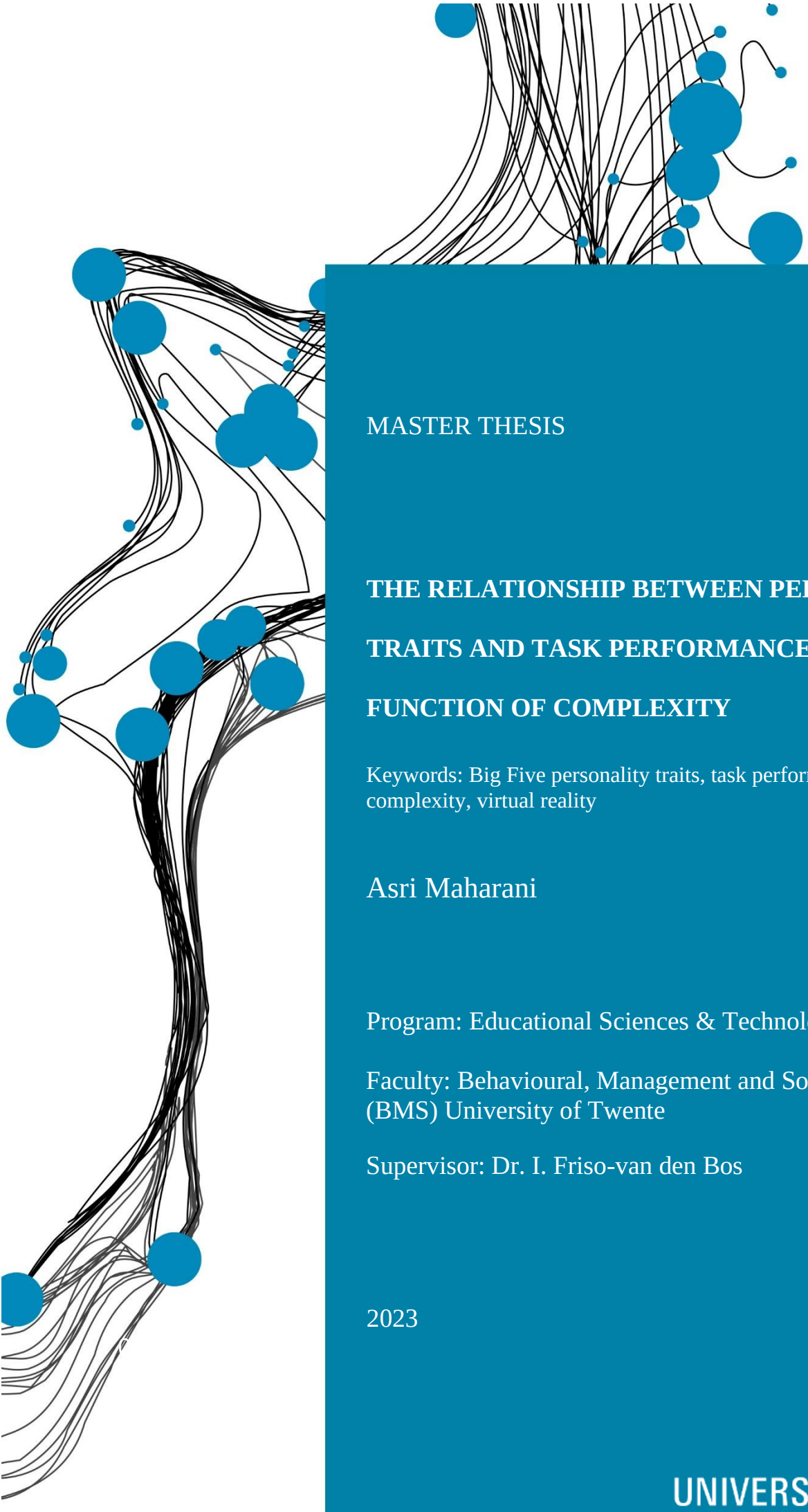

MASTER THESIS

THE RELATIONSHIP BETWEEN PERSONALITY TRAITS AND TASK PERFORMANCE AS A FUNCTION OF COMPLEXITY

Keywords: Big Five personality traits, task performance, task complexity, virtual reality

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Summary

The personality theory have been widely used to investigate personality in various fields such as job and academic performance. The existing literature on the relationship between personality and job performance mainly relied on data from workplace settings such as questionnaires, supervisor ratings, and training performance. Despite the widespread use of personality as a pre-employment evaluation tool also a long history of personality and performance research, it has yet to be investigated whether the relationship between personality and task performance is moderated by the complexity of the task at hand.

The purpose of this study was firstly as an attempt to explain unique variance in task performance using personality, secondly to find out whether there was a difference in task performance at different levels of task complexity and, thirdly, to find out whether complexity moderates the relationship between personality and task performance. The study was conducted as experimental research with a quantitative method. The data was collected from 56 participants who performed asphalt compaction tasks in a VR simulation. None of the participants had experience with asphalt compacting.

The asphalt compaction simulation included two types of weather situations: sunny-warm and rainy-cold. Compacting asphalt in sunny-warm weather is a low complexity task given that the road roller operator does not have to deal with the asphalt mixture's heat loss as quickly as in rainy-cold weather. In rainy-cold weather, heat loss occurs more rapidly, which causes the asphalt mixture to solidify and settle before the road roller operator can finish the compaction process. This time pressure adds an additional level of difficulty.

Prior to the experiment, the participants filled out questionnaire about personality based on the Big Five personality traits theory. The study found that there was a significant association

between neuroticism and task performance, and conscientiousness and task performance, which might explain unique variance of ‘quality performance’ in the sunny-warm scenario (low complexity). However, the study found no difference in performance results (neither ‘quality’ nor ‘quantity’) under different levels of task complexity. Overall, complexity did not moderate the relationship between personality and task performance in the VR simulation. This study provided new insight into the relationship between personality and performance in the context of the construction industry by conducting research in a controlled environment, which is distinct from previous studies on personality and performance that generally only relied on workplace data. It suggested that personality can be used to aid in the selection and design of task allocation to optimize performance in accordance with individual differences.

Introduction: The Relationship Between Personality Traits and Task Performance as a Function of Complexity

Personality is an important aspect of an individual's life. It is defined as persistent traits that govern our behaviour across various situations (Stangor & Walinga, 2014). Personality consistency increases with age (Caspi & Roberts, 2001), though personality traits retain the possibility of change in adulthood. Given that personality is a stable trait over time, understanding an individual's personality can help predict their tendencies to respond to various situations in the future (Ziegler et al., 2019).

The Big Five personality traits have been frequently used to investigate personality. Agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience are the Big Five personality traits (McCrae & John, 1992). Over the last few decades, the Big Five personality traits have been used to investigate the relationship between personality and performance in various fields and aspects of life, for example, in job performance (Barrick & Mount, 1991), team performance (Peeters et al., 2006), and academic performance (Mammadov, 2021). As many investigations have proven the association between personality and job performance, personality assessments have become standard pre-employment tools in many firms' personnel screenings.

