formation of a main category 'design creation' that consisted of seven sub categories. After testing this structure, we retained seven categories, four of which with a content that slightly differed from the initial classification. The content of the DBQT sub category 'design task organization' surprised us in the sense that behaviors

Table 4.4 *Factor Loadings for Design Cooperation Items (n=100)*

		Factor		
DBST category label	*Item*	*1*	*2*	*3*
Cooperation	Kept informal contacts with each other	.78		
Cooperation	Were considerate of each other's strenghts/weakenesses	.72		
Cooperation	Stood in for each other if necessary	.68		
Cooperation	Helped and supported each other	.66		
Cooperation	Worked on gaining mutual trust	.66		
Cooperation	Adjusted ourselves to each other	.54		
Cooperation	Established informal contacts	.53		
Cooperation	Showed responsibility for ups and downs of our team	.52		
Cooperation	Shared our knowledge	.41		
Cooperation	Brought each other's functioning up for discussion		.89	
Cooperation	Brought team's functioning up for discussion		.81	
Cooperation	Called our functioning within our team to account		.79	
Making decisions	Taken enough time to decide			.75
Making decisions	Substantiated decisions			.69
Communication	Reported individual decisions			.61
Making decisions	Deliberated amongst each other			.57
Communication	Kept in regular contact			.54
Making decisions	Recorded decisions			.43
Making decisions	Strove for reaching consensus			.42
Eigen value		*7.64*	*3.47*	*2.53*
Variance explained		*23.87*	*10.85*	*7.90*
Cumulative variance explained		*23.87*	*34.72*	*42.62*

Note. Principal Axis Factoring, Varimax Rotation with Kaiser Normalization; Factor loadings below .30 are not shown in the table

concerning establishing the design goal did not turn out to be considered essential for the design process. Both problem-solving theories (e.g., Dörner & Wearing, 1995; Newell & Simon, 1972) and results of other studies into designing in teams, however, point to their

importance (e.g., Badke-Schaub & Frankenberger, 2002). An explanation for this may lie in the fact that the assignment, and thus the design goal, was already clear to the students and had therefore not to be discussed. The team's discussion did focus on how to achieve the goal given the constraints of the assignment and their team.

This latter discussion is reflected in the DBQT's 'design task organization' category that emerged, which category is related to the satisfaction outcome variables of the teamwork. The differentiation between 'information gathering' and 'elaboration of the design' as suggested in the DBST did not hold when tested. These two aspects of the design process appeared to be connected. This was a less surprising finding, given the iterative nature of design processes. Elaborating the design without taking notice of new information springing from the progress of the design thus far or from external sources would be unwise, to say the least. To reflect this entangledness, we relabeled the emerged DBQT category 'information-based designing'. Given the fact that in many design-team-related studies only the processes that lead to the concept of the design are studied, we feel that the fact that this study shows that 'information-based designing' behaviors also relate to the elaboration of the design is of added value.

The opposite effect appeared with regard to the solution-related behaviors. These were all classified under a single heading in the DBST categorization, but testing the structure showed two dimensions underlying this category, namely ‘building the solution space’ and ‘confining the solution space’. Considering the limited number of behaviors in the initial scale, we did not expect a refinement of the DBST sub category, but distinguishing between these aspects is in line with problem-solving and design-process theories (Carroll & Johnson, 1990; Dörner, 1996; Lipshitz & Bar- Ilan, 1996; Pahl, Beitz, Wallace, Blessing, & Bauert, 1996) and results from previous design team research (Badke-Schaub & Frankenberger, 2002; Stempfle & Badke-Schaub, 2002). Apparently this differentiation is very profound and thus even shows itself for the few solution-related behaviors that were included. This refinement enriches the DBST categorization. We have to note, however, that the number of behaviors in both DBQT sub categories is rather small, which is an undesirable characteristic of a measurement scale from a methodological point of view.

Table 4.5 *Reliability of the DBQT Scales: Crohnbach's Alphas and Stability (n = 98-106)*

DBST category labels (n_{items} [a])	*DBQT scale labels* (n_{items})	*Crohnbach's α concept phase*	*Crohnbach's α elaboration phase*	*Stability*[d]
Design creation (37)	Design creation (24)			
Establishing the design goal (6)	Design task organization (3)	.61	.67	.62***
Elaboration (5) & Information (6)	Information-based designing (5)	.76	.79	.62***
Solutions (4)[b]	Building solution space (2)	*r* =.58***	*r* =.68***	.66***
Solutions (4)[b]	Confining solution space (2)	*r* =.30**	*r* =.25**	.37***
Phase transition (3)	Phase transition (3)	.82	.88	.61***
Reflecting on the design (8)	Reflecting on the design (5)	.80	.73	.44***
Adjusting based on reflection (5)	Adjusting based on reflection (4)	82	.79	.50***
Design planning (16)	Design planning (12)			
Planning time (5)	Planning time (5)	.82	.89	.55***
Keeping Schedule (11)	Keeping schedule (7)	.91	.86	.47***
Design cooperation (32)	Design cooperation (19)			
Cooperation (13)[c]	Cooperation (9)	.86	.86	.52***
Cooperation (13)[c]	Reflecting on team functioning (3)	.88	.87	.41***
Making decisions (6) & Communication (13)	Making decisions (7)	.81	.89	.50***

Note. [a] After condensing the original categories; [b] and [c] Scales are identical; [d] Correlation between designers' responses in the concept phase and elaboration phase; ** $p \leq .01$; *** $p \leq .001$

The other sub categories ‘phase transition’, ‘reflecting on the design’, and ‘adjusting based on reflection’ were condensed, but the behaviors were all in line with the DBST sub category headings. The importance of reflection and acting upon it has been established in a number of studies (e.g., Reymen, 2001; Valkenburg, 2000; West, 1996b) and again shows from our results. The finding that consciously making the transition between two design process phases is of importance. It underpins findings of Stempfle and Badke-Schaub (2002), which showed us that for complex problems transitions between generating, analysing, and evaluating ideas have to be made in order to arrive at satisfying solutions (p. 491). It expands their findings in the sense that these transitions have to be made consciously.

For the main category ‘design planning’, the initial categorization structure was retained after testing. Only four items had to be discarded and the content of the remaining behaviors constituted both DBST sub categories ’planning time’ and ‘keeping schedule’. Both DBQT scales showed robust psychometrical qualities.

For the main category ‘design cooperation’, three sub categories appeared after testing the DBST structure, but --as with the ‘design creation’ category-- some rearranging and relabelling took place within the DBST's three-category structure. Within the rather large DBST sub category ‘cooperation’ two sub categories could be distinguished. The first DBQT sub category 'cooperation' fits the DBST 'cooperation' sub category perfectly, but the second one ‘reflection on team functioning’ proved to be a refinement within the DBST sub category itself. Not only does this newly established DBQT sub category underline the previously noted importance of reflection during designing, it also shows that reflecting on the team's functioning is different from reflecting on the design. Distinguishing between both forms of reflection corresponds with West's (1996b) work on reflexivity in teams. In spite of the logic behind separation between the two forms of reflective behaviors, the fact that both forms of reflection each stem from a separate analysis calls for the need of substantiation of this finding in future design team research.

The DBST sub category ‘making decisions’ was retained after testing, but some behaviors that were classified under the DBST sub category 'communication' were added to it, because they also supported the decision-making process. The fact that decision-making falls under the heading of this main category has to do with the general formulation of the

decision-making behaviors. In both the problem-solving and the design literature, arriving at a decision is the end phase of the problem-solving or design process, but from the interviews with the designers it appeared that decisions had to be regarded from a more broad perspective: decisions also concern planning the design process and cooperating within the design team. Results obtained when testing the DBST structure confirms this general approach.

The fact that an important DBST category like 'communication' had to be discarded from the final DBQT may be explained by the fact that communication is implicit to a large number of behavioral items in the DBQT (e.g., 'in mutual consideration', 'deliberated', 'notified and reminded each other', and 'signaled and reported'). Since communication is considered to be important throughout the whole of the design process (Dorst, 2003; Eckert & Stacey, 2001; Stempfle & Badke-Schaub, 2002), we think it is better to have communication represented in each behavioral DBQT sub category as is the case now, than as a single stand-alone sub category like in the DBST.

We conclude this discussion with an answer to the research question. The two studies we have conducted provided us with a large number of behaviors that appear to be critical for a variety of outcomes that adhere to successful design task completion. The structure that can be imposed upon these behaviors is comprehensive, clear-cut, to a large extent replicable, and in line with results of studies into single aspects of the design process.

Strengths, Limitations, Practical Applications, and Suggestions for Future Research

Throughout the discussion of each of the main categories some limitations of this research have already been addressed. In our opinion the three most important limitations concern the number of respondents, the kind of teams in the second study, and the measurement of the outcomes of the teamwork. To start with the number of respondents, the ratio between the number of respondents and number of items we performed factor analysis upon was a bit unfavorable. If in future studies the sample is larger, this will firstly allow for a test of the complete DBST structure at once and not of each of the three main categories separately. Secondly, it might alter the content of the DBQT sub categories by increasing the number of items in each of them and thus the content and sub category structure.

Finally, it may increase the reliability of the DBQT's 'design task organization' category, which is somewhat below acceptable levels.

Although the conditions under which the teams in the second study designed were representative of designing in general (an open assignment, restricted resources, a strict deadline, the outcome was of importance to the team members), the characteristics of the teams studied might restrict the generalisability of the DBQT. The teams under study (a) were self-managed, (b) were composed of relatively inexperienced designers, (c) worked on innovative design assignments, (d) did not interact directly with a client, (e) worked together for a relatively short period of time, and (f) consisted of members who interacted frequently. For teams with characteristics that deviate from those described above, the validation process will have to be repeated. The DBST is a good point of departure, given its comprehensiveness. Based on the team characteristics, relevant categories or items can be selected from the DBST and the resulting list of behavioral items can be tested following the process described in study 2.

Finally, with regard to the predictive value of the DBQT, it will be important to relate DBQT process ratings to design outcomes rated by other people than the design team members themselves, since this may have led to distortion of results due to common method (percept-percept correlations) or single source variance.

The strengths of our study clearly encompass the integrative approach we took to analyzing the design process and this is reflected in the resulting instrument. Not only did we address the design creation or problem-solving part that is needed to arrive at a successful design, but via task analysis the planning and social part of the design process were also reflected upon and included in the final questionnaire. This way our results add to previous studies into problem-solving and designing.

Another strength of our study is the fact that the DBQT has a range of applications. The fact that the DBQT can be scored by both design team members themselves and external raters (like researchers, managers, or educators) allows for a comparison of the different ratings, which may provide interesting information in itself. Furthermore, the DBQT can be used for research, practice, or education on designing. For research purposes, the DBQT offers means to quantitatively study relationships between (a) different design behaviors, (b) antecedents of design behavior (e.g., knowledge, skills, attitudes, and other

characteristics of designers or characteristics of the design team) and design behaviors (King & Anderson, 1999), and (c) design behavior and design outcomes (e.g., timeliness, quality, or personal outcomes for designers). In our review of the literature we found no study that offered such an instrument, nor one that addressed the relationship between antecedents and design behavior. We found only one study that addressed the relationship between design behavior (communication) and outcomes (Badke-Schaub & Frankenberger, 2002). For practical purposes, the information obtained with the DBQT can be used by (student-) design team members: it can enlarge their awareness of critical design process dynamics and their relationships with antecedents or outcomes via focussed reflection, and thus serve to improve design processes (Reymen, 2001; Stumpf & McDonnell, 2002). It can also be used by managers, or leaders of (student-)design teams: they can either manipulate antecedents (e.g., team composition in terms of team member expertise (Atman, Cardella, Turns, & Adams, 2005; Atman, Chimka, Bursic, & Nachtmann, 1999) or team member personality (Kichuk & Wiesner, 1997)), alter aspects of the design process, or educate design team members by assigning them to suitable training programs. Finally, for educational purposes, information obtained via the DBQT can be used to tailor educational programs to the most important aspects of teamwork or to specific needs of student designers.

A final strength concerns the validity of the DBQT. The fact that we collected critical behaviors from professional team members with various backgrounds of which the importance and the structure behind a large number of those behaviors reappeared when testing them in student design teams favors the general validity of our results. We therefore express the hope that both the DBST and the DBQT will be used as both a research tool and a tool to reflect upon design team functioning in (educational) practice. This will increase our knowledge on design team processes and their relationships with antecedents and outcomes. This knowledge may serve to enlighten design practitioners, educators and -- maybe most of all-- design students, because after all, designing remains a multifaceted and difficult matter that teases the minds and actions of many.

Chapter 5

Designing in Teams: Does Personality Matter? *

An input-process-output framework of designing in teams was researched among 26 multidisciplinary student design teams (n = 128) that competed in a design contest. The elevation of agreeableness and conscientiousness (input) were positively related to generic design behaviors (process) in both the concept and elaboration phase of the design process. Generic design behaviors were positively related to contest result and team member ratings of the design's technical realization (output). Input-process, input-output, and process-output relationships were also studied for specific design behaviors and these relationships were different for the concept phase and elaboration phase. The conclusions add to the knowledge of how design processes relate to design team member characteristics and design effectiveness and hold implications for design research and practice.

Design processes that take place in teams have been studied many times and in many ways (e.g., Baird, Moore & Jagodzinsky, 2000; Cross, Christiaans & Dorst, 1996; Reid, Culverhouse, Jagodzinski, Parsons, & Burningham, 2000; Stempfle & Badke-Schaub, 2002; Valkenburg, 2000). Nevertheless, it is still far from transparent exactly how design processes contribute to the successfulness of designs as this relationship has received only limited scientific attention (Badke-Schaub & Frankenberger, 2002). Furthermore, as there

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would be no design processes without designers, studying the relationships between design team member characteristics and design processes is indispensable. Here again only a few studies are available (Kichuk, & Wiesner, 1997; Robinson, Sparrow, Clegg, & Birdi, 2005). 15 years ago, King and Anderson (1990) already signalled the need for more scientific studies that would address the effect of team composition and processes which take place in innovative teams. As it appears now, scholars have only partly been able to give rise to this call, and, in spite of all their research efforts, we still have precious little understanding of how design team member characteristics contribute to design processes and how both contribute to design team effectiveness.

The aim of this study is to add to the knowledge of how design processes relate to design team member characteristics and design effectiveness (in terms of the design product) by studying these relationships based on an *input-process-output* framework of team effectiveness proposed by Hackman (1987). This framework posits that inputs combine to influence team *processes* on the one hand and team *output* on the other hand, and that team processes and team outputs are related to each other. Such an integrative/comprehensive approach to studying design team effectiveness has, to our knowledge, not been adopted before. To present our input-process-output model of designing in teams, we discuss design team member characteristics, design processes, and design team performance in more detail in the remainder of the introduction, working from back to front. Thereafter we present the research hypotheses and questions and these are summarized in the research model.

5.1 Design Team Performance

Studying design team effectiveness is not a simple matter. This mainly has to do with the definition of a successful design. It can adhere to the quality (which also encompasses innovativeness), the timely delivery of the design, or to the costs made to come up with the design (cf. Frankenberger & Badke-Schaub, 2002). These outcomes are more or less intertwined. Time, and thus costs, can be spared by shortening the design process, but this may diminish the quality. Moreover, if you buy cheaply you may pay dearly if a lot of incremental designing is needed before the design can be taken into production. On the other hand, a highly innovative product may turn out to do so well on the market that

despite a long and costly development time return on investment in terms of both time and costs is high. So the intertwinedness is such that there will be a trade off between quality, timeliness, and costs. Furthermore, the value of quality is not univocally determinable (Dorst, 2003, p. 30; Gann & Whyte, 2003). Designs that may seem to lack quality or innovativeness now may turn out to be very useful for incremental designing on the same product or for the design of new products tomorrow.

In organizational practice, companies employ their own guidelines regarding quality, timeliness, and costs depending upon their organizational mission, business strategy, and market. And even within a single organization design teams may have to work under different constraints. Dissimilarities that arise as a consequence of differences in choices that are made within a single organization or between organizations make it difficult to generalize findings concerning organizational design team effectiveness. To counteract this incomparability of outcomes, design teams have often been studied in laboratory settings[6], which may naturally raise questions regarding the external validity of such results.

A related complicating matter is the measurement of design team effectiveness. Time and costs involved appear to be easily and objectively measurable quantities, but this may hold true for time only. Regarding costs, the lack of clarity in definition makes them difficult to measure. If costs were well defined, measurement could proceed objectively if data were available. Defining quality is even more difficult. And even if the concept of quality were well defined, its measurement remains problematic, because the issue of who should rate it immediately arises. A choice has to be made between design team members, design team leaders, supervisors, clients, or independent raters. In other words, the operationalization of quality will have consequences for the objectivity of the measurement, as well as for relationships to be established between on the one hand input and process variables and on the other hand output variables. Rating quality from multiple perspectives (cf. 360° assessment (e.g., Milliman, Zawacki, Norman, Powell, & Kirksey, 1994)) may present researchers with the most complete and reliable results.

[6] An additional complicating issue of studying design teams in organizational practice is the sensitivity of the information that might be disclosed during the study of such teams. This might make organizations reluctant to allow researchers to study their design teams.

Reiterating, we can state that the interrelatedness of quality, time, and costs, the definition of costs and quality, the operationalization of quality, and the choice of rater are all factors that complicate research into design team effectiveness. To address this complexity we use several objective and subjective outcome variables in this study.

5.2 Design Processes

In order to enhance our understanding of design team processes, design team member communication, negotiation, reflection, and social processes have been studied in depth but in isolation (Cross & Clayburn-Cross, 1996; Eckert & Stacey, 2001; Stempfle & Badke-Schaup, 2002; Stumpf & McDonnell, 2002; Valkenburg, 2000). Lately, a more integrative approach toward the study of designing is advocated. Working from such an integrative approach, we performed a task analysis of designing in multidisciplinary teams (see Chapter 4). Interviewing design team members from various backgrounds via the Critical Incident Technique (Flanagan, 1954), we collected a set of behaviors supposedly critical for successful design task completion. On this set of behaviors the *Design Behavior Scales for Teams* were based (see study One in Chapter 4). After testing the structure of a subset of these scales, the *Design Behavior Questionnaire for Teams* (DBQT) was constructed (see study 2 in Chapter 4).

The DBQT consists of 55 critical design team member behaviors divided over three main categories *design creation*, *design planning*, and *design cooperation*. Within these three main categories, 12 sub categories are distinguished which we name here and, where necessary, we briefly clarify them. Sub categories under the main category 'design creation' are the following. First, *design task organization* addresses the organization of the work once the design problem has been established. Second, *information-based designing* relates to developing the design thoroughly based on all available and relevant information. Third, *building the solution space* concerns the generation of possible solutions. Fourth, *confining the solution space* is about restricting the number of possible solutions. Fifth, *phase transitions* bears upon the extent to which conscious transitions are made between phases in the design process, for instance between determining the concept and elaborating the design. Sixth, *reflecting on the design* is about reflection upon the development of the design. Seventh, *adjusting based on reflection* relates to the way the design and design

behaviors are adjusted upon evaluations. The eighth through twelfth sub category need no additional clarifying, they are labeled: *planning time, keeping schedule* (both belonging to the main category 'design planning'), and *cooperation, reflecting on team functioning*, and *making decisions* (all three belonging to the main category 'design cooperation').

Phases in the Design Process

In design research, scholars have established that design teams go through different design process phases in establishing a design concept (King & Anderson, 1990; Stempfle & Badke-Schaub, 2002). These phases and the transitions between them are reflected in the DBQT's main category 'design creation'. Moreover, for project teams in general it was found that their work proceeds through two phases (Gersick, 1988, 1989; Ockhuysen & Waller, 2002; Waller, Zellmer & Giambatista, 2002). In her punctuated equilibrium model, Gersick (1988, 1989) distinguished one phase before and one after the so-called midpoint transition. In the phase before the midpoint transition, teams explore their task, the problem, and alternative solutions (cf. *information gathering phase* (Ockhuysen & Waller, 2002) and *orientation phase* (Waller et al., 2002). At the midpoint transition, teams decide what alternative solution will be elaborated upon in the remainder of the project and how they will proceed in doing so. In the phase after the midpoint transition, details of the selected solution are worked out (cf. *resolution phase* (Ockhuysen & Waller, 2002) and *evaluation and control phase* (Waller et al., 2002)). The first project phase (pre-midpoint-transition, information gathering or orientation phase) maps well onto the design project phase in which the concept has to be established, which --in line with Peeters et al. (see Chapter 3)-- we refer to as the *concept phase* from this point forward. The second project phase (post-midpoint-transition, resolution or evaluation and control phase) maps well onto the design phase in which the selected concept has to be elaborated and built. We refer to this phase as the *elaboration phase* (see Chapter 3) from this point forward.

Based on the finding that in project teams activities differ in both phases, for design teams design activities can be expected to differ in the concept and elaboration phase and this may also hold for design team member behavior. Having noted this, we conclude that the DBQT has to be administered in both the concept and elaboration phase to arrive at an accurate description of design team member behavior throughout the design project.

Team Composition in Terms of Design Team Member Personality

As King and Anderson (1990) noted, there are a number of design team characteristics that are worthy of scientific attention (e.g., leadership, team composition, minority influence, team structure). Robinson et al. (2005), for instance, studied effects of design team member competencies. What's more, over the last decade a line of research has been build up in which the importance of team member personality with regard to team performance is underscored (e.g., Barrick, Stewart, Neubert & Mount, 1998, Mohammed & Angell, 2003; Neuman, Wagner & Christiansen, 1999; Van Vianen & De Dreu, 2001). More specifically, Kichuk (1999) and Taggar (2000) demonstrated effects of team member personality on team performance for samples that consisted of design teams only. As personality has an influence on team performance in general and on design team performance in particular, it is interesting to pose the question how both design team member personality and design team performance relate to design processes.

A well accepted and consistently replicated (John, 1990; Mount & Barrick, 1995) framework with which personality is described is the Five-Factor Model of personality, also known as the Big Five. The five factors or traits that are distinguished within this framework are: *extraversion*, *agreeableness*, *conscientiousness*, *emotional stability*, and *openness to experience* (De Raad, 2000; McCrae & John, 1992; Wiggins, 1996). Personality, described in terms of these five traits, remains relatively stable over time and across situations (Hofstee, Kiers, De Raad, Goldberg & Ostendorf, 1997; John & Srivastava, 1999; McCrae & Costa, 1997). The extent to which a trait applies to a person predisposes him or her to behave in a certain way (Robertson & Callinan, 1998). Extraverts can be characterized as social and talkative, whereas introverts are silent and prefer solitude. Agreeable people are gentle and cooperative, whereas nonagreeable people are bossy and impose their will on others. Conscientious persons are self-disciplined and organized, as opposed to nonconscientious persons who are sloppy and have chaotic work styles. Emotionally stable individuals can be described as calm and poised, whereas emotionally unstable or neurotic individuals are easily upset or stressed. Finally, people that are open to experience are critical and imaginative; conversely people that are not open to experience form no opinion of their own and follow the majority (Costa & McCrae, 1992; Hendriks, Hofstee & De Raad, 1999).

To be able to study the effects of personality at the team level, researchers typically convert individual personality trait scores into *elevation* and *variability* scores to reflect team composition in terms of personality (Barrick et al., 1998, Kichuk & Wiesner, 1998; Mohammed & Angell, 2003; Neuman et al., 1999; Van Vianen & De Dreu, 2001). Trait elevation is generally operationalized by the average or sum of the individual trait scores. Trait variability is operationalized by a team's variance or standard deviation score for a certain trait. Lately, a variability measure has been introduced that assesses dissimilarity to other team members at the individual level (see Chapter 4). So, when studying the effects of team composition in terms of personality on team processes and outcomes, one best uses the elevation and variability scores for each of the Big Five traits, which is what we do in this study.

5.3 This study

Since there is hardly any empirical evidence present on which to build hypotheses regarding the relationship between design team composition in terms of personality and design team member behaviors, we take the overall results of the meta-analysis on team composition in terms of personality and team performance as point of departure (see Chapter 2)[7]. In this meta-analysis it was shown that elevation in agreeableness and conscientiousness relate positively to team performance, and that variability in agreeableness and conscientiousness relate negatively to team performance. These meta-analytical results form the basis of our first set of hypotheses regarding input-output relationships:

Hypothesis 1a: Elevation of agreeableness is positively related to design team outcomes.

Hypothesis 1b: Elevation of conscientiousness is positively related to design team outcomes.

[7] Since overall sample was already relatively small, we chose to base our hypotheses on results from that sample and not on those resulting from the moderator analysis on student teams, which may seem more appropriate considering the type of team under study.

Hypothesis 1c: Variability in agreeableness is negatively related to design team outcomes.
Hypothesis 1d: Variability in conscientiousness is negatively related to design team outcomes.

As the DBQT was constructed based on the question 'Which design team member behaviors contribute to the successful completion of a design?', all items in the DBQT can be expected to positively contribute to design team performance in both the concept phase and elaboration phase of the design project. Each of the sub categories can also be expected to be positively related to design team performance. However, as we expect different behaviors to be relevant in the concept phase compared to the elaboration phase of the design project, relationships between DBQT subcategories and team performance may also be different for each phase. This results in the following hypotheses regarding process-output relationships:

Hypothesis 2a: The combined DBQT behaviors are positively related to design team outcomes in both phases of the design project.
Hypothesis 2b: The DBQT sub categories are positively related to design team outcomes, but relationships may differ between phases of the design project.

When we extrapolate the hypotheses regarding the effect of elevation and variability in conscientiousness and agreeableness on design performance to design behavior, we arrive at the subsequent hypotheses regarding input-process relationships:

Hypothesis 3a: Elevation of agreeableness is positively related to the combined DBQT behaviors.
Hypothesis 3b: Elevation of conscientiousness is positively related to the combined DBQT behaviors.
Hypothesis 3c: Variability in conscientiousness is negatively related to the combined DBQT behaviors.

Hypothesis 3d: Variability in agreeableness is negatively related to the combined DBQT behaviors.

The DBQT consists of 12 behavioral categories. To arrive at more detailed results, we explore relationships between both elevation and variability in agreeableness and conscientiousness and all DBQT sub categories in order to answer the following research questions:

Research question 1a: To which DBQT sub categories is elevation in agreeableness related?
Research question 1b: To which DBQT sub categories is elevation in conscientiousness related?
Research question 1c: To which DBQT sub categories is variability in agreeableness related?
Research question 1d: To which DBQT sub categories is variability in conscientiousness related?

Expected relationships among the study variables are summarized in the hypothesized input-process-output model of designing in teams (Figure 5.1).

5.4 Method

Participants

We conducted the research among student teams that completed a 'real life' design task. Respondents were all students at one of the three Dutch universities of technology. They participated in the design contests held in the autumn of 2003 at each of those three universities, known as 'Createch' in Eindhoven and Enschede, and as the 'Techniek Workshop' in Delft. At all three universities the design contest project was offered as an optional course for which course credits were awarded. The students could register as a team, part of a team, or individually. The course supervisors at each university saw to it that the teams were about equal in composition considering the disciplinary background of the team members. The teams under study can best be characterized as self-managed teams.

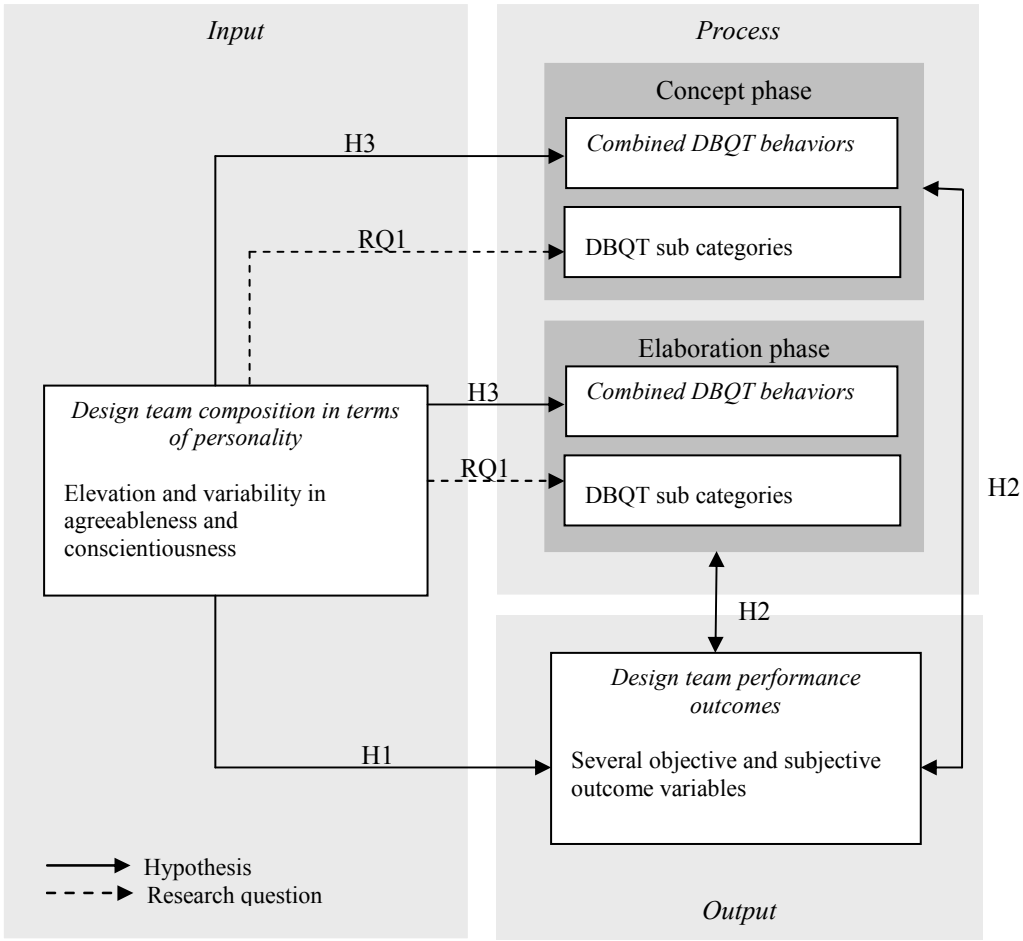

Figure 5.1 Hypothesized input-process-output model of designing in teams

As we were interested in team composition, teams had to be sufficiently complete to include them in the research. We defined 'sufficiently complete' as: all or all minus one team members filled out the personality questionnaire. Of the 33 design teams that competed in the contests (N = 158), personality data on 26 teams met this criterion (n = 128). Of these 26 teams, the size ranged from four to six members with an average team size of 5.12. Teams were predominantly male: 15 teams were all male, of the remaining 11 teams on average 61.7% of the members was male. The team composition ranged from two

up to four disciplinary backgrounds. Of the respondents 107 (83.6%) were male and 21 (16.4%) female. Their age ranged from 19 up to 28 years with an average of 21.5 years.