Much of the existing literature on the Big Five personality traits and performance focused on job performance (eg. Alsuwailem et al., 2016; Salgado, 1997; Touze, 2005). Therefore, research was mainly conducted in the workplace and relied on data such as questionnaires, performance ratings (i.e., supervisory ratings) and training performance (Salgado, 1997). The challenge of studying personality and performance in a real-world setting is that the outcomes are often influenced by situational factors in the environment or task (Gellatly, 1996; Kane,

1993), such as organizational behaviour, work environment and workload. Controlling for extraneous factors can be challenging, as they may introduce error measurements or biases. Despite this, performance appraisals (and supervisory ratings) are often conducted as if there are no factors beyond the employee's control that affect their performance. This is often unfair, and it is important to acknowledge the constraints and limitations work environments impose (Kane, 1993). Also, conducting this research in a laboratory setting is often challenging because work situations can be difficult to be replicate. This challenge can be tackled by conducting research on personality and performance in a VR setting, because VR can provide controlled environments with standardized stimulation, ensuring that all participants face the same scenario.

Additionally, despite the widespread use of personality as a pre-employment evaluation tool and a long history of personality and performance research, it has yet to be investigated whether the relationship between personality and performance is influenced by task complexity. In general, complexity refers to any objective task characteristic that involves a large amount of information, information diversity, or information change rate (Campbell, 1988).

Understanding the relationship between personality, task performance, and task complexity is important. Firstly, there is the possibility that every individual has a different attitude towards complex, novel, or uncertain situations based on differences in their personality (Kara & Kruteleva, 2020). Different levels of tolerance for complexity levels may affect how people perform a task. Since working conditions and situations vary, comprehending how people perform in different conditions enable us to identify which individuals are most likely to have higher performance under complex or difficult situations in the workplace. Therefore, to address this knowledge gap this study attempted to examine if complexity moderates the relationship between personality and task performance in a "real-world" VR setting. Secondly, by better

recognising how personality influences the performance of complex or novel tasks, we can provide new employees with more targeted and personalised training by determining whether a specific trait may necessitate a different technique to achieve a goal in training design.

The aim of this study was three-fold. To begin with, the Big Five personality traits were used to explain unique variance in VR performance. Next, this study aimed to determine whether there was a difference in performance under different levels of task complexity. Finally, the study set out to investigate if the relationship between personality and task performance (in a VR setting) is moderated by task complexity. The context adopted to investigate this was asphalt compaction, which was simulated using VR. In the VR scenarios, the complexity was determined by different types of weather. Rainy-cold weather was considered as high task complexity, meanwhile sunny-warm weather was equated with low task complexity.

Theoretical Framework

The Big Five Personality Traits

According to Raymond Cattell (1950), as cited in Corr and Matthews (2009), "Personality is that which permits a prediction of what a person will do in a given situation" (Cattell, 1950, p. 2). Gordon Allport (1937), as cited in Corr and Matthews (2009), described personality as psychophysical systems that determine how the individual uniquely responds to the environment. According to the APA dictionary (2023), a person's personality can be inferred from a pattern of behaviours, attitudes, emotions, feeling, habits, and how these characteristics combine into a whole person. In 1937, Allport and Odbert listed 18,000 words to describe an individual in the English language. Later, Norman elaborated on Allport and Odbert's initial work by classifying the words into seven categories (John & Srivastava, 1999; Norman, 1963).

However, a taxonomy for personality that provides a systematic framework needed to be practical. Cattell (1943) tried constructing a taxonomy based on Allport and Odbert's list (John & Srivastava, 1999). Catell conceptualized *the language personality sphere* rating scale and repeatedly claimed to have identified dozens of personality variables from 4500 traits (Chamorro-Premuzic & Furnham, 2005; John & Srivastava, 1999; Norman, 1963). Nonetheless, other researchers have proven that only five variables are replicable (Goldberg, 1993).

Initially, the Big Five personality traits consisted of agreeableness, conscientiousness, extraversion, emotional stability (vs. neuroticism) and culture (Goldberg, 1993). However, measuring openness as a preference for variety and imaginativeness leads to interpreting "culture" as openness to experience (McCrae & Costa, 1987). The five dimensions, often abbreviated as OCEAN (**O**penness to experience, **C**onscientiousness, **E**xtraversion, **A**greeableness and **N**euroticism) can provide a meaningful framework for identifying individual differences (Barrick & Mount, 1991). Each dimension is estimated to incorporate hundreds or thousands of traits (Goldberg, 1993).

The Big Five personality traits are the commonly utilized universal model of normal personality based on empirical evidence (Chmielewski & Morgan, 2012). Costa and McCrae's study (1990) stated that:

> The FFM (Five Factor Models/Big Five) could provide a common language for psychologists from different traditions, a basic phenomenon for personality theorists to explain, a natural framework for organizing research, and a guide to the comprehensive assessment of individuals that should be of value to educational, industrial/organizational, and clinical psychologist. (p. 177)

Based on the longitudinal evidence of Costa and McCrae's study (1990), personality defined by the five factor traits is stable over time. Specifically, this literature treats the five traits

as being dimensional. For example, people are more or less extraverted and high or low on agreeableness. The Big Five personality traits were developed using a small set of trait dimensions to capture and conceptualize as many individual personality variations as possible (Soto, 2020).

A measurement instrument widely used in personality research and clinical use, based on the Big Five personality traits, is the NEO-Personality Inventory-Revised (NEO-PIR). The NEO-PIR contains 240 items to assess the Big Five personality traits, with a shorter version consisting of 20 items also available. NEO-PIR is a self-report instrument with a five-point Likert response format, from *strongly agree* to *strongly disagree,* used to examine agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience. The five personality traits represent stable individual differences. Individuals differ according to how they think, feel, and behave (an individual may score higher or lower on a particular trait than others) (Chmielewski & Morgan, 2012). The Big Five personality traits can predict the manifestation of real characteristic in behaviour by forecasting the central tendency of broad distributions with high variability and predicting such distributions to some degree of accuracy, with correlations between projected average levels ranging from 0.42 to 0.56 (Fleeson & Gallagher, 2009), meaning there is a moderate degree of correlation between personality and a person's likely behaviour in a given situation.

1. Agreeableness

Agreeableness is described as how well a person gets along with others (Chmielewski & Morgan, 2012). This trait is connected to being courteous, flexible, trusting, good-natured, cooperative, forgiving, soft-hearted, straightforward, altruistic, modest, and tolerant (Barrick & Mount, 1991; Chmielewski & Morgan, 2012). Rather than being antagonistic and rude, agreeable

individuals are cooperative and polite (Soto, 2020). According to Habashi et al., (2016), people with higher agreeableness levels are most likely to show emotional reactions and decide to help people in need. According to Barrick, Mount and Judge's (2001) study, agreeableness did not predict job performance in individuals. However, agreeableness was found to be one of the strongest predictors of performance in teamwork, due to its cooperative behavioural traits. (Bradley et al., 2013).

2. Conscientiousness

Conscientiousness is associated with being hardworking, goal-oriented, persevering, persistent, careful, competent, self-disciplined, and responsible (Barrick & Mount, 1991; Chmielewski & Morgan, 2012). Conscientious individuals tend to be task-focused and orderly (Soto, 2020). Across different occupations, conscientiousness has a strong association with productivity and extra-role work behaviour (Chirumbolo, 2017). Due to their hardworking attitude, conscientious individuals tend to pursue demanding tasks to show their competencies and contributions to task accomplishment (Holman & Hughes, 2021). Based on Hurtz and Donovan's (2000) research on task performance, job dedication, and interpersonal facilitation, conscientiousness was the best predictor of job performance among all the traits investigated. Salgado et al. (2013) argued that the reason conscientiousness is the best predictor of job performance in many professions is because it is unlikely that any job exists that does not require traits such as order, perseverance, prudence, self-control, effort, or self-motivation.