Assignments

Each team had to design and build from scratch a robot that had to perform a specific task. Here we provide a brief description of each of the three assignments. At the university in Eindhoven, the teams had to build a floating device the steering and velocity of which was controlled by a spring animal remote. The depth and direction of the bend made on the spring animal determined the speed and direction of the vehicle. The vehicle had to be able to move in water, to pick up balls that floated on the water, and to drop the balls on a dedicated area of a slowly rotating disc situated 5cm above the water surface at the other side of the basin. Functions related to the taking in, lifting, and dropping of the balls had to be controlled by a handheld remote. At the university in Delft, the teams had to build a vehicle controlled by a remote. It had to be able to move out of a castle courtyard through a gate with a height of about 55cm, move around the arena, and pick up balls from the arena floor. The balls had to be lifted to a height required to either throw them over the castle wall (height 65cm) on the opponent's side of the arena or drop them into one of the window holes situated approximately 70cm above the arena surface in the opponent's castle towers. At the university in Enschede, the teams had to build a vehicle that was controlled by a remote and that had to be able to move over dry surface and through water. After the vehicle had left the starting area, it had to enter a small water basin via a descent and take in water once in the deeper part of the basin. Next, it had to be able to move out of the water via an ascent at the other side of the basin and the water that had been taken in had to be put under pressure. A pumping device on the vehicle had to be used to extinguish a number of small fires alongside a route of about 3m that was entered next. At the end of this route the vehicle had to stop in the end station and signal its finish electronically.

Working on the Project

At each university there was a dedicated space in which the teams could design and build their vehicles. Each team had their own workspace, but they could see the other teams at work as their workspaces were separated by movable walls. At the university in Eindhoven,

the project was spread out over a period of six weeks. In this period the teams could work on the design project in the time they had available next to the activities on their regular course schedule. At the universities in Delft and Enschede the project was condensed into a week that was dedicated to this project only (Monday till Sunday). The teams could work during the day and during the evening until 22.00h (and 24.00h on the final night) at each of the three universities. Although the project period differed between universities, the actual designing and building time was roughly similar.

Before the contest started, the teams were centrally briefed on the project plan, assignment, rules and conditions, and on the contest itself. Each participant received a booklet in which these topics were addressed in more detail. After having handed in the concept of the design (to the supervisors) the teams received an assignment-specific standardized tool and material kit to construct their design with. Furthermore, the teams at each university had a small and fixed 'budget' (of credits) with which they could acquire additional materials from or under approval of the contest coordinators (teaching-assistants). The contest coordinators saw to it that project regulations were adhered to and provided assistance were needed to facilitate the building and testing of the designs without ever interfering with the construction of the designs themselves. At the deadline of the design period, the designs had to be placed on an exhibition table in order to be judged (by course supervisors and a contest committee of judges). Once it had been placed on the exhibition table the teams could no longer work on the design.

Contest

At all three universities an arena was built specifically for the design contest. At the universities in Eindhoven and Delft the designs met in the arena and could thus interfere with each other, in Enschede there were two separated, mirrored routes. All contests took place in rounds, starting with qualifying rounds, followed by quarter finals (Eindhoven only), semi finals, and a final. Per university the matches were identical over rounds: for each match there was a fixed amount of time (only the finalists had about a third of the regular match time added, which was announced in advance) and the teams received points for each ball dropped or each fire extinguished. The teams that received the most points

proceeded to the next stage of the contest. In between matches the teams could fix damage that their design had sustained during the battle.

Procedure

The research was introduced as part of the central opening presentations held at each of the universities. Students were told that the research team was interested in how design processes and outcomes in teams varied as a function of the team's composition, since team members differ in various ways (teamwork approach, personal goals, subject of study, willingness to invest effort). They were also informed of how their anonymity would be ensured. At the end of the presentation the students were asked to volunteer as participants in our research, and, if they did, they were asked to fill out the personality questionnaire at the end of the opening presentation. At that same time they could indicate whether they appreciated feedback on their personality scores and a summary of the study results on a separate sheet. Students from all teams participated. Next, design behavior was self-rated using the DBQT when handing in the design concept, and once more when reaching the end of the elaboration phase (when approximately 10% of the project time remained). Finally, respondents filled out an evaluation of the design and the project immediately after the finished designs had been put on the exhibition tables. In the week after the contest, respondents received the feedback on their individual personality scores. They received a summary of results after the study had been completed.

Measures

Input.

Team member personality was measured via a self-report of the Five-Factor Personality Inventory (FFPI) (Hendriks et al., 1999). Using the extensively validated FFPI, each of the Big Five traits was measured by 20 items (ten positively and ten negatively formulated). Each item was scored on a 5-point scale varying from *not at all* (1) to *completely* (5). Examples of items for the traits used in this study are: *agreeableness* 'Orders people around' (negative) and *conscientiousness* 'Does unexpected things' (negative).

To arrive at team elevation scores, individual team member scores were aggregated to a team mean score for each trait. Team variability scores were computed by aggregating

individual dissimilarity scores to a team mean dissimilarity score (cf. Chapter 4). As most team personality researchers use trait variance or standard deviations to operationalize team variability, we also conducted our analyses with the standard deviation (as recommended by Bedeian and Mossholder (2000)). This yielded results that were nearly identical to those obtained with the aggregated individual dissimilarity scores.

Process.

Design process behaviors were measured using the Design Behavior Questionnaire for Teams (see Chapter 3). For all 55 DBQT items, respondents indicated to what extent they agreed with it on a 5-point Likert scale varying from *highly disagree* (1) to *highly agree* (5). For each of the 12 sub categories we present the number of items and an exemplary item. *Design task organization* was measured by 3 items, e.g., 'We determined the sub division of the design problem in mutual consideration'. *Information-based designing* was measured by 5 items, e.g., 'We used all available information'. *Building the solution space* was measured by 2 items, e.g., 'We came up with as many solutions as possible'. *Confining the solution space* was measured by 2 items, e.g., 'We restricted the number of solutions'. *Phase transitions* was measured by 3 items, e.g., 'We consciously made the transition from determining the concept to elaborating the design'. *Reflection* was measured by 5 items, e.g., 'We signaled and reported inconsistencies between sub designs'. *Adjusting based on reflection* was measured by 4 items, e.g., 'We adjusted sub designs to the overall design'. *Planning time* was measured by 5 items, e.g., 'We made a realistic overall time planning'. *Keeping schedule* was measured by 7 items, e.g., 'We reminded each other of timely delivery of sub results'. *Cooperation* was measured by 9 items, e.g., 'We helped and supported each other'. *Reflecting on team functioning* was measured by 3 items, e.g., 'We brought each other's functioning up for discussion'. *Making decisions* was measured by 7 items, e.g., 'We substantiated decisions'.

We assumed the DBQT sub category scores to be 'shared unit properties' (Kozlowski & Klein, 2000), meaning that individual scores could be aggregated to a team mean score to reflect the team's position on a particular category. The theoretical assumption of the sharedness of the properties can be statistically checked via computation of the agreement measures ICC(1) and ICC(2). ICC(1) can be seen as the reliability with which an individual

rating reflects the group mean (Bliese 2000, p. 356). ICC(1) values typically range from .00 to .50 according to James (1982), but Bliese (2000) narrowed this range down to .05 to .20, in exceptional cases to .30. ICC(2) represents an estimate of the reliability of the group mean (Bliese 2000, p. 356). Higher values indicate more reliability. Mean ICC(1) for the DBQT sub categories was .22 (range .01 - .50) for the concept phase and .21 (range .10 - .48) for the elaboration phase. Mean ICC(2) for the DBQT sub categories was .57 (range .06 - .84) for the concept phase and .56 (range .37 - .83) for the elaboration phase. These values are such that aggregation of the individual scores to a team mean score is justifiable.

For three DBQT sub categories, data were missing for one up to three teams in the concept phase. We used an EM (expectation-maximization) algorithm to calculate estimates for the missing data, as this strategy has been shown to be superior to other missing data treatment strategies (Dormann & Zapf, 2002).

The *combined DBQT behaviors* were operationalized by summing the scores on all 55 DBQT items per individual team member and aggregating these summed scores to a team mean score. ICC values indicated that aggregating the combined scores to the team level was justified ($ICC(1)_c = .33$, $ICC(1)_e = .23$, $ICC(2)_c = .71$, and $ICC(2)_e = .61$).

Outcomes.

To accommodate for the complications signaled in the introduction, we used several outcome measures in this study: (a) the design project was evaluated and graded by independent raters, (b) the design products were qualitatively ranked per university based upon a competition against each other, and (c) team members rated the technical realization of the design. These performance measures differ in degree of objectivity and together provide a comprehensive measurement of the effectiveness of the design. Below we discuss each outcome in more detail.

Supervisory ratings of team performance (project grade) were based on the quality of the design. The quality was evaluated by multiple design expert course leaders based on the concept of the design, the design itself, and the project report, and by contest judges based on their evaluation of the design before the contest took place. So, the course grade was not dependent upon the result of the contest.

Contest results were derived by ordering team results across universities per round starting with the finalists, followed by the semi finalists, and lastly quarter finalists and qualifying rounds based on the three subsequent criteria: (1) the place achieved in the contest (from highest to lowest), (2) the number of matches that had to be played to reach this place (from many to few), and, if further differentiation was needed, (3) within one university: the score achieved in that round (from highest to lowest). By applying these criteria an unambiguous ordering could be made. This order was reversed so that higher scores indicate better contest results. When testing differences in mean ranking between universities (Kruskal-Wallis), no significant differences were found (χ^2 (2) = 3.09, n.s.).

Design team member rating of the design's technical realization was given upon design completion before the contest took place. Team members were asked to indicate the technical realization of their team's design compared to those of the other teams on a 5-point scale ranging from *much worse* (1) to *much better* (5). Individual scores were aggregated to derive a team level indication of the design's technical realization (ICC(1) = .38, ICC(2) = .75).

Data-analysis

Considering the small sample under research, hypotheses 1 through 3 were tested using correlations, one-tailed with an alpha of p = .05. To answer RQ1, correlations were inspected two-tailed with an alpha of p = .05. Spearman's Rho correlations were computed for the contest result variable, Pearson's product-moment correlations were computed for all other variables.

5.5 Results

Descriptive statistics for team composition in terms of personality for agreeableness and conscientiousness, the combined DBQT behaviors in the concept and elaboration phase, the supervisory rating of team performance, the contest results, and team member rating of the design's technical realization are shown in Table 5.1 (mean, standard deviation, range, and Chrohnbach's alpha). The internal consistency was satisfactory for all scales with exception of that of the DBQT sub category 'design task organization', for which consistency was somewhat below acceptable levels.

The correlations that are used to test H1 (a through d), H2a, and H3 (a through d) are shown in Table 5.2 and are discussed in the text as well. For reasons of parsimony, we present the correlations between input and outcome variables and the DBQT sub categories in the text only (H2b, RQ1). Additionally, results regarding input-process, input-output, and process-output relationships are presented in Figure 5.2.

Team Composition and Team Outcomes (H1)

Contrary to our expectation, elevation in agreeableness and the supervisory rating of team performance are not correlated (r = -.15, n.s.), so H1a was not confirmed. Elevation in conscientiousness and the supervisory rating of team performance are significantly correlated (r = .34, p = .05), which confirms H1b. Neither variability in agreeableness (r = .18, n.s.) nor variability in conscientiousness (r = .17, n.s.) is related to the supervisory rating of team performance. So, our hypotheses H1c and H1d were not confirmed for this outcome. The team performance measures contest results and team member rating of the design's technical realization are not related to either the elevation or the variability in the personality measures studied.

Combined DBQT Behaviors, DBQT Sub Categories, and Team Outcomes (H2)

In line with our expectations (H2a), the combined DBQT behaviors correlate significantly with the contest results in the concept (r = .33, p = .05) and elaboration phase (r = .35, p = .04). The same was found for correlations between the combined DBQT behaviors and the team member rating of the technical realization of the design in both the concept (r = .46, p = .01) and elaboration phase (r = .39, p = .02). Although the correlations between the combined DBQT behaviors and supervisory ratings of team performance are positive, they are not significant (concept phase r = .23, n.s.; elaboration phase r = .26, n.s.).

In answer to H2b, we inspected correlations between the DBQT sub categories and team outcomes and report significant correlations per outcome. The supervisory rating of team performance is significantly related to planning time (r = .43, p = .01) and keeping schedule (r = .35, p = .04) in the elaboration phase. The results of the contest relate significantly to the DBQT sub categories information-based designing (r = .51, p = .004), adjusting based on reflection (r = .36, p = .04), and keeping schedule (r = .38, p = .03) in the concept phase

Table 5.1 *Descriptive Statistics for All Study Variables*

Variable	*M*	*s.d.*	*range*	*α*
Input				
Elevation of				
- agreeableness	3.73	.20	3.38 - 4.13	.84
- conscientiousness	3.27	.20	2.93 - 3.64	.90
Variability in				
- agreeableness	.53	.20	.23 - .97	--
- conscientiousness	.68	.27	.25 - 1.23	--
Process				
Combined DBQT behaviors[a]	3.37/3.41	.30/.26	2.46 - 3.97/2.82 - 4.07	.93/.92
DBQT sub categories				
- design task organization[a]	3.57/3.48	.46/.66	2.67 - 4.75/1.83 - 4.67	.59/.65
- information-based designing[a]	3.51/3.64	.55/.66	1.93 - 4.45/2.40 - 4.56	.74/.78
- building the solution space[a b]	3.59/3.68	.57/.56	2.00 - 4.88/2.50 - 5.00	.55***/.57***
- confining the solution space[a b]	3.70/3.87	.51/.56	2.75 - 4.83/2.75 - 4.83	.28**/.24*
- phase transitions[a]	2.88/2.71	.55/.70	1.33 - 4.00/1.00 - 3.67	.78/.88
- reflection[a]	3.51/3.67	.47/.45	2.35 - 4.40/2.80 - 4.44	.79/.74
- adjusting based on reflection[a]	3.69/3.88	.42/.47	2.50 - 4.25/2.81 - 5.00	.84/.81
- planning time[a]	2.53/2.48	.60/.57	1.00 - 3.52/1.00 - 3.30	.81/.80
- keeping schedule[a]	2.73/2.83	.60/.63	1.43 - 3.43/1.00 - 3.66	.91/.89
- cooperation[a]	3.93/3.91	.30/.32	3.07 - 4.44/3.28 - 4.42	.87/.88
- making decisions[a]	3.84/3.75	.59/.71	3.00 - 4.57/3.14 - 4.43	.74/.74
- reflecting on team functioning[a]	2.54/2.79	.35/.32	1.33 - 3.67/1.00 - 4.33	.88/.86

Table 5.1 *continued*

Variable	*M*	*s.d.*	*range*	*α*
Output				
- supervisory ratings of team performance	7.23	.59	6.00 - 9.00	--
- contest result	--	--	1.00 - 33.00	--
- team member rating of the design's technical realization	3.06	.71	1.80 – 4.67	--

Note. [a] descriptives for the concept phase are presented first, those for the elaboration phase last;
[b] for two-item categories correlations instead of *α*s are presented;
* $p \leq .05$ (two-tailed); ** $p \leq .01$ (two-tailed); *** $p \leq .001$ (two-tailed)

and to information-based designing ($r = .44$, $p = .01$) and adjusting based on reflection ($r = .55$, $p = .002$) in the elaboration phase. Finally, the design team member's rating of the technical realization of the design relates significantly to information-based designing ($r = .47$, $p = .01$), adjusting based on reflection ($r = .35$, $p = .04$), planning time ($r = .36$, $p = .04$), and keeping schedule ($r = .62$, $p = .001$) in the concept phase and to information-based designing ($r = .43$, $p = .01$), reflection ($r = .34$, $p = .05$), adjusting based on reflection ($r = .40$, $p = .02$), and planning time ($r = .36$, $p = .04$) in the elaboration phase.

As hypothesized in H2b, the results show that relationships between DBQT sub categories and team outcomes are somewhat different for the concept phase and elaboration phase. Generally, information-based designing, adjusting based on reflection, planning time, and keeping schedule appear to matter in both phases of the design project. However, in the elaboration phase, reflection is added as a DBQT sub category that relates significantly to team outcomes. Furthermore, the DBQT sub categories planning time and keeping schedule relate to different outcomes of the teamwork in each of the project phases.

Team Composition and Combined DBQT Behaviors (H3)

As expected, elevation in agreeableness and the combined DBQT behaviors in both the concept phase ($r = .34$, $p = .04$) and elaboration phase ($r = .40$, $p = .02$) are significantly correlated, which confirms H3a. The same is found for elevation in conscientiousness and the combined DBQT behaviors in both the concept phase ($r = .36$, $p = .04$) and elaboration

Table 5.2 *Correlations between Team Composition in Terms of Personality, Combined DBQT Behaviors, and Team Outcomes*

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Elevation of agreeableness[a]	--							
2. Elevation of conscientiousness[a]	.39*	--						
3. Variability in agreeableness[a]	-.13	-.07	--					
4. Variability in conscientiousness[a]	.02	.32	.32	--				
5. Combined DBQT behaviors (concept phase)[a]	.34* (H3a)	.36* (H3b)	-.14 (H3c)	.23 (H3d)	--			
6. Combined DBQT behaviors (elaboration phase)[a]	.40* (H3a)	.38* (H3b)	-.16 (H3c)	.24 (H3d)	.82**	--		
7. Supervisor ratings of team performance[a]	-.15 (H1a)	.34* (H1b)	.18 (H1c)	.17 (H1d)	.23 (H2a)	.26 (H2b)	--	
8. Contest results[b]	-.01 (H1a)	-.08 (H1b)	-.03 (H1c)	-.11 (H1d)	.33* (H2a)	.35* (H2b)	.40*	--
9. Team member rating of the design's technical realization[a]	.06 (H1a)	.11 (H1b)	-.06 (H1c)	-.17 (H1d)	.46** (H2a)	.39* (H2b)	.48**	.72**

Note. [a] Pearson's product-moment correlations; [b] Spearman's Rho correlations; * $p \leq .05$ (one-tailed); ** $p \leq .01$ (one-tailed)

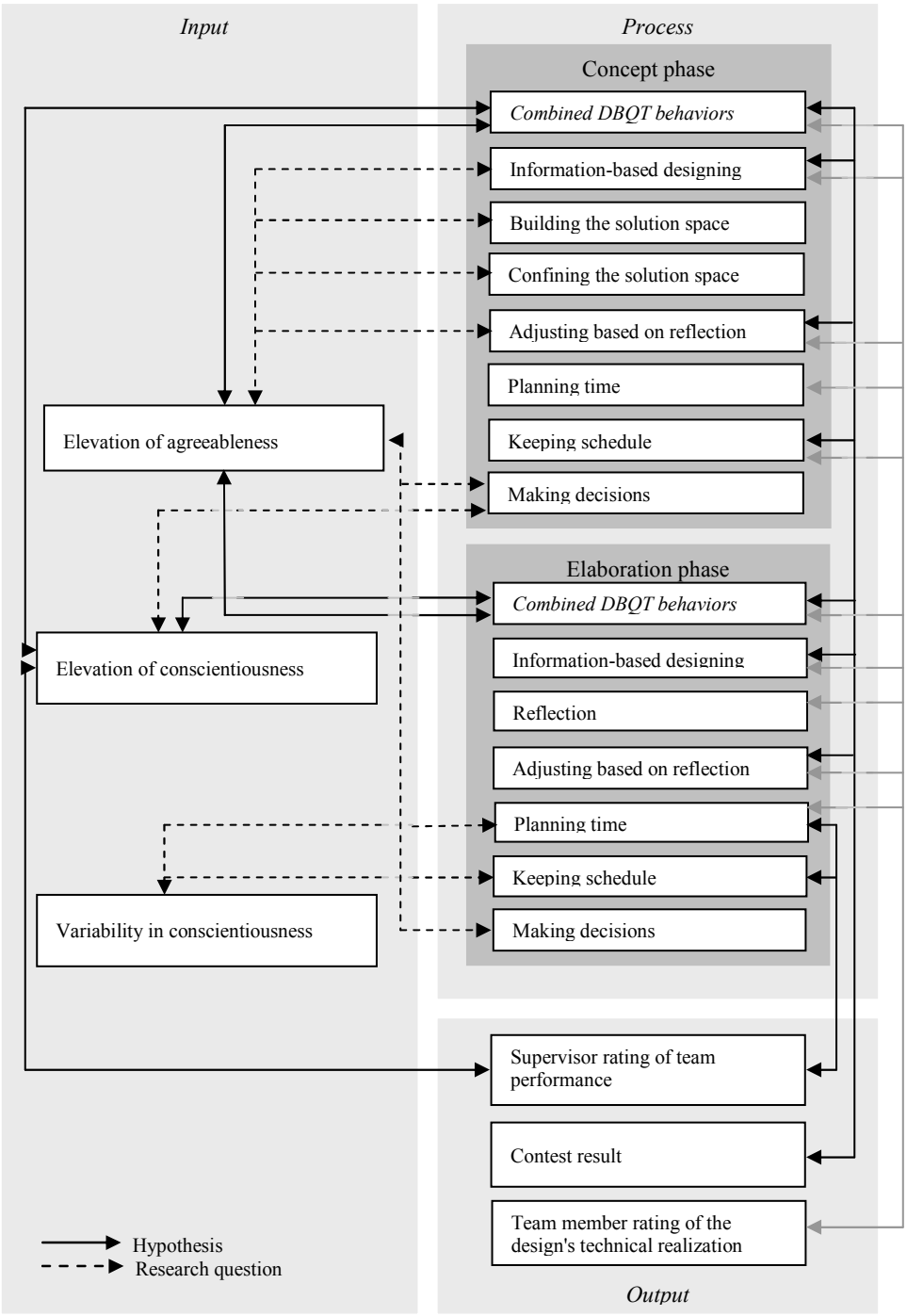

Figure 5.2 Observed input-process, input-output, and process-output relationships of designing in teams
Note. All arrows represent positive relationships

phase (r = .38, p = .03), which confirms H3b. Neither variability in agreeableness nor conscientiousness or the combined DBQT behaviors are correlated with design behavior in either of the phases (concept phase: agreeableness r = -.14, n.s., conscientiousness r = .23, n.s.; elaboration phase: agreeableness r = -.16, n.s., conscientiousness r = .24, n.s.), which is not in line with expectations presented in H3c and H3d.

Team Composition and DBQT Sub Categories (RQ1)

When inspecting the correlations between elevation of agreeableness and the DBQT sub categories (RQ1a), we found that elevation of agreeableness was positively related to information-based designing (r = .40, p = .04), building (r = .47, p = .02) and confining the solution space (r = .39, p = .05), adjusting based on reflection (r = .51, p = .01), and making decisions (r = .57, p = .003) in the concept phase. Furthermore, it was positively related to making decisions (r = .60, p = .001) in the elaboration phase. We found a significant relationship between elevation of conscientiousness (RQ1b) and the DBQT sub category making decisions (r = .48, p = .01) in the concept phase, but none in the elaboration phase. Variability in agreeableness had no significant relationship with any of the DBQT sub categories in any of the phases (RQ1c). Variability in conscientiousness was not related to any of the DBQT sub categories in the concept phase, but it was significantly related to planning time (r = .41, p = .04) and keeping schedule (r = .44, p = .03) in the elaboration phase (RQ1d). Correlations between the personality measures and all other DBQT sub categories were not significant.

5.6 Discussion

Based on an input-process-output model of team effectiveness, relationships between team composition in terms of designer's personality, design processes, and design outcomes were researched. We discuss our findings first and subsequently reflect on limitations, strengths and implications of our results.

Input-Process Relationships of Designing in Teams

Regarding input-process relationships, we found elevation of agreeableness to be related to most design process variables. In the concept phase, elevation of agreeableness is positively

related to the combined DBQT behaviors, information-based designing, building and confining the solution space, adjusting based on reflection, and making decisions. In the elaboration phase, it is positively related to the combined DBQT behaviors and making decisions. The fact that there are many relationships between elevation of agreeableness and design behavior sub categories in the concept phase but only one in the elaboration phase might be explained by the fact that team members are relatively unacquainted with each other in the concept phase. Behaving friendly and cooperatively in this phase may be an important prerequisite to get a feel of one another and to make design processes run smoothly. Later on in the project, team members have gotten to know each other and work relationships have been established. Behaving agreeable remains important, but it does not influence specific design processes as much as when the project had just started.

As expected, elevation of conscientiousness is positively related to the combined DBQT behaviors in both project phases and to making decisions in the elaboration phase. Finally, variability in conscientiousness is positively related to planning time and keeping schedule in the elaboration phase of the project. This input-process relationship is surprising, as variability in conscientiousness was expected to be negatively related to design processes (which in turn would positively influence team outcomes). The fact that variability in conscientiousness has a positive influence in this study might be explained by the fact that it is related to specific behavioral categories in a specific design phase and not to team performance in general (cf. Chapter 2). In teams in which team members differ in the extent to which they are conscientious, the more conscientious team members may signal the need for scheduling and monitoring of time towards the end of the project just to keep their less conscientious team mates on track.

Input-Output Relationships of Designing in Teams

Meta-analytical findings regarding input-output relationships between both agreeableness and conscientiousness and team performance (see Chapter 2) were only replicated for the positive effect of elevation in conscientiousness on team performance. The fact that elevation in agreeableness was of no influence on team performance is in line with findings from the moderator analysis that the effect of elevation of agreeableness was absent in student teams (see Chapter 2) and strengthens this meta-analytical result. Effects of

variability in both agreeableness and conscientiousness on performance were --as expected-- generally negative, though nonsignificant. As the meta-analytical effects of variability in agreeableness and conscientiousness were negative in both the overall and the student team sample, the nonsignificance of our findings in this respect is remarkable. It may be attributed to the relatively small sample we studied.

Process-Output Relationships of Designing in Teams

The combined DBQT behaviors relate positively to multiple outcome measures (contest results, design team member rating of the design's technical realization, and to a moderate extent to supervisor ratings of team performance). Furthermore, five of the 12 DBQT sub categories (information-based designing, reflecting, adjusting based on reflection, planning time, and keeping schedule) have positive relationships with one or more outcomes. It goes without saying that our findings should be reestablished in future design process research, but based on these results, the DBQT holds promising methodological and predictive qualities. The main categories 'design creation' --from which the sub categories information-based designing, reflecting, and adjusting based on reflection stem-- and particularly 'design planning' --which is fully made up of the sub categories planning time and keeping schedule-- provide the most cause to be included in future research.

Phases in the Design Process

We expected that specific design behaviors might relate differently to team outcomes in the concept and elaboration phase of the design project. Based on our results, we can conclude that, in order to come up with a qualitatively good design, different behaviors are important in different phases. For high team performance it turns out to be important to integrate all relevant information and to adjust the design and design behavior when new information becomes available when developing the design concept. This result is in line with findings from Gersick (1988, 1989) regarding behaviors displayed in the pre-midpoint transition phase. These kinds of behavioral actions have also been found to be important in design research (e.g., Badke-Schaub & Frankenberger, 2002; Stempfle & Badke-Schaub, 2002) and in problem solving theories (e.g., Carroll & Johnson, 1990; Lipshitz & Bar-Ilan, 1996). When elaborating the design, these behaviors remain important, but planning and

monitoring the use of time now also become important. We found that displaying time-related regulatory behavior later on in the project is positively related to supervisor and team member's ratings of team performance. This is in line with Gersick's (1988) notion that team members realize that project time is running out once they have passed the project's midpoint and with findings that planning in the execution phase of the project supports team performance (Gevers, Van Eerde & Rutte, 2001). The fact that we also find different input-process relationships in each of the project phases strengthens our conclusion in this respect.

Input-Process versus Input-Output relationships of Designing in Teams

If we look at our results from the input-process, input-output, process-output framework of team effectiveness (Hackman, 1987), we have to conclude that team composition in terms of personality affects design processes much more than it does team effectiveness. These findings provide support for team personality researchers who attempt to establish input-process relationships (e.g., Barrick et al., 1998; Van Vianen & De Dreu, 2001).

Limitations, Strengths, and Directions for Future Research

The main limitation of this research is that, due to the small sample size, analyses have been mainly of a correlational type. Even though the longitudinal character of our data (personality was measured before processes, which in turn were measured before outcomes) may give us some confidence in the causality of the relationships we found, conclusions would be much more powerful had they been based on results from regression analysis or even structural equation modeling in which effects of process variables were controlled for those of team composition variables. Here lies an opportunity for future research in this field.

Another limitation has to do with the way we tested effects of personality. When testing for effects of a single personality trait, scholars advise to control for the effects of the other personality traits (McGrath, 1998; Kozlowski & Klein, 2000), as by doing so the concept of personality as a whole is best reflected in the results. Again due to the size of the sample under study, we were not able to follow this recommendation. Although the meta-analyses on which we based our hypotheses also only used single-trait correlations, it

would have been desirable to have established the effects of agreeableness and conscientiousness while controlling for effects of the other traits (cf. Mohammed & Angell, 2003; and see Chapter 3).