3. Extraversion

The extraversion trait is often linked with being sociable, assertive, warm, gregarious, positive, as well as with excitement-seeking traits such as friendly, talkative, outgoing, energetic, and enthusiastic (Barrick & Mount, 1991; Chmielewski & Morgan, 2012; Goldberg, 1993)

Highly extraverted people tend to be assertive and social instead of quiet and reserved (Soto, 2020). Thus, people with a low extraversion level are characterised as quiet, restrained, and withdrawn (Chamorro-Premuzic & Furnham, 2005).

In the workplace, individuals with high levels of extraversion are more sensitive to praise and recognition, motivated by rewards, have higher-order goals, and benefit from enthusiasm and assertiveness traits (Bozionelos, 2004; Furnham et al., 1999; Judge & Ilies, 2002; Wilmot et al., 2019). They outperformed introverts in demanding tasks that required divided attention (Corr & Matthews, 2009). It has been found that when tasks change from high to low difficulty, individuals with higher in extraversion might find it difficult to adapt to the transition, which in turn decreases their performance. This is because lower difficulty tasks create less stimulating situations, which puts individuals with high levels of extraversion at a disadvantage due to their lower level of arousal (Cox-Fuenzalida et al., 2006).

4. Neuroticism

Neuroticism is characterized by distress, anxiety, depression, anger, embarrassment, worry, vulnerability, and insecurity (Barrick & Mount, 1991; Chmielewski & Morgan, 2012). People with high levels of neuroticism often react poorly to environmental stress which may lead to poor work performance due to emotional preoccupation, exhaustion, and distraction (Widiger & Oltmanns, 2017). Generally, neuroticism is a trait that predisposes individuals to experience psychological distress (Chmielewski & Morgan, 2012). According to McCrae and John (1992), individuals with low neuroticism were not automatically linked to positive mental health, however they could be defined as calm, relaxed, even-tempered, and unflappable persons.

However, a lack of confidence and optimism make highly neurotic individuals less likely to develop ambition and dedicate themselves to their work (Bozionelos, 2004). Individuals with

high levels of neuroticism tend to experience a decrease in task performance in response to changes in workload. They associate sudden changes with stressful events, interpreting them negatively, which therefore affects their performance (Cox-Fuenzalida et al., 2004).

5. Openness to Experience

According to Soto (2020), individuals who score high on openness to experience trait have a lot of interests and are sensitive to art. This trait is associated with being imaginative, creative, inventive, open to unusual ideas, adventurous, cultured, curious, broad-minded, and artistically sensitive (Barrick & Mount, 1991; Chmielewski & Morgan, 2012; Salmon, 2012). Individuals with a high score in this dimension are independently minded and capable of tolerating more ambiguity, so they are often the first to embrace new ideas and beliefs (Salmon, 2012).

Openness to experience is positively related to performance in high-complexity jobs rather than low-complexity jobs. This can be explained by the fact that one of the traits of openness to experience is to be adventurous and embrace challenges. Therefore, people with high levels of openness to experience do not fit repetitive jobs (Mohan & Mulla, 2013). As a consequence, people with higher openness to experience tend to respond to the change (newness and difference) of environment in adaptive ways (Griffin & Hesketh, 2004). Although openness to experience has low correlation with job performance (Barrick et al., 2001), it has been a good predictor of long-term performance. Individuals who are highly open to experience have more motivation to pursue career advancement, which in turn predicts their long-term trajectory (Minbashian et al., 2012).

Personality as a Predictor of Performance

As mentioned in the introduction, the research on personality and performance has been conducted in various fields. Specifically, with regard to personality and job performance, studies have been conducted across several of occupations, such as sales (Furnham & Fudge, 2008), nursing (Alan & Baykal, 2021), and policing (Salgado et al., 2013). Although personality and job performance has been studied across many occupations, the author is not aware of any studies related to personality and performance in the construction industry. Studies in the construction industry mostly investigate safety behaviour, not job performance (e.g. Hasanzadeh et al., 2019; Gao et al., 2020). Since research has shown that personality is correlated with factors such as teamwork (Payne, 2021), job satisfaction (Judge et al., 2000), and training performance (Woodman et al., 2010), it is equally important to investigate the relationship between personality and job performance in the construction industry, as with any other jobs and industries.

Motowidlo and Harrison (2013) stated that job performance can be defined as the expected value of the individual to the organization over a given period. There are four dimensions of job performance:

1. task performance,
2. contextual performance,
3. adaptive performance
4. and counterproductive work behaviour.

(Koopmans et al., 2011).

Task performance refers to activities that occur in the job such as implementing technical processes and providing materials or services (Borman & Motowidlo, 1993; Griffin, 2007). In

the context of an air traffic controller, task performance factors included maintaining situational awareness, executing control actions, conducting communication tasks, and operating facilities (Griffin et al., 2000). These factors can also be applied to the asphalt compaction context, such as which part of the road to compact first, what distance to keep from the paver (situational awareness); roller speed, many short strokes, or fewer long strokes, turning points (control action); communicating with co-workers handling the asphalt mixture (communication), and operating the machine (Vasenev et al, 2013).

Meanwhile, contextual performance is described as activities without specific tasks and goals, such as cooperation and maintaining organizational goals (Reilly, 2012). Adaptive performance refers to an individual's ability to adjust their actions and behaviours in response to new or changing environments (Charbonnier-Voirin & Roussel, 2012). Counterproductive work behaviours are defined by Spector et.al (2006) as potentially harmful actions for the organizations that are carried out by employees through intentionally aggressive behaviour. These behaviours may occur due to personal and situational factors (Zhu & Zhang, 2021), organizational constraints, interpersonal conflict, or organizational injustice (Li & Chen, 2018). Yet, most research on personality and job success focused on task performance and contextual performance as a two-dimensional concept (Delima, 2019). However, this study focused on the single dimension of task performance which is asphalt compaction. Asphalt compaction is a specific task and with measurable goals.

Barrick and Mount (1991) used three types of performance measures at work: productivity, training performance, and employee data. Consequently, the data relied on ratings (i.e supervisor ratings, co-workers ratings, client ratings). Therefore, it is prone to variations in perspective and personal bias, which might influence the evaluations. Since bias may occur, it is

important to identify how consistent raters are in their own assessment and to ensure the reliability, validity, and relevance of the personality inventories in work situations (Louche, Pansu, & Papet, 2001, as cited in Touze, 2005). Due to the limited studies specifically focused on personality and 'task performance' as the main dimension, this study also included research on personality and job performance (two-dimensional; task performance and contextual performance) in the theorical framework.

Among the Big Five personality traits, conscientiousness was shown to be the best job performance predictor across several studies (Alsuwailem et al., 2016; Barrick & Mount, 1991; Salgado, 1997). The correlations vary between 0.04 for openness to experience and 0.22 for conscientiousness (Barrick & Mount, 1991). Though the correlations are not as high as could be expected, across jobs and industries personality traits, especially conscientiousness, it still account for a small portion of explaining variance in job performance (Hurtz & Donovan, 2000).

Schmidt and Hunter (1998) found that personality, especially conscientiousness traits, in combination with GMA (General Mental Ability) had rather good validity in terms of predicting job performance. The possible explanation is that people with higher conscientiousness put greater effort into developing higher levels of job knowledge, which leads to better job performance. From their research, the variables that determine job performance are general mental ability, job experience, and personality traits, such as conscientiousness. However, a meta-analysis conducted by Hurtz and Donovan (2000) emphasized other traits are equally important as conscientiousness for certain jobs. For example, jobs that require social interaction, such as manager and sales representative, have been linked to job performance predicted by extraversion (Barrick & Mount, 1991).

According to de Jong et al. (2019), personality traits predicted work preference, which in turn predicted the career roles individuals pursued. For example, extraversion, conscientiousness, and openness to experience were associated with roles such as maker, expert, and presenter. This suggested that participants in studies on personality and job performance may be performing jobs that they ended up in due to their personality. Overall, based on previous studies, it has been found out that personality traits are valid predictors of some occupations (Barrick & Mount, 1991). These studies were conducted in real-world settings. Therefore, an innovative element in this study (and research design) is to allow participants to perform tasks in a profession that they did not voluntarily choose and in a controlled environment.

The Role of Task Complexity

A complex task and a demanding goal may result in improved task performance due to the influence of both cognitive and motivational processes (Campbell, 1988). The degree of complexity of a task can be determined by what extent these tasks are not repetitive and how hard it is to define the goal, individual decision-making opportunities, as well as the degree to which problem-solving procedures are well-defined (Wallace et al., 2008).

The relationship between personality and performance in controlled complex situations has not yet been explored. However, Zhang, et al. (2013) conducted a study on the interaction between task complexity, performance, and mindfulness traits, which might shed some lights on research into personality, performance, and complexity. Their study used supervisor ratings as task-performance measure. It was found that the trait of mindfulness was positively associated with both task and safety performance for high complexity tasks. However, for low complexity tasks, the trait of mindfulness had no impact on safety performance while negatively affecting task performance. In sum, this study found an association between mindfulness traits, task

performance, and (high) complexity. Additionally, Cox-Fuenzalida et al, (2004) noted that another trait, such as neuroticism, is associated with a decrease in task performance when there is change the workload. Meanwhile, people with a higher level of openness to experience tend to respond to changes in their environment in adaptive ways (Griffin & Hesketh, 2004) which, in turn, may positively affect their performance in difficult tasks. Therefore, it is relevant to conduct further research in this area to determine which personality traits are associated with performance, and to further expand the knowledge on the relationship between personality and performance in tasks that involve complexity.

Most research on personality and performance has focused on job performance, which was often conducted in real-world job settings with data obtained via ratings and questionnaires (e.g. Abdullah et al., 2013; Hung, 2018; Waheed et al., 2017;). However, these settings may not be ideal due to the lack of standardization and the difficulty of isolating personality as the main predictor. VR has the potential to tackle this problem because it provides control over the environment, and can be used to standardize the stimulation, ensuring that all the participants can face exactly the same scenario. Therefore, this study aimed to address this gap by conducting research in a VR setting.

The context of task performance in this study was asphalt compaction. Asphalt compaction is an intricate job. It is a complex undertaking that demands carefully coordinated labour. The operator needs to be aware of many things at once, such as the degree of compaction achieved, cooling rate, co-workers' vehicles, and the supply of asphalt (Vahdatikhaki et al., 2019). Density is among the most important parameters in asphalt mixture, as it affects the lifespan of the asphalt pavement (Ray Brown, 1990; Rea & Haghshenas, 2019). Cold temperatures increase the challenge for the road roller operator due to the difficulty of achieving

optimal density of the asphalt material (Johnson, n.d.). When the ground is too cold, heat loss from the asphalt mixture happens at a higher rate, causing it to solidify and settle before the road roller operator can finish the compaction (Rea & Haghshenas, 2019).

Besides weather and temperature, road roller operators need to be aware of their vehicle speed. If vehicle speed is too high cracks may appear, creating gaps and ripples in the compaction. Meanwhile, a vehicle speed that is too slow can lead to permanent asphalt pavement degradation (rutting) (*Guide to Asphalt Compaction*, 2012; Prokopev et al., 2021; Rum Harnaeni et al., 2018,). VR can be used to stimulate these factors in realistic training scenarios (Vahdatikhaki et al., 2019). VR users were better able to visualise the planning perspective (asphalt compaction patterns). For example, VR simulations can show a rollers' trajectory, asphalt cooling rate, and output this data as measures of compaction efficiency and process consistency (Renato et al., 2021). In this regard, VR is a suitable medium to practice compaction skills. VR users can customize scenarios to focus on and repeat specific aspects of asphalt compaction, such as speed or turning technique.

Simulation in VR

The term Virtual Reality (VR) refers to a type of computer-generated simulation in which the user's state and activities are recognized, and response information is fed back or augmented to give the user the feeling of being completely immersed in the simulation. The user can navigate and interact with simulated environments (Mihelj et al., 2014). It offers the most intuitive interaction with the digital world, minimizing the cognitive load of learning a new custom user interface which might not feel realistic (Mouritzis et al., 2014). VR users can interact with virtual objects, validate new technologies, and learn how to control a system safely and remotely. A simulation is usually implemented as a computer program that mimics the

operation of a system. VR simulation adds an immersive, 3D experience that gives a realistic feeling, and the user can interact with its components (Clarke, 2021; Mihelj et al., 2014; Mouritzis et al., 2014).

VR is a technology that has been used extensively in psychology and behavioural research (Hakim & Hammad, 2022). However, it has yet to see extensive usage within the field of personality and performance (in complex scenarios). Generally, research in this field has been conducted in real-world settings, which has made it difficult to control the complexity of the environment. In a VR setting researchers can create, manipulate, control, and standardised the experimental design. VR can also replicate complex situations that might be difficult or expensive to reproduce in the real world.

The potential advantages of VR are many. Xie et al. (2021) stated that VR can minimize the cost of training in real-world settings. VR also provides a safe environment with minimal exposure to potentially hazardous situations. The third advantage of VR training is that it may effectively replicate the aural, tactile, kinesthetics, and olfactory senses, in addition to visual information (Xie, et.al, 2021). Previous research suggests that VR can be effectively utilised as a training medium, with evidence of enhanced psychomotor performance, information acquisition, and spatial ability when people or teams are trained using VR (e.g., Changgen & Xuemai, 2017; Tichon & Limerick, 2011).

This technology is ideal for otherwise dangerous training since it allows for different viewpoints that are not available in real-world environments, allows for virtual visualization of equipment, and enables active learning by providing learners with a sense of control, as they can repeat the situation as many times as needed (Pérez-Ramírez & Ontiveros-Hernández, 2019). Additionally, amateurs can safely use the technology to learn new techniques and methods in a

virtual world without being put at risk. As VR provides simulation that is nearly similar to the real world, it can potentially be used to measure task performance in complex scenarios.

Research Question and Hypotheses

The existing literature demonstrated that personality is a predictor of performance. To the best of the author's knowledge, no study has looked at the possibility of personality predicting performance at various levels of task complexity. Most of the research on personality and performance has been conducted in the field of job performance. Due to the lack of uniformity in design and the difficulty in identifying personality as the key predictor, this approach may not be optimal. Thus, this study aims to address this knowledge gap by conducting research in a VR setting. VR has the potential to replicate complex tasks and provide an easier way to observe and analyse putative associations between personality and performance.

The three main research questions are:

RQ1: Can one or more of the Big Five personality traits explain unique variance in task performance?

RQ2: Will task performance vary noticeably between different levels of task complexity?

RQ3: Is the relationship between personality and task performance moderated by different levels of task complexity?

The following hypothesis were formulated based on the theoretical framework.

H1: The Big Five personality traits (conscientiousness and neuroticism in particular) can explain unique variance of task performance.