A final limitation has to do with the relationships between design processes and the team member rating of the design's technical realization. These relationships may have been affected by common method or single source variance as both process and outcomes were rated by team members themselves. The fact that the other outcomes are not affected by such bias compensates for this limitation, as does the fact that both variables were rated at other points in time during the project. However, it might be interesting to have both team members and independent observers fill out the DBQT in future research and to compute interrater agreement measures or compare relationships between DBQT categories and other variables for both ratings. One might argue that this limitation also applies to input-process relationships, but as personality scores were aggregated to team composition measures and former research has established convergence between self-report and other's report of personality (e.g., Albright, Kenny & Malloy, 1988; Bernieri, Zuckerman, Koestner & Rosenthal, 1994; Funder, Kolar & Blackman, 1995), we think this form of bias was of neglectable influence here.

Bearing these limitations in mind, we consider it a strength that we have conducted our research in a relevant sample of design teams: the teams were multidisciplinary, performed a 'real life' design task, worked under constraints and towards a hard deadline, were in competition with each other, and could take notice of the work of the other teams. These are all conditions that professional design teams face as well and they thus add to the generalizability of our conclusions.

Furthermore, we have been able to measure design outcomes in three different ways. The measures differed in content and in source of measurement. If we inspect correlations among them we can conclude that they are related (as all correlations are significant), but that they adhere to different aspects of performance (as correlations are not of such magnitude that they explain no unique variance). The strong correlation between the team member rating of the design's technical realization and the contest result (r = .72, p = .00) may indicate that designers themselves have good insight into the quality of the design they

made. As the outcomes relate to different aspects of the design process, future design researchers are advised to include multiple outcome measures in their research.

Finally, we have been able to present a number of input-process, input-output, and process-output relationships and thus accomplished the aim of this study: add to the knowledge of how design processes relate to design team member characteristics and design effectiveness. Our findings, though preliminary, hold implications for design research and design practice. For design research, our results may be encouraging and may even incite design researchers to adopt an approach similar to ours in their research. For design practice, our results have implications for team composition and design processes. As the personality of design team members is related to both design processes and outcomes, mapping (differences in) team member personality and creating awareness of effects of elevation of both agreeableness and conscientiousness and of variability in conscientiousness among team members is an advisable course of action. If at all possible, teams might even be composed in such a way that it facilitates design processes and team performance. With respect to design processes, our results show that careful integration of information, reflecting upon the design, and making adjustments based on outcomes of these reflections are important determinants of design performance throughout a design project. Display of such behaviors should therefore be encouraged, for instance by scheduling these topics on the regular team meeting agenda, or by assigning a team member the task of monitoring the team behavior and signaling problems regarding results ensuing from these behaviors. Furthermore, planning and monitoring the use of time becomes of particular importance when the deadline comes in sight. In the end phase of the project, teams should thus be aware of the remaining time, e.g. by visualizing their time schedule, expressing temporal reminders, or by regularly reviewing accomplishment of the time schedule in team meetings. With regard to our recommendations on both team composition and design processes, team members might benefit from explicit training. As this research addressed student designers, such training activities could be integrated in the regular curriculum. By means of a final recommendation, we propose that student designers experience a lot of realistic design teamwork during their education, as they most likely will become members of a multidisciplinary design team once they start their career as a professional designer.

Chapter 6

General Discussion

Studying teams, team processes, and team effectiveness means embarking upon a journey into an extensive research domain. This is not surprising, as looking at the inputs, processes, and outputs of teamwork (McGrath, 1984), a vast number of variables presents itself as research object. For inputs, McGrath distinguished between individual- (e.g., personality traits), group- (e.g., group structure), and environmental level factors (e.g., rewards for performance) and he specified many per level. Group processes are numerous as well; think, for instance, of planning, cooperation, and communication. Finally, outputs are divided into performance outcomes (e.g., quality of the product) and other outcomes (e.g., member satisfaction), and again many more examples than the two presented here could be given. Now these are only the variables. Were one to take into consideration the relationships between the variables or concepts mentioned, one might soon lose overview. The field of team research has done justice to the richness of this research domain, as becomes apparent from the many studies on teamwork, several overview articles (e.g., Guzzo & Dickson, 1996; Salas, Sims & Burke, 2005), and journals specifically dedicated to this topic (e.g., Group Dynamics, Theory Research and Practice; Group and Organization Management; Small Group Research). So, where does the work presented in this dissertation fit into this comprehensive research field in terms of inputs, processes, and outputs?

Regarding inputs, this study researched into the effects of personality of the team members in terms of the Big Five personality traits, working from what is customary in current team composition research. Authors in the field of teamwork or group dynamics (e.g., Belbin, 2004; Forsyth, 1999; Napier & Gerschenfeld, 1999; Stewart, Manz, & Sims, 1999; West, 2004) reflected on individuals in teams and on how team composition affects team outcomes. Almost without exception, the authors mentioned above discussed effects of fit between individual team members. They distinguished between similarity fit (team members possess characteristics that are similar, which supposedly leads to positive team outcomes) and dissimilarity fit (each team member brings in their unique qualities, the combination of which is supposed to lead to positive team outcomes), and discussed how various forms of fit affect team functioning and team outcomes for a number of personality characteristics. However, if they zoomed in on effects of the Big Five, this issue of fit was discussed for a limited number of traits only. Although there are many speculations about effects of (dis)similarity fit between team members for all traits, there is relatively little research to cite in this respect. Researchers who did study effects of team composition in terms of the Big Five personality traits looked at effects of the variability of each of these traits separately at the team level. Furthermore, in line with research of effects of the Big Five personality traits at the individual level, they studied effects of the elevation of separate traits within a team. Finally, there is a minority of researchers who looked at the minimum and maximum score in a team for separate traits.

In line with the focus of previous research into effects of team composition in terms of the Big Five research, which was predominantly on the elevation and variability of separate traits, these operationalizations were studied in this research as well (Chapter 2 and 5). However, in order to advance this line of research, a measure was introduced which operationalized individual trait dissimilarity by means of an individual's distance to the other team members on a trait. By doing so, effects of team composition in terms of personality could be studied at the individual team member level (Chapter 3). Additionally, effort was made to study effects of combinations of traits on individual satisfaction with the team (Chapter 3), instead of studying effects of separate traits. Results of these endeavors are discussed in more detail in the next section.

This brings me to the processes that were studied. Turning back to the literature on team composition, teamwork, and group dynamics, it is noticeable that --again almost without exception-- authors point to the fact that the primary reason for team assembling is the task the team has to perform. So, it is important to clearly delineate the team task, or rather the processes needed to accomplish the team task. In this research, the task that was focused on was the innovative designing that takes place in multidisciplinary teams. As there was no instrument available to map design processes taking place in multidisciplinary teams needed to accomplish this task, our contribution consisted of a task analysis performed on design processes. This task analysis resulted in the Design Behavior Scales for Designing in Teams (DBST) (Chapter 4, Study 1). A subset of the DBST was used to construct (Chapter 4, Study 2) and validate (Chapter 4, Study 2 and Chapter 5) the Design Behavior Questionnaire for Teams (DBQT). The behaviors in this questionnaire bear on the creation of a design, the planning of a design project, and the social processes that take place among design team members.

Finally, outputs included in our research were mainly performance outcomes and in addition one personal outcome. More in particular, the performance outcomes were split up into team performance in general and design team performance in particular. For team performance in general (supervisor-rated performance of teams in general, professional teams, and student teams), a meta-analysis was performed on the relationships between team composition in terms of the Big Five personality traits and team performance (Chapter 2). This meta-analysis is the first in its kind. Furthermore, design team performance in particular was studied (supervisor-rated performance, contest performance, and self-rated performance) (Chapter 5). These kinds of design outcome had not been studied in relationship to design processes or design team composition before. The final (personal) outcome studied was that of individual satisfaction with the team (Chapter 3). This outcome of teamwork was introduced as a new topic in team composition research.

In the remainder of this discussion, I first discuss results regarding relationships between the inputs and outputs specified above. Thereafter, I reflect on what these results mean for future research into team composition in terms of the Big Five personality traits. Next, design processes and the design task are reflected upon and results regarding relationships between inputs and processes are discussed, again ending with a reflection on

implications for future research. I end this discussion with practical suggestions for professional and student design teams that follow from the results of this research.

6.1 The Relationship between Team Composition in Terms of the Big Five Personality Traits and Team Outcomes

The relationship between team composition in terms of the Big Five personality traits and team performance in general was researched in the meta-analysis in the first study (presented in Chapter 2). The relationship between team composition and design team performance was researched in the fourth study (presented in Chapter 5), and finally, the relationship between individual personality and dissimilarity to other team members' personality on the one hand and individual satisfaction with the team on the other hand was researched in the third study (presented in Chapter 3). I have ordered the discussion of results per outcome. However, by presenting an overview of results per trait in Table 6.1, I have also summarized findings per trait per outcome.

A meta-analysis on the relationship between Big Five trait elevation and trait variability on the one hand and supervisor-rated team performance on the other hand was performed for work teams in general. A moderator analysis was performed for professional and student work teams. The results showed that team performance in general is positively related to elevation of agreeableness and conscientiousness and negatively by variability in agreeableness and conscientiousness. The other traits had no significant effect on team performance in general. The results of the moderator analysis showed somewhat different relationships for both sub samples. For professional teams, the relationships established for teams in general were also found, albeit somewhat stronger. Additionally, variability in openness to experience had a small but significant negative relationship with professional team performance. For student teams, elevation of emotional stability, and variability in agreeableness, conscientiousness, and emotional stability were all negatively related to team performance. Considering the small number of correlations on which the moderator analysis was performed, the main conclusion of this study was that elevation and variability in both agreeableness and conscientiousness are the Big Five team composition variables that are most interesting to be included in future research.

Table 6.1 *Summary of Results on the Relationships between Elevation and Variability of the Big Five Personality Traits and Team Outcomes.*

Study	*Outcome Measures*	*Predictor Measures*									
		Elevation of					*Variability in*				
		EX	*AG*	*CO*	*ES*	*OP*	*EX*	*AG*	*CO*	*ES*	*OP*
study 1	Team performance of										
	- teams in general	0	+	+	0	0	0	-	-	0	0
	- professional teams	0	+	+	0	0	0	-	-	0	-
	- student teams	0	0	0	-	0	0	-	-	-	0
study 3	Individual satisfaction with the team	- (in inter-action)	+	0	+	0	- (in inter-action)	0	-	0	0
study 4	Design processes		+	+				0	+		
	Design team outcomes		0	+				0	0		

Note. 'EX' = extraversion; 'AG' = agreeableness; 'CO' = conscientiousness; 'ES' = emotional stability; 'OP' = openness to experience; '+' = positive relationship; '0' = no relationship; '-' = negative relationship; relationships in the shaded parts were not researched.

Based on the main conclusion of the meta-analysis, relationships between Big Five trait elevation and variability and design team outcomes were only researched for agreeableness and conscientiousness. Results showed that only elevation of conscientiousness was directly related to the design teams' performance.

Using multilevel analysis, the effects of individual trait elevation, the dissimilarity to the other team members' trait score, and the interaction between individual trait elevation and trait dissimilarity on individual satisfaction with the team were studied simultaneously. A positive main effect was found for individual agreeableness and emotional stability and for dissimilarity to other team members' conscientiousness. Furthermore, for extraversion, a moderation was found: satisfaction with the team is only negatively related to dissimilarity to the other team members' extraversion for members whose individual extraversion is low.

Reflection on the Relationships between Team Composition in Terms of the Big Five Personality Traits and Team Outcomes

Inspecting the relationships found between team composition in terms of personality and the various team outcomes studied, significant findings turn up most consistently for conscientiousness (see Table 6.1). Team elevation of conscientiousness is positively related to almost all types of team performance studied. The same is true for individual dissimilarity and team variability in conscientiousness. Although the findings for agreeableness closely resemble those of conscientiousness in this study, team elevation of agreeableness is not significantly related to design team performance, nor is it significantly related to design team members' individual satisfaction with the team. Results for the other traits are consistent in the sense that they show hardly or no relationship with team outcomes. The fact that relationships are fairly consistent over traits, operationalizations, and outcomes is encouraging as it substantiates the predictive validity for a specific set of Big Five trait operationalizations.

Nevertheless, when considering the number of trait operationalizations and outcomes under study, I also have to note that the number of significant effects is somewhat disappointing. The same is true for the magnitude of the effect sizes and thus the amount of outcome variance that is explained by team composition trait operationalizations. Thinking back to the complexity of the research domain I sketched in the introduction of this chapter,

this finding is not completely surprising. Considering the number of possible input variables that may affect team processes and both input and process variables that may affect team outcomes –not to mention the numerous relationships that are possible between them-, it is understandable that only a small proportion of the variance in team outcomes is explained by team member personality and team composition in terms of personality.

Zooming in on team composition in terms of personality itself also provides for explanations of the small number of effects and the small effect sizes that were found. One explanation adheres to the effects of personality in every day team practice, the other to the measurement of personality. If one regards the effects of personality in everyday team practice, intuitively almost everyone agrees that the personality of team members influences team functioning. When talking to people about teams of which they were a member, almost everyone could recall examples of how teammates hindered or supported their team in performing well through behavior that emanated from their personalities. Think of the team member who consumed the majority of speaking time during team meetings without really saying something relevant (highly extravert, lowly agreeable), the team member who never finished his or her sub task in time (lowly conscientious), the team member who thought out of the box and had that particular eureka brain wave (open to experiences), or the team member who always complained about the fact that the team would not succeed anyway and considered this to be ample reason to withhold his or her contributions from the team (lowly emotionally stable, lowly conscientious). On the other hand, these people can also immediately tell you how the rest of the team responded to the behavior of those teammates in order to make the best of supportive teammate behavior, or to compensate for hindering teammate behavior ('We diminished formal meetings', 'we assigned that person only unimportant tasks and took on more work ourselves', 'we all collected additional information to implement that idea', or 'we called that team member to account on his or her behavior'). The reaction chosen again may have been in part dependent on the respective team members' personality. Furthermore, the reaction chosen will have elicited a response from the team member to whom the action was directed, but it will also have affected the other team members (for instance, working relationships in the team may have improved, sub groups may have been formed, a leader may have emerged, or conflicts may have arisen). This will have provided a new status quo on which all team

members again will have reacted according to their personality. In all fairness, it would be an illusion to think that the effects of such complex sequences of personality action and reaction on team outcomes can be adequately captured by relating a personality assessment at the beginning of a project to only a few measurements of team processes during the course of a design project.