H2: Task performance will vary noticeably between task complexity because it is expected that difference traits handle complexity in distinct ways.

H3: Task complexity moderates the relationship between personality (the Big Five personality traits) and task performance, positively or negatively depending on the traits.

From a Human Resource Development (HRD) perspective the answers to these research questions could help improve employee and team personnel selection processes. Understanding how personality affects performance in different contexts allow us to discover which individuals are most likely to do well in complex or difficult situations in the workplace. With this knowledge, we can provide employees with more targeted and tailored training by determining whether a particular trait requires a different training approach in order to achieve the desired learning outcomes.

Method

Research Design

This study was conducted as experimental research using a quantitative method. The experimental research was based on a within-subjects design, indicating that each participant experienced the conditions given in the research (Seltman, 2018). In this case, every participant experienced asphalt compaction in both sunny-warm and rainy-cold conditions.

Participants

The participants in this study were a random sample of 61 people in Copenhagen, Denmark. However, three people did not complete the simulation because of motion sickness. The age range of the participants was 19-70 years old, with a mean of 35.44 years old and a standard deviation 13.37. The participants were acquired by convenience sampling, with no specific criteria related to driving, VR, or experience in asphalt compaction. Therefore, everyone could participate. For this study, the selection was primarily based on the ease of obtaining a

sample recruited through Facebook. None of the participants had experience driving a road roller.

Table 1

The Participants Gender

Gender	Number of Participants	Percentage
Male	38	62.3%
Female	21	34.4%
Non-Binary	1	1.6%
Preferred not to say	1	1.6%
Total	61	100%

Table 2

The Participants VR Experience

VR Experience	Number of Participants	Percentage
No experience	18	29.5%
1-3 times	32	52.5%
4-6 times	4	6.6%
More than 6 times	7	11.5%
Total	61	100%

However, due to a technical issue when saving the video recordings, the total number of participants came down to 56 people.

Procedure

Participants in this study were recruited via Facebook posts on the page of an international expat community in Copenhagen, Denmark. Participants voluntarily participated in this study. Data collection was conducted in a private home office and during two home visits. Prior to the experiment, participants were given a brief introduction and explanation of the study. They were then asked to sign a consent form before filling in questionnaires about their demographic information (gender and age), VR experience, and personality traits. Next, a

presentation was given to the participants about basic asphalt compaction techniques, including the details of what they needed to pay attention to, such as weather differences and compaction patterns. Subsequently, the VR headset was set up for the participant. Each participant experienced the road roller simulator twice for eight minutes each. All participants used both VR simulations counterbalancing in rainy-cold and sunny-warm conditions.

VR Instrument: Asphalt Compaction Simulation

This study used an asphalt compaction simulation in a VR environment to investigate the relationship between personality and task performance in scenarios that varied in complexity. The asphalt compaction simulation was developed by The University of Twente for the Connecting The Dots Projects (*Connecting the dots*, n.d.). In this simulation, the participants were tasked to compact a road. There were several scenarios, including weather (sunny or rainy), time for conducting road compaction (day or night), and various road shapes. In this study, the participants performed compaction on a sunny-warm day as a low-complexity task and on a rainy-cold day as a high-complexity task. The road shape in both simulations was the same (a straight road). Eight minutes were allocated for each simulation. In addition to the weather, the temperature was posed a significant difference. The sunny-warm day had a temperature of 35^{o}C, while the rainy-cold day had a temperature of 5^{o}C.

Compaction can be performed in cold weather provided that the asphalt mixture does not freeze (Waalkes, 2003). A cold-rainy day, however, quickly lowers the temperature of the asphalt mix. Consequently, the compaction must be performed as soon as possible to prevent the mixture from freezing. Therefore, compacting asphalt on a cold-rainy day increases the complexity.

In this study, the asphalt compaction simulation software was run on a Windows 10 computer. Participants wore an Oculus Rift S VR headset equipped with a Logitech G29 steering wheel and Thrustmaster T.16000m joystick. The participants' activities in the VR environment were recorded and saved as video.

Task performance consisted of the compaction performance score awarded by the VR simulation (hereafter 'quantity indicator'), as well as a score awarded for the asphalt compaction strategy, as provided by the video coding (hereafter 'quality indicator'). The 'quantity indicator' assessed the number of compactions, with under-compaction (1-2 passes) and over-compaction (more than 6 passes) scoring zero, while good compaction (3-5 passes) scored one (see appendix). The score was derived automatically in the VR simulation and consisted of the average of the correct (good compaction) passes made.

The 'quality indicator' assessed the speed of the road roller, the angle of the road roller when moving to another track, whether the road roller was driving in reverse on half of the track, how long the road roller remained immobile, and if the operator attempted to steer while immobile (see appendix). All these aspects have an impact on the quality of asphalt in the end. The 'quality indicator' assessed each pass made by the road roller. One pass was defined as going forward and backward. Each quality indicator was valued as one when performed correctly and set to zero otherwise. For each pass, all awarded points were translated into percentages. The final score was calculated as the average of all the pass percentages.

Code-Recode Interrater Reliability

Cohen's Kappa was used for interrater reliability testing (McHugh, 2012), which assesses the level of consistency of a single rater. This was necessary because the data for the 'quality performance' relied on the assessment of a single rater (the researcher). In this study, 25% of the

'quality performance' data was coded a second time and compared to the original set using Cohen's kappa. The result showed that the Cohen's kappa value was 0.44. According to McHugh (2012), a value between 0.41-0.60 is considered moderate. Therefore, the consistency of the 'quality performance' video-coding is considered acceptable.

Personality Traits

The shortened version of the NEO-PIR personality test researched by Donnellan et al. (2006) was used to determine the participants' personalities. The shortened instrument had 20 questions in English, rated on a five-point Likert scale, with response options of *strongly disagree, disagree, neutral, agree,* and *strongly agree*. Each personality trait was measured by the average score of the questionnaire. Prior to scoring, items with negative loadings were reverse scored. The score of each personality trait was then computed.

To assess the validity of the personality instrument used, a factor analysis was conducted. The results are displayed below.

Table 3

Results From a Factor Analysis of The Big Five Personality Traits Questionnaire

	Factor				
	1	2	3	4	5
E1	.644				
E2	.755				
E3	.503				
E4	.663				
A1			.538		
A2			.477		
A3			.399		
A4			.417		
C1					.304
C2					.556
C3					.377
C4					.543
N1		-.715			
N2		-.496			
N3		-.474			

N4	.355	
O1	.572	
O2		.698
O3		.764
O4	.516	

Note. Extraction Method: Principal Axis Factoring.
Rotation Method: Oblique with Kaiser Normalization.
a. Rotation converged in 14 iterations.

The factor analysis of the Big Five personality traits instrument was conducted by principal component analysis with oblique rotation method. The Kaiser-Mayer-Olkin (KMO) value of 0.50 was considered acceptable for factor analysis (Reddy & Kulshrestha, 2019). The table 3 indicated that the extraversion loaded onto the first factor. Agreeableness items were loaded onto factor three, and conscientiousness items were loaded onto factor five. Three items of neuroticism loaded onto the factor two, one item loaded onto factor three. Each two items of openness to experience were separated into factor three and four. The result of the factor analysis might be characterised as somewhat unreliable due to the small sample size. Normally, minimum of 100 subjects would be necessary. Additionally, each subscale needs to have a sufficient number of items, as at least 30% would be dropped during the analysis (Ellis, 2016). In this case, ideally, unrelated items should be eliminated. However, it was also important to note that the researchers who developed this personality instrument tested the instrument in five studies; two of which were repeated weeks and months later (Donnellan et al; 2006). Across all the studies, the instrument showed acceptable internal consistencies (α value above .60), while the instrument used in this study had the α value .64. Overall, the instrument appeared to be appropriate for use as a shorter test of the Big Five personality traits (Donnellan et al; 2006).

Reliability Test of The Personality Instrument

The reliability of the personality instrument was assessed with Cronbach's α. The degree to which a measurement instrument can consistently give similar results for similar

participants, under similar settings, is referred to as its reliability (Ursachi et al., 2015). In this test, the NEO-PIR personality instrument yielded a Cronbach's α value of .64. The Cronbach's α value for extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience are .72, .45, .40, .47 and .53, respectively.

Statistical Analysis

The first hypothesis of this study was The Big Five personality traits (conscientiousness and neuroticism in particular) can explain unique variance of task performance. The first hypothesis was assessed using multiple linear regression analysis. The independent variables were each of the personality traits. The dependent variable was task performance of asphalt compaction (in the VR simulation).

The second hypothesis stated that task performance will vary noticeably between task complexity because it is expected that difference traits handle complexity in distinct ways. To analyse the second hypothesis, a paired t-test was used to compare the differences in task performance under varying levels of complexity. The third hypothesis stated that task complexity moderates the relationship between personality (the Big Five personality traits) and task performance, positively or negatively depending on the traits. The repeated measures ANCOVA and multiple linear regression were used to analyse this relationship.

Results

Normality Test Assumptions of The Analysis

Several assumptions must be fulfilled to ensure that the statistical inference is valid. Among them are continuous and independent data, a sufficient sample size, and the requirement that the residuals should be normally distributed, with no outliers. The results of the Shapiro-Wilk normality test on the 'quality performance' data showed a *p*-values of .06, indicating that

the data were normally distributed ($p > .05$). Meanwhile, the 'quantity performance' data showed p-values <.001, suggesting that the data significantly deviated from a normal distribution ($p < .05$).

Correlations and Descriptive Statistics

Table 4

Correlations between Personality Traits and Performances

		Correlations								
		A	C	E	N	O	SUN_ Quantity	SUN_ Quality	RAIN_ Quantity	RAIN_ Quality
A	r	1								
C	r	.07	1							
E	r	.08	.06	1						
N	r	.02	.07	.01	1					
O	r	.36**	.03	.27*	.27*	1				
SUN_Quantity	r	-.14	-.02	.05	.21	.12	1			
SUN_Quality	r	-.00	.22	.06	-.41**	.10	-.12	1		
RAIN_Quantity	r	-.18	-.01	.19	.23	.22	.22	.11	1	
RAIN_Quality	r	-.04	.19	.04	-.37**	-.02	.04	.67**	.01	1

Note. **. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

* A = Agreeableness; C = Conscientiousness; E = Extraversion; N = Neuroticism; O = Openness to experience

* r = Pearson's correlation; p = Sig. (2-tailed)

The correlations between the five personality traits were all positive, but mostly very weak. The only deviation from this pattern were modest correlations between openness to experience and the three traits agreeableness (.36), extraversion (.27) and neuroticism (.27), respectively. The correlations between the performance measures were generally higher than the correlations between personality traits and mostly positive, but not determined with a precision that warranted further conclusions. The only deviation from this pattern was a strong correlation (0.67) between 'RAIN (high task complexity) quality' and 'SUN (low task complexity) quality. The estimated correlations between personality traits and task performance measures were

modest and of uncertain direction with the exceptions of the correlation between neuroticism and 'RAIN (high task complexity) quality' (-.36) and 'SUN (low task complexity) quality (-.41), respectively.

Descriptive statistics of the personality questionnaire and 'quantity' and 'quality' performance measures in both scenarios (sunny-warm and rainy-cold) are displayed in Table 5.

Table 5

Descriptive Statistics of Personality Score

	N	Minimum	Maximum	Mean	Std. Deviation
Agreeableness	56	2.75	5.00	4.07	0.50
Conscientiousness	56	2.00	4.75	3.47	0.61
Extraversion	56	1.75	4.50	3.25	0.67
Neuroticism	56	1.50	4.25	2.61	0.58
Openness_to_experience	56	2.75	5.00	3.96	0.60
SUN_Quantity	56	0.00	3.39	0.97	0.91
RAIN Quantity	56	0.00	3.60	1.14	0.88
SUN Quality	56	40.00	90.00	61.36	12.82
RAIN Quality	56	30.00	84.00	59.70	13.71
Valid N (listwise)	56				

Using Personality to Explain Unique Variance in Task Performance in VR

For the first hypothesis, multiple linear regression was used to investigate whether the Big Five personality traits (conscientiousness and neuroticism in particular) could explain unique variance in task performance in a VR setting. In total, there were four types of performance scores: 'quality' and 'quantity' performance for both the sunny-warm (low complexity task) and rainy-cold scenarios (high complexity task). The dependent variable in each regression analysis was performance score and the independent variables were personality traits.

1. **'Quantity Performance' in a Low Complexity Task**

Table 6

Multiple Linear Regression Personality-Low Complexity Task ('Quantity Performance')

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Partial Eta Squared
		B	*SE*	β			
1	(Constant)	0.88	1.38		0.64	.52	
	Agreeableness	-0.35	0.26	-0.19	-1.32	.19	.027
	Conscientiousness	-0.03	0.20	-0.02	-0.16	.88	.003
	Extraversion	0.01	0.19	0.01	0.05	.96	.001
	Neuroticism	0.27	0.22	0.18	1.25	.22	.034
	Opennes_to_experience	0.22	0.24	0.14	0.91	.37	.020

Note. A. Dependent Variable: Low complexity task_Quantity performance

The first statistic showed that *personality was not associated to 'quantity performance' in a low complexity task* (p = .49). The R^2 value was .08, meaning that only 8% of the 'quantity performance' result could be explained by personality traits. Based on the p = .49, it can be concluded that personality traits did not significantly explain unique variance of 'quantity performance' in the sunny-warm scenario. The partial eta squared, which indicate the contribution of the personality traits to 'quantity performance' variance in low complexity task, were .001-.034 for each trait respectively.

2. 'Quality Performance' in a Low Complexity Task

Table 7

Multiple Linear Regression Personality-Low Complexity Task ('Quality Performance')

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Partial Eta Squared
		B	*SE*	β			
1	(Constant)	58.86	17.30		3.40	.001	
	Agreeableness	-2.61	3.30	-0.10	-0.79	.434	.009
	Conscientiousness	5.30	2.56	0.25	2.07	.043	.062
	Extraversion	0.56	2.38	0.03	0.24	.814	.001
	Neuroticism	-10.71	2.76	-0.49	-3.89	<,001	.218

	Openness_to_experience	5.27	2.96	0.25	1.78	.081	.046

Note. A. Dependent Variable: Low complexity task_Quality performance

The second statistic showed that *personality was associated with 'quality performance' in a low complexity task* (p = .005). The R^2 value was .28, meaning that 28% of the 'quality performance result' could be explained by personality traits. The highest standardized coefficient was for neuroticism with a (absolute) value of -0.49, indicating that a one standard deviation increase in neuroticism was associated with 49% decrease in 'quality performance' in a sunny-warm scenario.