This brings me to the measurement of personality. In the first set of examples in the preceding paragraph, I attempted to give an indication of the Big Five traits that may have caused the behavior described. The reader will have noticed that some descriptions referred to two traits. This implies that there are behaviors which cannot be captured by a single trait. Moreover, the Big Five framework implies that personality always has its effect through the concerted influence of all five traits. At the team level this would mean that each team member brings in a personality pattern made up of five indicators. If we would assume that a team member's personality score on each trait can be high, intermediate, or low (which is, of course, a simplification and immediately raises definition questions of 'high', 'intermediate', and 'low'), the number of possible personality patterns for a single person would be 3^5 (=243). In a team, each member would bring in one of these 243 personality patterns, which makes the number of possible team composition patterns for a three-person team 243^3 (=14,348,907). Researching all these team composition patterns is, of course, undoable, and one might even wonder if such a research effort could yield usable results. Considering that, besides this, each trait consists of a number of facets that describe personality and behavior resulting from it more in depth, the number of team composition patterns to be researched would explode even further. It is therefore not surprising, but uncalled-for nevertheless, that personality researchers focus on effects of single facets and traits, and sporadically on interactions between traits, and that researchers into team composition in terms of personality study isolated effects of elevation and variability per trait, instead of trying to capture the effects of the complex personality pattern that really describes the team. In this dissertation, the meta-analysis and the study in which input-process and input-output relationships were researched built on this line of work. Given the complexity described above, it is all the more notable that some input-output effects consistently emerged. These effects may be used as point of departure for researchers in this area to shape their future research on effects of patterns of personality. Furthermore, in

the study in which effects of team composition in terms of personality on individual satisfaction with the team were researched, we tried to approach operationalizing the pattern of team composition, by looking at the individual level effects of all traits and all trait operationalizations simultaneously. We succeeded in doing so, as this approach yielded significant results that provide more detailed insight into effects of team composition in terms of personality than those available so far. Nonetheless, one might argue that, although already a step forward, this approach does not come close to capturing the complexity of patterns described above either and that the results that emerged from this study are not that deviant from what has been found in studies that employ team level operationalizions of team composition in terms of personality. So, at first glance this method might seem a lot of extra work with fairly little yield. Nevertheless, one should consider that this approach is the first of its kind and that it is in line with recommendations of scholars in the team composition research field (McGrath, 1998; Kozlowski & Klein, 2000). More research is needed to evaluate its value properly.

Future Team Composition in Terms of Personality Research

In retrospect, I would not advise other team composition researchers to research effects of single-trait team-level operationalizations, but I do have specific ideas of how to proceed instead. In my opinion, the complexity of the effects of personality in teams that have to be researched needs to be reduced. This can be done in two ways. First of all, one can consider the dimensions of the Big Five too coarse to be of use when studying effects of personality in a team (which shows from the relative poverty of results in the studies presented in this dissertation). Responding to this limitation, researchers might instead choose to look at effects of a limited but relevant sub set of the more refined facets of which each Big Five trait is composed (like LePine (2003) did for conscientiousness). As these facets describe personality, and thus behavior stemming from it, in greater detail, they may be better linkable to specific team processes or outcomes. This was not done in the research presented in this dissertation, as there was no overview of effects of the Big Five traits on team performance yet. So it was not clear from which traits facets should be selected. Now that results from the meta-analysis provide directions in this respect, this recommendation

becomes more feasible. The downside of this suggestion is, of course, that effects of team member personality are not captured as a whole. This brings me to another alternative.

In an effort to capture effects of personality as a whole and to reduce complexity at the same time, researchers could also choose to use a personality instrument that is more specifically tailored to effects of personality in a team. A team-oriented instrument that springs to mind in this respect is that of Belbin (2004). Using Belbin's Team-Role Self Perception Inventory, a team member is assigned one primary team role based on his or her specific behavior in a team. This condensed personality description per team member hugely limits the number of possible patterns when researching the effect of patterns of personality in teams (eight possible roles per team member result in $8^3 = 512$ possible patterns for a three-member team, as opposed to the 243^3 possible patterns mentioned previously). In fact, using Belbin's team roles, team composition experiments have already been conducted (Parrington & Harris, 1999; Prichard & Stanton, 1999). Nevertheless, although Belbin's team roles are often used for team training purposes and are intuitively appealing, their main limitation for research are their poor psychometric qualities. The team roles have low internal consistency and they are highly intercorrelated (Fisher, Hunter, & Macrosson, 2001; West, 2004). Suggestions to use a personality description that is not based on the Big Five framework may come across as disputable, as the Big Five framework is a well established and accepted instrument for the measurement of personality. Given the face validity of the team roles and the robustness of the Big Five framework, it is not surprising that efforts have been made to find out how the Belbin team roles relate to the Big Five (Fisher et al., 2001). Such efforts remain pointless, however, until a more psychometrically sound team role instrument has been developed.

As the citations show, in line with both recommendations some research has already been conducted. I think both types of research will aid in arriving at a personality description that is team specific and low in complexity, but a more systematic approach might be adopted in doing so. In my view the following subsequent research steps should be taken to further research in this area. First, research into effects of specific Big Five facets will have to accumulate in order to present us with more insight in which parts of personality really matter in teamwork. The meta-analysis presented in this dissertation may direct researchers in their selection of Big Five facets to study. Second, as soon as a clear

overview of effects of facets exists, the relevant facets might be combined into a team personality instrument, like for instance a new set of team roles, or they could be used to compress existing team role instruments (e.g., Belbin's Team Roles (Belbin, 2004), or Myers-Briggs Type Indicator (Myers & Briggs, 1962)). Finally, once arrived at a valid team personality instrument, the matter of operationalizing team composition resurfaces. With the introduction of the Personality Trait-Based Interactionist Model of Job Performance, Tett and Burnett (2003) actually advocated that the individual should be the starting point when researching effects of personality within a social context like a team. Working from this model, additional research, for instance like that presented in this dissertation' study on relationships between team member personality and individual satisfaction with the team, will have to show whether effects of team composition in terms of personality should indeed be researched using operationalizations of personality that place the individual in the team context, whether team level operationalizations are more suitable, or whether we still have to look for different ways of operationalizing and analyzing effects of team composition, for instance using pattern analysis (Tabachnick & Fidell, 2001).

So far, I took personality as a point of departure in reflecting on relationships between team member personality and team effectiveness. But with good reason one might also argue that the way in which team members' personalities interact is determined by what is important in a project at a specific point in time. In fact, you only have to take a glance at any piece written on teamwork to find that authors --almost without exception-- state that the effects of personality are dependent upon the task a team has to perform. This brings this discussion to the design task and relevant team processes in this respect. Both are reflected upon in the next section.

6.2 The Relationship between Team Composition in Terms of the Big Five Personality Traits and Design Processes

Design Process Measurement

Up till now, design processes have been studied in many ways, but in none of these studies researchers used design behavior questionnaires, neither was such a questionnaire constructed. That is why this task was taken up as part of the research in this dissertation.

The results of this endeavor are presented in Chapter 3 of this dissertation. The construction of this questionnaire proceeded along three steps. In the first step of constructing the instrument, design process measurement scales --the Design Behavior Scales for Teams-- were constructed based on interviews with professional multidisciplinary design team members. In the second step, a sub set of these behaviors that applied to multidisciplinary student design teams was tested for structure and reliability, which resulted in the Design Behavior Questionnaire for Teams (DBQT). Finally, the predictive validity of the DBQT was tested in the fourth study in which relationships between multidisciplinary design team composition, design processes, and design team outcomes were tested. Tests of the DBQT's structure, reliability, and stability revealed that the psychometric qualities of the instrument are satisfactory. Since its predictive validity was tested using the same sample, this might pose limitations to the DBQT's predictive validity. These results provide enough basis for considering the DBQT a promising instrument to use in future design team research.

Future Research regarding the Methodological Properties of the DBST and DBQT

To establish the psychometric properties of the DBQT more decisively, a first suggestion for future research is that validation of the instrument should be replicated in other samples. It would be, for instance, highly informative if the DBQT's psychometric qualities could be re-established in a sample of professional design teams, or in a sample of (professional and student) design teams that work on longer projects or under supervision of an appointed project leader. Furthermore, the DBQT might be customized for the use in specific samples by adding scales from the DBST. Results from this latter type of research could serve to tailor the DBQT for sample-specific use in future research, but they also provide valuable information for design practice and education (to be discussed in the paragraph 'Implications for design team practice and education').

Before I turn to relationships between design team composition in terms of personality, and design team processes and design team effectiveness, it is important to see how the results on these relationships for multidisciplinary design teams can generalize to other types of team. In order to make statements about the generalizability, I first describe the design task from a design literature perspective and thereafter I match these descriptions to those offered in prevailing task taxonomies from the social sciences literature.

Classifying the Design Task

In the design literature, designing and the design task have been reflected upon from two paradigms (see Dorst (1997) for a comprehensive comparison of designing from both perspectives). One paradigm is that of positivism, which considers the design task to be a task of *rational problem solving*: the ill-defined design problem is solvable if the correct order of phases (analysis, synthesis, simulation, evaluation) is followed (Simon, 1969). Nowadays, this view on designing is to be considered applicable to design tasks with a well-defined design goal only (Dorst, 2003, p. 15). However, innovative designing is characterized by ill-defined or 'wicked' problems: (a) the design goal is dependent upon the interpretation of the people involved in the design process and the design goal develops throughout the design process, (b) the design process itself is influenced by all kinds of influences from the context in which it takes place, and finally, (c) designers themselves can go about the design process any way they choose (Dorst, 2003, p. 22). Social constructivists hold such a view on the design task and see it as one of *reflection-in-action* (Schön, 1983). From this perspective, designers have to name relevant factors in the design situation, frame the design problem, move toward a solution, and evaluate the moves that have been made. After this evaluation, (part of) this sequence of steps will have to be repeated, which makes designing a highly iterative process.

The design task as described in the design literature can now be classified by using three influential task taxonomies from the social psychology literature. These taxonomies are those of Hackman and Morris (1975), Laughlin (1980), and Steiner (1972). In the taxonomy of Hackman and Morris (1975), three classes of performance-related tasks are distinguished: (a) *production tasks*, in which a team needs to generate ideas or images, (b) *discussion tasks*, in which a team has to evaluate a certain issue, and (c) *problem solving (or planning) tasks*, in which a team needs to solve a specific problem, and, in order to do so, team members first need to formulate a plan of action. Laughin (1980) proposed a continuum on which a team task can be placed. This continuum ranges from *judgmental tasks*, in which no single answer or judgment is superior, to *intellective tasks,* in which the team has to find the one correct, superior answer to a problem. Finally, Steiner's taxonomy (1972) distinguishes between (a) *additive tasks*, in which a team needs to sum resources in order to succeed, (b) *compensatory tasks*, in which a team needs to average individual

inputs in order to succeed, (c) *conjunctive tasks*, in which team members need to function at a minimally acceptable level in order for the team to succeed, and (d) *disjunctive tasks*, in which only one team member needs to function well in order for the team to succeed.

When thinking of designing as a rational problem solving task, it can be best characterized as a problem solving task (Hackman & Morris, 1975), or an intellective task (Laughlin, 1980). Considering designing as a reflection-in-action task, it can be classified as both a(n idea) production task and discussion task (Hackman & Morris, 1975), and as a judgmental task (Laughlin, 1980). This characterization of the design task is in line with what Dorst (1997, p. 167) described for design activities viewed from both paradigms. Designing as described from both paradigms is not that easily classified using Steiner's taxonomy (1972), as it is based on the contributions of the team members and not on the nature of the task. Steiner's taxonomy can be applied when taking into consideration that the research presented in this dissertation deals with multidisciplinary design teams. The task can be classified as both additive and conjunctive: each team member has to contribute his or her disciplinary share (additive) and has to do so at a minimally acceptable level (conjunctive) in order for the design to succeed (Steiner, 1972). Seeing the design task as either ill- or well-defined, this classification can be somewhat refined in terms of design task characterization. If the design problem is ill-defined (reflection-in-action), additive and conjunctive task characteristics present themselves more in the conceptual contributions each team member makes from within his or her disciplinary background. If the design problem is well-defined (rational problem solving), these task characteristics present themselves more through contributions of disciplinary skills in elaborating the design sub tasks. Finally, if one member has a brain wave that strongly furthers the conceptual or elaboration process, the task might also be characterized as disjunctive (Steiner, 1972).

Now, it is interesting to hold these two views and corresponding classifications of designing against the two phases of the design process that were researched in this dissertation (the concept and elaboration phase). The design task in the concept phase is best characterized as one of reflection-in-action, and in the elaboration phase as one of rational problem solving. In the concept phase, the design goal has to be developed from scratch. The design team members will have to go through a number of iterations of reflection-in-action activities to come up with a feasible concept. Once they commence to

elaborate this concept in the elaboration phase, however, the designing will move toward rational problem solving, as the goal (concept) is now defined and concrete steps can be taken towards building the design. Nevertheless, in the elaboration process the design team members will still encounter new (smaller, sub-) design problems as they go along, which again require naming, framing, moving, and evaluating. These courses of action can be expected to be less frequently needed the more thoroughly designed the concept is. So, designing remains a task that is characterized as reflection-in-action, but this will gradually decrease toward the end of the elaboration phase.

Considering this division of tasks over phases, the results described in this dissertation for the concept phase of the design work can be expected to generalize to teams that perform (idea) production tasks, discussion tasks, and judgmental tasks. And although this will also remain true to some extent for the results described for the elaboration phase, these results will probably better generalize to teams that perform problem solving or intellectual tasks. Throughout both design project phases, results will generalize to teams that perform additive or conjunctive tasks, as in both phases team members need to bring in a minimal amount of their disciplinary knowledge or skills. With this classification in mind, we can turn to the discussions of relationships between team composition in terms of personality and design processes for both phases.

Reflection on the Relationships between Team Composition in Terms of the Big Five Personality Traits and Design Processes

Based on meta-analytical findings on relationships between team composition in terms of personality and team performance, a selection was made regarding the traits and operationalizations that were studied in relationship to design team processes. Only elevation and variability in agreeableness and conscientiousness were related to design processes as measured using the DBQT. The results show that elevation of agreeableness mainly has (positive) relationships with the DBQT sub categories information-based designing, building and confining the solution space, adjusting based on reflection, and making decisions, and that this is especially true in the concept phase. Variability in agreeableness is not related to any of the DBQT sub categories. Both elevation and variability in conscientiousness have positive relationships with some DBQT sub

categories: elevation in conscientiousness with making decisions and variability in conscientiousness with planning time and keeping schedule. Combining these results with those discussed in the section on input-output relationships, I conclude that team members' agreeableness most strongly affects design processes, whereas design team members' conscientiousness most strongly affects design outcomes.

I will now reflect on differences found between input-process and input-output relationships. In team composition research, scholars distinguish between task-related traits (that affect task execution) and team-related traits (that affect team functioning). Agreeableness is considered to be a team-related trait and conscientiousness a task-related trait. This differentiation is also made for outcomes of teamwork, namely task performance (e.g., quality, timeliness) and contextual performance (e.g., moral and showing personal concern). The results presented here can be considered to be in line with this distinction. Agreeableness relates to team processes --and thus to team functioning--, conscientiousness to task-related processes and task performance. The DBQT also included categories that specifically tapped into the social functioning of the team (cooperation and reflection on team functioning). The fact that agreeableness is not related to these team-related or contextual DBQT processes --as one might have expected based on this distinction--, but *is* related to DBQT processes that are associated with task execution leads me to conclude that the social functioning of the team pervades the task-related processes in design teams. Conscientiousness only has relationships with task-related DBQT processes (making decisions, planning and keeping schedule), as would have been predicted based upon the distinction between task- and team-related traits and outcomes.