The *p*-value for neuroticism was less than .001, and .04 for conscientiousness. This indicated that neuroticism and conscientiousness were associated with 'quality performance' and predicted a noteworthy part of the variation in 'quality performance' in a sunny-warm scenario. Meanwhile, agreeableness, extraversion, and openness to experience had *p*-values less than .05; therefore, they were not statistically significant. Neuroticism had the highest contribution to 'quality performance' variance in low complexity (sunny-warm scenario) with a partial eta squared' of .218.

3. 'Quantity Performance' in a High Complexity Task

Table 8

Multiple Linear Regression Personality-High Complexity Task ('Quantity Performance')

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Partial Eta Squared
		B	*SE*	β			
1	(Constant)	0.76	1.28		0.59	.56	
	Agreeableness	-0.49	0.25	-0.28	-2.01	.05	.069
	Conscientiousness	-0.01	0.19	-0.01	-0.07	.95	.000
	Extraversion	0.09	0.18	0.07	0.48	.63	.004
	Neuroticism	0.24	0.20	0.16	1.19	.24	.024
	Openness_to_experience	0.38	0.22	0.26	1.75	.09	.052

Note. A. Dependent Variable: High complexity task_Quantity performance

The third statistical finding revealed that *personality was not associated to 'quantity performance' in a high complexity task* (p = .13). The R^2 value was .15, meaning that 15% of the 'quantity performance' result could be explained by personality traits. The partial eta squared, which indicate the contribution of the personality traits to 'quantity performance' variance in high complexity task, were .000-.069 for each trait respectively.

4. 'Quality Performance' in a High Complexity Task

Table 9

Multiple Linear Regression Personality-High Complexity Task Quality Performance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Partial Eta Squared
		B	*SE*	β			
1	(Constant)	65.74	19.58		3.36	.00	
	Agreeableness	-2.46	3.74	-0.09	-0.66	.51	.007
	Conscientiousness	4.86	2.89	0.22	1.68	.10	.046
	Extraversion	0.83	2.70	0.04	0.31	.76	.002
	Neuroticism	-9.57	3.12	-0.41	-3.07	.00	.152
	Openness_to_experience	2.38	3.35	0.10	0.71	.48	.008

Note. A. Dependent Variable: High complexity task_Quality performance

Table 9 showed that *personality did not statistically explain unique variance in 'quality performance' in a high complexity task (p = .05).* The R^2 value was .15, meaning that 15% of the variance in 'quantity performance result' could be explained by personality traits. The partial eta squared, which indicate the contribution of the personality traits to 'quality performance' variance in high complexity task, were .002-.152 for each trait respectively.

In conclusion, the first research question: *Can one or more of the Big Five personality traits explain unique variance in task performance?* was addressed as personality was found to explain some variance in the 'quality performance' measure in a sunny-warm scenario (low

complexity), but no significant correlations with ‘quantity performance’, nor for performance in the rainy-cold scenario. The traits of neuroticism and conscientiousness had noteworthy value in explaining the unique variance in ‘quality performance’ in the sunny-warm scenario.

Task Performance Results Under Different Levels of Task Complexity

For the second hypothesis, a paired t-test and Wilcoxon test were used to determine whether the performance measures varied systematically between the sunny-warm (low complexity task) and the rainy-cold (high complexity task) scenario. The Wilcoxon test was used because the normality assumption was violated for the ‘quantity performance’ data. The result of the dependent test for the ‘quality performance’ showed that there was no difference in performance on sunny-warm (low complexity task) scenario and cold-rainy scenarios (high complexity task) scenario (p value > .05). The result of the Wilcoxon test for the ‘quantity performance’ found a similar result (p > .05). In conclusion, the second research question which intended to be investigated whether different levels of task complexity led to different (variation) performance results in the VR environment, *did not find statistically differences in performance between the two scenarios.*

The Relationship Between Personality and Task Performance Moderated by Task Complexity

For the third hypothesis, initially repeated measured ANCOVA were used to examine the relationship between the Big Five personality traits and task performance moderated by task complexity. Each personality trait (agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience) were analysed for both ‘quality’ and ‘quantity’ performance in warm-dry and rainy-cold scenarios. A total of ten repeated measures ANCOVA were conducted. However, the test of normality for ‘quantity performance’ data in both scenarios showed that it

was not normally distributed. To address this, an additional multiple linear regression was added to assess the third hypothesis. In these analyses, the dependent variable was derived by calculating the difference between 'quality performance' in the low complexity task and 'quality performance' in the high complexity task.

Across all ten repeated measure ANCOVA tests, no effect was found between the Big Five personality traits and 'quantity' or 'quality' performance, across different levels of complexity. There was no significant interaction between the personality traits and complexity. In sum, the results indicated that *the relationship of personality traits and 'quantity' or 'quality' performance were not moderated by complexity*. This is clear from the F and *p* values in tables 10 and 11 below.

Table 10

Tests of Within-Subjects Effects for Personality Traits and 'Quantity Performance'

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Complexity	0.22	1.00	0.22	0.37	.55
Complexity * Agreeableness	7.78	9.00	0.86	1.47	.19
Complexity	0.46	1.00	0.46	0.64	.43
Complexity * Conscientiousness	3.45	11.00	0.31	0.44	.93
Complexity	0.24	1.00	0.24	0.44	.51
Complexity * Extraversion	9.95	11.00	0.91	1.64	.12
Complexity	0.09	1	0.09	0.14	.71
Complexity * Neuroticism	4.87	10	0.49	0.75	.68
Complexity	5.96	1.00	5.96	0.10	.75
Complexity * Opennes_To_Experience	608.09	9.00	67.57	1.18	.33

Table 11

Tests of Within-Subjects Effects for Personality Traits and 'Quality Performance'

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Complexity	79.76	1.00	79.76	1.38	.25
Complexity * Agreeableness	586.33	9.00	65.15	1.13	.36
Complexity	2.58	1.00	2.58	0.04	.84
Complexity * Conscientiousness	404.05	11.00	36.73	0.57	.84
Complexity	1.82	1.00	1.82	0.03	.86
Complexity * Extraversion	640.19	11.00	58.20	0.99	.47
Complexity	24.06	1.00	24.06	0.44	.51
Complexity * Neuroticism	748.09	10.00	74.81	1.35	.23
Complexity	0.26	1.00	0.26	0.42	.52
Complexity * Opennes_To_Experience	5.90	9.00	0.66	1.06	.41

An additional multiple linear regression was added to assess the third hypothesis. The results are shown in the tables below:

Table 12

Multiple Linear Regression of Personality-'Quantity Performance'

Model		Unstandardized Coefficients		Standardized Coefficients	t	
		B	*SE*	β		*p*
1	(Constant)	0.12	1.76		0.07	.94
	Agreeableness	0.15	0.34	0.07	0.43	.67
	Conscientiousness	-0.02	0.26	-0.01	-0.08	.94
	Extraversion	-0.08	0.24	-0.05	-0.31	.76
	Neuroticism	0.03	0.28	0.02	0.12	.91
	Openness_to_experience	-0.17	0.30	-0.09	-0.56	.58

Note. A. Dependent Variable: Quantity

The multiple linear regression above indicated that *personality traits did not (significantly) modify the difference in 'quantity performance' between the cold-rain and warm-dry scenarios* (p = .94). As a result, personality could not account for a statistically significant corelation of the variable in 'quantity performance'. The R^2 value was .01 meaning that only 1% of the 'quantity performance result' could be explained by personality traits.