That relationships between agreeableness and design process behaviors are predominantly present in the concept phase of the design project can be explained by looking at them from the task or by looking at them from a team development point of view, which I will do in that order. As the design task in the concept phase of the design project is fairly complex (as described in the previous section), agreeable behavior among team members may be important to smoothen the complex design processes that have to take place in this project phase. As design processes in the elaboration phase move toward problem solving, tasks become more concrete and sub tasks can be divided among members, so require less interaction, and thus less agreeable behavior may be needed for

successful task completion in this phase. Explaining these relationships from a team development point of view, it has to be noted that the vast majority of the team members in our research were unacquainted with each other at the start of the design project (concept phase). Agreeable behaviors like being friendly, courteous, cooperative, flexible, and forgiving may have been important to help establishing working relationships in the first project phase (the *forming*, *storming*, and *norming* stage of group development (Tuckman, 1965, Tuckman & Jensen, 1977)). In the elaboration phase, team members have become sufficiently familiar with each other and working relationships have been established (*working* stage of group development (Tuckman, 1965, Tuckman & Jensen, 1977)). Being agreeable may now become less important to get the job done.

Future Research regarding Relationships between Team Composition in Terms of Personality and Design Processes

Considering the differences in relationships found for agreeableness and conscientiousness and for the design task in the concept phase and the elaboration phase, it may be interesting to replicate the research into input-process and input-output relationships in (design) teams that face a design task that can be (almost) completely characterized as problem solving (e.g., certain types of incremental designing, teams that elaborate design concepts from development teams). It may also be interesting to replicate this research with teams that have to work together for longer periods of times, as group development may proceed differently in these teams, or with teams in which members are already familiar with each other, as they can be expected to have established working relationships. These types of research may help to clarify whether (a) conscientiousness is indeed task-related and agreeableness process- or contextual related, (b) the importance of agreeableness for design processes is especially focused in the first phase of the teamwork and the importance of conscientiousness more in the last phase, and (c) the importance of agreeableness for the design processes is due to the type of design task or to the stage of team development.

The above suggestions adhere to single traits, which is against recommendations I proposed for future research for team composition in terms of personality. A refinement of the suggestions presented in that section, which can be made based on these results, is that a newly developed team personality measure may have to include personality aspects that

either relate to team functioning, to task execution, or to both. This idea has partly already been incorporated in Belbin's team roles (e.g., *team workers* create and maintain the team spirit, whereas *implementers* provide practical translations and implementations of team ideas (Belbin, 2004)). Musing on possibilities here, perhaps a continuum with these extremes might be devised; maybe these extremes even are agreeableness and conscientiousness. For newly formed design teams, a working hypothesis to be tested in this respect might be that in the concept phase, or for ill-defined design tasks, teams composed of members that score toward the team-related extreme may serve team effectiveness best, whereas in the elaboration phase, or for well-defined design tasks, teams composed of members that score toward the task-related extreme may serve team effectiveness best.

Up till now, I extensively discussed what implications the research presented in this dissertation may have for future research. However, designers in the field, design students, and design educators may be more interested to learn what the implications of this research are for every day design team practice or education. These implications are the ones to which I devote my final reflections.

6.3 Implications for Design Team Practice and Education

Effectively performing teams in general are ideally composed of highly agreeable and highly conscientious team members, who also score similarly on these traits (low variability). The ideal composition of effectively performing design teams is similar to that of effective teams in general with regard to elevation of agreeableness and conscientiousness, although elevation of agreeableness affects design processes and not performance directly. The ideal composition of effectively performing design teams is also somewhat similar (low variability) with respect to variability in agreeableness and conscientiousness, as variability in both traits has a negative --though weak-- relationship with team performance. It has to be said, however, that variability in conscientiousness also had positive effects on regulatory time-related behaviors in the elaboration phase of the project. Furthermore, satisfied design team members are agreeable and emotionally stable and similar to other team members with respect to conscientiousness and they are lowly and similarly extravert. In answering the research question presented in the introduction of this

dissertation, I might be expected to recommend to compose design teams according to these guidelines, but such a suggestion would probably be unrealistic. Design teams in practice are often not stable in their composition, team members' disciplinary backgrounds are usually a much more important selection criterion than team member personality, and there are not that many people to select from in organizational practice. When I add to this the fact that personality is a relatively stable property (Costa & McCrae, 1992b, 1988), which makes it difficult to change, a better recommendation might be to maintain teams that have proven to be effective and to teach team members of less effective teams how to deal with team issues that arise from (differences in) personality on a behavioral level. That behavior can be effectively changed has been shown by (neo) behavioralists like J. B. Watson (1878-1950), I. P. Pavlov (1849-1936), and B. F. Skinner 1904-1990). Skinner has shown that through reinforcement desired behavior can be shaped and undesired behavior can be unlearned (extinguished). However, before this can happen, team members need to be taught what are and what are not desirable behaviors.

As conscientiousness is directly related to team performance, it is important to teach team members conscientiousness-related behaviors. These encompass, for instance, setting goals, working systematically, planning actions, monitoring activities toward achieving goals that were set, persistence, and exerting effort. A lot of these behaviors are taught in time management training programs (Green & Skinner, 2005; Lakein, 1973; Macan, 1994, 1996) that are offered nowadays. As agreeable behaviors support design processes, it will also be important to teach members to cooperate with others, support each other, behave friendly and courteous toward others, and to not impose one's will upon other team members. Team members also have to learn to deal with problems that arise when they encounter difficulties of opinion caused by differences in personality. These kinds of behavior are trained during team building training programs (e.g., West, 2004) that are widely available.

Furthermore, team members need to be taught what constitutes effective design processes. Based on the results presented in this dissertation, these behaviors encompass integrating information in the design and thoroughly developing the design, reflecting upon how design development is proceeding and how to adjust behavior to new information or events in the design process, planning the project time, monitoring activities in order to

keep schedule, and behaviors related to the decision making process. As organizations differ in the way they approach design projects, it is probably best if these behaviors are taught in-house with training programs that are tailored to the organizational circumstances in which design teams operate. I would advocate that these training programs are offered to a group of designers that extends beyond single design teams, as professional design teams often change in composition. All designers that are likely to become a member of a certain design team will then possess the same knowledge regarding design team functioning and can call upon each others' knowledge if needed. For student design team members, all knowledge and skills with regard to behavior related to conscientiousness, agreeableness, and design processes can be incorporated in the regular curriculum in specific team functioning courses, or integrated in courses on design methodology. Once design team members posses the knowledge and skills that are needed, it becomes important to transfer that knowledge to the work floor, so that effective behavior results from it. Research has shown that this does not automatically happen (Baldwin & Ford, 1988). This is where reinforcement comes in.

First of all, team members themselves can systematically reflect upon their use of the knowledge and skills acquired during training (Marx, 1982). They can compliment each other on things that went well and point each other at behaviors that can be improved and reflect on how to do so. Secondly, it will be important that project leaders pay attention to how the team functions as a whole (e.g., the project leader might take on the role of neutral discussion leader during team reflection sessions), and to how individual team members behave within the team (e.g., via systematic coaching and feedback) (Chhokar & Wallin, 1984). For student designers, these kinds of behavior can be shaped in real-life resembling design assignments such as the ones that were studied in the research presented in this dissertation, or in other meaningful design projects, like completing a design assignment for an organization. In the beginning of the educational program, a course leader may take on the role of project leader and provide coaching and feedback on team and team member functioning, but this may gradually shift to a situation in which the team members themselves take on the role of project leader in turn towards the end of the education. Furthermore, students can take part in professional design projects and shape their behavior according to that of professional designer role models. During such assignments, it will be

important that a professional design team member or project leader coaches the apprentice designer.

Once all of these training recommendations have been effectively implemented, professional and student design teams may experience the ultimate and probably most powerful type of reinforcement possible: reinforcement through team effectiveness itself. Team effectiveness can either lie in fulfillment acquired through successful team processes, or, and that is at the same time also the most profitable one for organizations, in developing designs that are of high qualitative standards. If the work and suggestions presented in this dissertation help design teams move toward achieving this goal, I consider this research to have been worth the effort.

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Summary

The increasing complexity of technological products and the increasing pace with which technological developments reach the market prompt organizations to deploy multidisciplinary design teams as a means to attain or maintain competitive advantage. On top of this, designing itself is a complex matter. Moreover, design team members have to deal with the dynamics of teamwork. All in all, this sets a stage in which any recommendation is welcome that aids in improving design team composition or design processes in order to advance design team effectiveness. Therefore in this dissertation the following research question was addressed: how should multidisciplinary design teams be composed so that processes emerge that lead to good designs? This question was researched using an input-process-output research model of team effectiveness. The input researched was design team composition in terms of team member personality. Processes researched were design processes that take place within innovative multidisciplinary design teams. Outcomes researched were objective and subjective design team performance outcomes and team member satisfaction with the team. The input-process-output research model on which the research was built posits that team composition in terms of personality is related to both design processes and design outcomes, and that design processes and outcomes have a reciprocal influence on each other (Chapter 1).

The framework that scholars predominantly use to describe personality is the so-called Five-Factor Model of personality, or the Big Five. Its five factors are extraversion (extraverts are talkative and socializing, whereas introverts are silent and avoid contacts), agreeableness (highly agreeable persons are soft natured, tolerant, and considerate of others, whereas non agreeable persons are bossy, egocentric and they impose their will), conscientiousness (highly conscientious persons are well-organized, precise, and work systematically according to a plan, whereas lowly conscientious persons are undisciplined, sloppy, and have a chaotic work style), emotional stability (emotionally stable persons are poised and can put problems or set backs aside easily, whereas emotionally unstable -or neurotic- persons are nervous, and get easily overwhelmed by problems or emotions), and finally, openness to experience (highly open persons are acute, critical and form their own opinion, whereas lowly open persons agree with everything, follow the majority, and have no opinion of their own). To research effects of personality at the team level, team members' Big Five trait scores are transformed into team composition scores, of which the most commonly used are (a) trait elevation: individual team member's trait scores are aggregated to a team mean score and (b) trait variability: individual team member's trait scores are used to compute a team variance score. To determine the effect of Big Five trait elevation and variability on team performance a meta-analysis was performed (Chapter 2). Results showed that for teams in general elevation in agreeableness and conscientiousness were positively and variability in agreeableness and conscientiousness were negatively related to team performance. Moderation by type of team was tested for professional teams versus student teams. Moderation results for agreeableness and conscientiousness were generally in line with the total sample results, although effects in professional teams were more pronounced. Furthermore, results showed that for professional teams variability in openness to experience was negatively related to team performance, whereas for student teams negative relationships were found between both elevation and variability in emotional stability and team performance. The results found for teams in general served to delineate the inputs in the research model.

By aggregating individual personality to the team level to derive measures of team composition, information about the (differences in) individual personality of team members is lost. As each member brings his or her personality into the team, the effects of

personality within a team are best described by a team composition operationalization that captures the pattern of personalities of the team members. In order to retain individual personality trait differences, a demographical dissimilarity measure was applied to compute individual dissimilarity to other team members' trait scores for each team member. To come closer to a team composition score that reflects the pattern of personalities of all team members, the effects of each team member's (a) individual Big Five trait scores, (b) dissimilarity to other team members' Big Five trait scores, and (c) interaction between (a) and (b) on individual satisfaction with the design team were researched using multilevel techniques (Chapter 3). It was found that team member satisfaction with the team was positively predicted by individual agreeableness, individual emotionally stability, negatively by dissimilarity in conscientiousness, and by an interaction between individual extraversion and extraversion dissimilarity. The interaction was such that similar and lowly extravert team members were most satisfied with their team. The individual dissimilarity operationalization that resulted from this study was used to operationalize trait variability as an input in the research model.

To determine which design process behaviors that should be studied and to construct an instrument to measure those behaviors with, a task analysis on designing in multidisciplinary teams was performed (Chapter 4). Interviews with professional design team members were performed to construct the Design Behavior Scales for Teams. A sub set of these scales was tested for structure, stability, reliability, and validity in a sample of student design team members. The Design Behavior Questionnaire for Teams (DBQT) resulted from these tests. The DBQT consists of 55 critical design team member behaviors that are divided into three main categories 'design creation', 'design planning', and 'design cooperation'. Within these three main categories, 12 sub categories are distinguished. Sub categories under the main category 'design creation' are (1) 'design task organization', which addresses the organization of the work once the design problem has been established, (2) 'information-based designing', which relates to developing the design thoroughly based on all available and relevant information, (3) 'building the solution space', which concerns the generation of possible solutions, (4) 'confining the solution space', which concerns restricting the number of possible solutions, (5) 'phase transitions', which bears upon the extent to which conscious transitions are made between phases in the design process, (6)

'reflecting on the design', which is about reflection upon the development of the design, and, (7) 'adjusting based on reflection', which relates to the way the design and design behaviors are adjusted after evaluations. The two sub categories of the main category 'design planning' are 'planning time' and 'keeping schedule'. The sub categories belonging to the main category 'design cooperation' are 'cooperation', 'reflecting on team functioning', and 'making decisions'. The DBQT generally shows satisfactory psychometrical qualities and was therefore used to specify and measure design process behaviors in the research model.

Finally, the complete research model of design team effectiveness was researched (Chapter 5). The research was conducted in a sample of student design teams that designed and built their own robot with which they competed in a contest. Inputs researched were team level trait elevation and trait variability for both agreeableness and conscientiousness. For trait variability individual dissimilarity scores were aggregated to a team mean dissimilarity score. Design processes in both the concept and elaboration phase of the design project were measured using the DBQT. Outputs researched were the contest results and team member and supervisor ratings of the design's quality. Results regarding input-output relationships only showed a positive relationship between elevation in conscientiousness and outcomes. Results regarding input-process relationships showed that elevation in both agreeableness and conscientiousness were positively related to the combined DBQT behaviors in both phases of the design project. More specifically, elevation in agreeableness was positively related to a number of DBQT sub categories in the concept phase of the design process, whereas variability in conscientiousness was positively related to DBQT time regulatory behaviors in the elaboration phase. Finally, a number of design processes was positively related to objective and subjective design outcomes.

Reflecting on these results (Chapter 6), a number of conclusions were drawn. First, the most consistent effects of design team member personality on both processes and outcomes show up for conscientiousness. Furthermore, elevation in agreeableness is mainly related to design processes. Regarding the phases in the design process, results show that agreeableness affects design processes in the beginning of the design project more, whereas conscientiousness affects design processes more toward the end of the project. Differences

in input-process and input-outcome relationships for both traits may be attributed to the fact that agreeableness is a team-related trait and thus relates to team-related or contextual outcomes of teamwork (i.e. design processes), whereas conscientiousness is a task-related trait, and thus relates to task-related outcomes of teamwork. Second, the effects of personality are generally small. This may have to do with the fact that (a) outcomes and processes are affected by a number of other variables that were not included in the research, (b) team composition in terms of personality is much more complex than can be reflected in aggregated team composition measures, and/or (c) the complexity of processes resulting from composition in terms of team member personality is not easily captured. Future research should preferably be directed at the construction of a measure of team composition in terms of personality that captures effects of personality as a whole which is less complex at the same time. Third, operationalizing team composition in terms of personality at the individual level is useful when studying effects of personality on individual outcomes of teamwork, as in this way more detailed results are obtained. Aggregating individual trait dissimilarity measures to the team level in order to study effects on team outcomes yields results that are similar to those obtained when using the team standard deviation for each of the trait scores. Fourth, the DBQT shows promising psychometrical qualities and has predictive value regarding design processes that take place in multidisciplinary teams. Nevertheless, in future research the predictive value has to be re-established in other design team samples.

Based on the findings described in this dissertation, practical guidelines for team composition of effective design teams were formulated. An alternative approach to improving team effectiveness may be to teach (student) designers what and how (differences in) personalities can affect design processes and outcomes, how to deal with these effects, and which design behaviors are effective in which phase of the design project.

Samenvatting

(summary in Dutch)

De toenemende complexiteit van technologische producten en de toenemende snelheid waarmee technologische ontwikkelingen de markt bereiken zetten organisaties ertoe aan multidisciplinaire teams in te zetten om een strategische concurrentiepositie te behalen of te behouden. Bovendien is ontwerpen zelf een complexe aangelegenheid en hebben ontwerpteamleden te maken met de dynamiek van het werken in een team. Al met al creëert dit een situatie waarin elke aanbeveling aangaande de compositie van ontwerpteams of ontwerpprocessen welkom is om de effectiviteit van ontwerpteams te verhogen. Daarom wordt in dit proefschrift de volgende onderzoeksvraag behandeld: hoe moeten ontwerpteams worden samengesteld zodat er processen ontstaan die leiden tot goede ontwerpen? Deze vraag is onderzocht op basis van een input-process-output model van teameffectiviteit. De onderzochte inputvariabele was teamcompositie in termen van persoonlijkheid van de teamleden. De onderzochte processen waren ontwerpprocessen die plaatsvinden in multidisciplinaire ontwerpteams die innovatief ontwerpen. De onderzochte outputvariabelen waren objectieve en subjectieve prestatieuitkomsten van ontwerpteams en de tevredenheid van de teamleden met het team. Het input-process-output model waarop het onderzoek gebaseerd was, veronderstelt dat teamcompositie in termen van persoonlijkheid gerelateerd is aan zowel ontwerpprocessen als ontwerpuitkomsten en dat ontwerpprocessen en uitkomsten elkaar wederzijds beïnvloeden (Hoofdstuk 1).

Het meest invloedrijke raamwerk dat door wetenschappers wordt gebruikt om persoonlijkheid mee te beschrijven, is het zogenaamde vijf factoren model van persoonlijkheid, ook wel de 'Big Five' genoemd. De vijf factoren in het model zijn: extraversie[8] (extraverten zijn praatgraag en gedragen zich sociaal, terwijl introverten zwijgzaam zijn en contacten uit de weg gaan), mildheid (milde personen zijn zachtaardig, tolerant en houden rekening met anderen, terwijl niet-milde personen bazig en egocentrisch zijn en anderen hun wil opleggen), ordelijkheid (ordelijke personen zijn georganiseerd, nauwkeurig en werken systematisch en planmatig, terwijl onordelijke personen ongedisciplineerd en slordig zijn en een chaotische werkstijl hebben), emotionele stabiliteit (emotioneel stabiele personen zijn evenwichtig en zetten zich makkelijk over problemen of tegenslagen heen, terwijl emotioneel onstabiele -of neurotische- personen nerveus zijn en zich makkelijk laten overweldigen door problemen of emoties) en ten slotte intellectuele autonomie (intellectueel autonome personen zijn scherp, kritisch en vormen hun eigen mening, terwijl intellectueel niet-autonome personen het met alles eens zijn, de meerderheid volgen en geen eigen mening hebben). Om effecten van persoonlijkheid op het teamniveau te onderzoeken worden persoonlijkheidsscores van teamleden op ieder van de Big Five dimensies getransformeerd tot teamcompositiescores. De meest gebruikte teamcompositiescores zijn (a) elevatie: de dimensiescores van individuele teamleden worden geaggregeerd tot een gemiddelde teamscore en (b) variabiliteit: de dimensiescores van individuele teamleden worden gebruikt om de variantie in een team te berekenen. Om van ieder van de Big Five dimensies de effecten van elevatie en variabiliteit op teamprestatie vast te stellen, is er een meta-analyse uitgevoerd (Hoofdstuk 2). De resultaten lieten zien dat voor teams in het algemeen elevatie van mildheid en ordelijkheid positief en variabiliteit in mildheid en ordelijkheid negatief gerelateerd waren aan teamprestatie. Moderatie van het type team is getest voor professionele teams versus studententeams. Moderatieresultaten voor mildheid en ordelijkheid kwamen over het algemeen overeen met de resultaten voor teams in het algemeen, hoewel de effecten voor professionele teams meer uitgesproken waren. Verder toonden de resultaten dat voor professionele teams

[8] De Nederlands factorlabels zijn ontleend aan de handleiding van de Five–Factor Personality Inventory (Hendriks et al., 1999); de Engelse labels zijn respectievelijk extraversion, agreeableness, conscientiousness, emotional stability en openness to experience.

variabiliteit in intellectuele autonomie negatief gerelateerd was aan teamprestatie, terwijl voor studententeams negatieve relaties werden gevonden voor zowel elevatie als variabiliteit in emotionele stabiliteit. De resultaten die zijn gevonden voor teams in het algemeen zijn gebruikt om de inputvariabelen in het onderzoeksmodel af te bakenen.

Door individuele persoonlijkheid te aggregeren naar het teamniveau gaat informatie over (verschillen in) individuele persoonlijkheid verloren. Omdat ieder teamlid zijn of haar persoonlijkheid meebrengt in het team, kunnen de effecten van persoonlijkheid in een team het best beschreven worden aan de hand van een operationalisatie die het patroon van persoonlijkheden van de teamleden vangt. Om verschillen tussen individuen op persoonlijkheidsdimensies te behouden is een demografische verschilmaat gebruikt om voor ieder teamlid voor elk van de vijf dimensies het verschil tussen de score van hem- of haarzelf en die van de andere teamleden te berekenen. Om het patroon van de persoonlijkheden met een teamcompositiemaat te benaderen zijn effecten onderzocht van (a) de individuele Big Five scores, (b) de verschilscores tussen individuele Big Five scores en scores van de andere teamleden en (c) interacties tussen (a) en (b) op tevredenheid met het ontwerpteam met behulp van multileveltechnieken (Hoofdstuk 3). Hieruit bleek dat de tevredenheid van teamleden met hun team positief voorspeld werd door individuele mildheid en emotionele stabiliteit, negatief door verschil in ordelijkheid en door de interactie tussen individuele extraversie en verschil in extraversie ten opzichte van de andere teamleden. De interactie zag er als volgt uit: teamleden die laag scoorden op extraversie en daarin leken op hun teamgenoten waren het meest tevreden met hun team. De individuele verschilmaat die resulteerde uit deze studie is gebruikt om in het onderzoeksmodel de input 'variabiliteit' te operationaliseren voor elk van de Big Five dimensies.

Om te achterhalen welke ontwerpprocesgedragingen bestudeerd zouden moeten worden en om een instrument te construeren om deze gedragingen mee te meten is een taakanalyse uitgevoerd voor ontwerpen in multidisciplinaire teams (Hoofdstuk 4). Op basis van interviews met professionele ontwerpteamleden zijn de 'Design Behavior Scales for Teams' opgesteld. Van een deelverzameling van deze schalen is de structuur, stabiliteit, betrouwbaarheid en validiteit getest in een onderzoeksgroep bestaande uit studentenontwerpteams. Uit deze tests resulteerde de 'Design Behavior Questionnaire for

Teams' (DBQT). De DBQT bestaat uit 55 kritische gedragingen van ontwerpteamleden die zijn verdeeld over de drie hoofdcategorieën: 'design creation', 'design planning' en 'design cooperation'. Binnen deze drie hoofdcategorieën kunnen twaalf subcategorieën onderscheiden worden. Subcategorieën van de hoofdcategorie 'design creation' zijn: (1) 'design task organization', deze categorie betreft de organisatie van het werk vanaf het moment dat het ontwerpprobleem is vastgesteld, (2) 'information-based designing', deze categorie betreft het grondig ontwikkelen van het ontwerp op basis van alle beschikbare en relevante informatie, (3) 'building the solution space', deze categorie betreft het genereren van mogelijke oplossingen, (4) 'confining the solution space', deze categorie betreft het inperken van het aantal mogelijke oplossingen, (5) 'phase transitions', deze categorie betreft het bewust maken van overgangen tussen fases in het ontwerpproces, (6) 'reflecting on the design', deze categorie betreft het reflecteren op de ontwikkeling van het ontwerp en (7) 'adjusting based on reflection', deze categorie betreft de manier waarop het ontwerp en ontwerpgedragingen worden aangepast op basis van evaluaties. De twee subcategorieën van de hoofdcategorie 'design planning' zijn: 'planning time' (het plannen van de tijd) en 'keeping schedule' (volgens planning blijven werken). De subcategorieën behorende bij de hoofdcategorie 'design cooperation' zijn: 'cooperation' (samenwerking), 'reflecting on team functioning' (reflecteren op het functioneren van het team) en 'making decisions' (besluiten nemen). Over het algemeen bezit de DBQT goede psychometrische kwaliteiten en is daarom gebruikt om de ontwerpprocessen in het onderzoeksmodel te specificeren en de ontwerpprocesgedragingen te meten.

Ten slotte is het complete onderzoeksmodel voor effectiviteit van ontwerpteams onderzocht (Hoofdstuk 5). Het onderzoek is uitgevoerd in een groep van studentenontwerpteams die een eigen robot ontwierpen en bouwden waarmee ze deelnamen aan een wedstrijd. Onderzochte inputvariablen waren elevatie van en variabiliteit op de dimensies mildheid en ordelijkheid. De variabiliteitscore op teamniveau werd verkregen door individuele verschilscores te aggregeren naar een gemiddelde teamverschilscore. In zowel de conceptfase als in de uitwerkingsfase van het ontwerpproject zijn de ontwerpprocessen gemeten met behulp van de DBQT. Onderzochte ontwerpuitkomsten waren de wedstrijdresultaten en de kwaliteitsbeoordelingen van het ontwerp van teamleden zelf en van hun supervisoren. Betreffende input-output relaties was er alleen een positief

verband tussen elevatie van ordelijkheid en ontwerpuitkomsten. Voor input-process relaties bleek zowel elevatie van mildheid als ordelijkheid positief gerelateerd te zijn aan de gecombineerde set van DBQT gedragingen in beide fasen van het ontwerpproject. Om preciezer te zijn vertoonde elevatie in mildheid een positief verband met een aantal subcategorieën van de DBQT in de conceptfase, terwijl variabiliteit in ordelijkheid positieve verbanden had met gedragingen uit DBQT subcategorieën die betrekking hadden op het reguleren van tijd in de uitwerkingsfase. Ten slotte was een aantal ontwerpprocessen positief gerelateerd aan objectieve en subjectieve ontwerpuitkomsten.

Reflecterend op deze resultaten kan een aantal conclusies getrokken worden (Hoofdstuk 6). Ten eerste worden de meest consistente effecten van persoonlijkheid van de ontwerpteamleden op zowel ontwerpprocessen als ontwerpuitkomsten gevonden voor ordelijkheid. Elevatie van mildheid blijkt voornamelijk gerelateerd te zijn aan ontwerpprocessen. Met betrekking tot de fases in het ontwerpproces laten de resultaten zien dat mildheid meer van invloed is in het begin van een ontwerpproject, terwijl ordelijkheid het ontwerpproces meer beïnvloedt tegen het eind van het project. Verschillen in input-output en input-process relaties voor beide dimensies zouden te maken kunnen hebben met het feit dat mildheid een team gerelateerde dimensie is en daarom vooral relaties heeft met team gerelateerde of contextuele uitkomsten van teamwerk (i.e. ontwerpprocessen), terwijl ordelijkheid een taak gerelateerde dimensie is en dus relaties heeft met taak gerelateerde uitkomsten van teamwerk. Ten tweede zijn effecten van persoonlijkheid over het algemeen klein. Dit kan te maken hebben met het feit dat (a) uitkomsten en processen ook worden beïnvloed door een aantal variabelen die niet in het onderzoek zijn opgenomen, (b) teamcompositie in termen van persoonlijkheid veel complexer is dan door geaggregeerde teamcompositiematen kan worden weergegeven, en/of (c) de complexiteit van processen die ontstaan door teamcompositie in termen van de persoonlijkheid van teamleden niet eenvoudig te vangen is. Toekomstig onderzoek zou voornamelijk gericht moeten zijn op het construeren van een maat om teamcompositie in termen van persoonlijkheid mee te meten die effecten van persoonlijkheid als geheel omvat en tegelijkertijd minder complex is. Ten derde is het operationaliseren van teamcompositie in termen van persoonlijkheid zinvol als individuele uitkomsten van teamwerk worden bestudeerd, omdat op deze wijze meer gedetailleerde resultaten worden verkregen. Het aggregeren van individuele verschilmaten

naar het teamniveau om effecten ervan op teamuitkomsten te bestuderen, leidt tot resultaten die vergelijkbaar zijn met resultaten die verkregen worden wanneer voor ieder van de dimensies de standaarddeviatie in het team wordt gebruikt. Ten vierde bezit de DBQT veelbelovende psychometrische kwaliteiten en heeft het predictieve waarde voor ontwerpprocessen die plaatsvinden in multidisciplinaire teams. Niettemin moet de predictieve waarde in toekomstig onderzoek in andere ontwerpteam onderzoeksgroepen worden bevestigd.

Gebaseerd op de bevindingen beschreven in dit proefschrift kunnen praktische richtlijnen worden geformuleerd voor de samenstelling van ontwerpteams. Een alternatieve aanpak om de effectiviteit van teams te verhogen is (student-)ontwerpers aan te leren (a) welke (verschillen in) persoonlijkheden ontwerpprocessen en uitkomsten kunnen beïnvloeden, (b) hoe dat gebeurt, (c) hoe hiermee om te gaan en (d) welke ontwerpgedragingen effectief zijn in de verschillende fases van een ontwerpproject.

About the author

Miranda Peeters was born in Utrecht on June 11th, 1968. She moved to Nieuwegein in 1978 where she completed her preparatory scientific education (VWO) at the Cals College in 1987. Thereafter she went to the Domstad Akademie in Utrecht where she was educated to become an elementary teacher with a specialization in Jenaplan education. In 1991 she moved to Son and taught at the elementary Jenaplan school in Bergeijk for five years. In 1996 she went back to school herself and started a study in Psychology at the University of Tilburg. She specialized in Work and Organizational Psychology and completed her study *cum laude* with a dissertation on the effects of time management on burnout for elementary teachers in 2001. The dissertation you are now holding is the result of the Ph.D.-research she conducted at the Human Performance Management Group at the Technische Universiteit Eindhoven between 2001and 2005. Her research interests concern teams in general: their composition, dynamics, and performance.