Table 13

Multiple Linear Regression Personality-'Quality Performance'

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	
		B	*SE*	β		*p*
1	(Constant)	-6.87	17.04		-0.40	.69
	Agreeableness	-0.14	3.25	-0.01	-0.04	.97
	Conscientiousness	0.44	2.52	0.02	0.17	.86
	Extraversion	-0.26	2.35	-0.02	-0.11	.91
	Neuroticism	-1.14	2.71	-0.06	-0.42	.68
	Openness_to_experience	2.89	2.91	0.16	0.99	.33

Note. A. Dependent Variable: Quality performance

The multiple linear regression above indicated *that personality traits did not (significantly) modify the difference in 'quantity performance* between the cold-rainy and warm-dry scenarios (p = .69). The R^2 value was .02 meaning that only 2% of the quality performance result could be explained by personality traits. Overall, for the third hypothesis, it is suggested that *the relationship between personality (the Big Five personality traits) and task performance did not moderated by task complexity.*

Discussion

This study had three aims; firstly, the Big Five personality traits were used to explain unique variance in VR performance. Next, this study aimed to determine whether there was a

difference in performance under different levels of task complexity. Finally, the study set out to investigate if the relationship between personality and task performance (in a VR setting) is moderated by task complexity.

Personality, Task Performance, and Complexity

For the first hypothesis, the result showed that personality only explained variance in 'quality performance' in a sunny-warm scenario. In this situation, neuroticism had a negative correlation with performance and conscientiousness had a positive correlation. As supported by previous research, individuals with high levels of neuroticism may experience poor work performance (Widiger & Oltmanns, 2017). People with high neuroticism appeared to make fewer correct responses in low to high workload conditions, which was associated with coping responses that are less adaptive, less focused and more emotion-based, ultimately affecting their performance (Cox-Fuenzalida et al., 2004). Additionally, neuroticism was linked to anxiety and insecurity, which might affect performance (Barrick et al., 2001). Therefore, a high level of neuroticism potentially caused a decline in asphalt-compaction quality performance in the sunny-warm scenario.

The finding that neuroticism did not explain any variation in 'quality performance' in the rainy-cold scenario could be because it did not generated a high level of attention demand, which was the root cause of the detrimental effect of neuroticism on performance (Corr & Matthews, 2020). Wilson et al. (2018) showed that people with high levels of anxiety (a trait in neuroticism) may have difficulty changing their behaviour when facing a new or changing situation, in comparison to people with low anxiety. According to Afshar et al.'s (2015) study, individuals handle stressful and challenging situations differently based on their personality traits. Some individuals with high levels of openness to experience and conscientiousness approach difficult

tasks with enthusiasm, determination, and positive problem engagement. On the other hand, individuals with neuroticism might become stressed and overwhelmed by the same level of difficulty and are more likely to use passive and avoidance coping mechanisms. This, in turn, potentially affects their task performance. In this study, the effect of neuroticism only emerged in the low complexity task scenario in 'quality performance'.

Based on Eysenck's Theory (as cited in Saylik et al., 2018), the performance of individuals with high neuroticism is determined by levels of arousal. The easy task elicits a low arousal, while the difficult task elicits high arousal. However, since performance and arousal are linked as inverted U-shaped function, the optimal performance occurs at intermediate arousal level. Therefore, the high task complexity (warm-day scenario) should have caused higher levels of arousal in individuals with high neuroticism, in turn decreasing their performance. However, this result did not present in this research. Further research is needed to confirm this effect, preferably with a different research design.

Meanwhile, conscientiousness has long been proposed to be the most important predictor of the Big Five personality traits in relation to performance (Barrick et al., 2001). This is consistent with one of the results of this study that demonstrated a noteworthy positive relationship between conscientiousness and asphalt-compaction task performance. However, conscientiousness could not explain the variance in 'quality performance' in the rainy-cold scenario. According to Wilmot and Ones (2019), conscientiousness has a weaker relationship with high complexity jobs, meaning that the positive impact of conscientiousness toward performance is not as high as it is in low complexity jobs. This is due to the characteristic of high complexity jobs, which may require skills to solve novel and unstructured problems. This might not align with the trait of conscientiousness, with which people would be more eager to engage

in well-structured and goal-directed performance. The other three Big Five personality traits could not explain the unique variance in task performance in the VR scenarios. This was similar to the results in the meta-analyses done by Barrick et al. (2001) and Zell and Lesick (2022), which found that extraversion, agreeableness, and openness to experience were not associated with job performance. However, their study might have been too broad and generalized, as Hurtz and Donovan (2000) argued that other traits can indeed predict performance in certain professions. More research into personality and performance in various industries (in addition to asphalt compaction) is needed to gain a fuller picture.

Personality also could not explain unique variance in 'quantity performance' in both VR scenarios. A possible explanation for this could be that the 'quantity performance' measure was related to repetition, i.e. driving a road roller back and forth. The 'quantity' task performance dimension might not have created enough engagement for individual differences to surface, affecting their level of motivation. As motivation has been shown to be associated with personality (Bencsik et al., 2016), low motivation could contribute to the lack of personality's predictive power in this case. Furthermore, in this study, the brief asphalt-compaction training given to the participants had greater emphasis on 'quality performance' behaviour over 'quantity performance'. As a result, participants might have been better prepared for 'quality performance' rather than 'quantity performance', resulting in superior performance in this measure.

As stated previously, the main difference between the sunny-warm and cold-rainy scenarios were the level of complexity. Asphalt compaction was a complex task to begin with; however, the difference in the weather temperature added to the complexity. The sunny weather helped to maintain the temperature of the asphalt, allowing the road roller operator to work with less time pressure. In contrast, in the rainy-cold weather, the road roller operator had to make a

quicker decisions during the compaction task. However, in this study there was no difference in task performance between the two scenarios. This might be because complexity was managed differently not only due to individual differences such as personality traits, intelligence, or motivation, but also by means of individual experience and perception. Thus, individuals might have had a different perception of the complexity inherent in a scenario. Differences in perception may also have occurred since all the participants were novices with no prior knowledge or experience in the field of asphalt compaction. As a result, they may not fully have realized the complexity of asphalt compaction in rainy-cold weather, leading them to approach the compaction task in the same way as they did in sunny-warm weather, which had a lower complexity. In addition, some individuals may have possessed driving skills, which may have enabled them to manoeuvre the asphalt compaction roller with greater ease, resulting in greater performance. However, in this study, driving skills were not a prerequisite. Driving skills may have contributed to the performance. This observation is supported by the study of Risto and Martens (2014) who found no significant difference between driving skills in virtual and real-world environments. Therefore, a participant's real world driving experience may affect their performance in VR.

Although all the participants in this study were given a presentation to provide them with prior knowledge and an idea of how to perform asphalt compaction, they might still not have been able to visualise the difference in complexity posed by the sunny-warm and rainy-cold scenarios. This was also demonstrated by the second hypothesis, which showed no difference in performance results between the sunny-warm scenario (low complexity) and the rainy-cold scenario (high complexity). Judge et al. (2000) suggested that there was a moderating effect of (job) complexity on the relationship between personality and job satisfaction. However, in this study, the third hypothesis demonstrated that the relationship between the Big Five personality traits and task

performance was not moderated by task complexity. This may be due to the fact that the majority of previous research on performance combined task performance with contextual performance (Barrick et.al, 2001), and there is a stronger correlation between personality and contextual performance than between personality and task performance (Motowidlo & Van Scotter, 1994). Meanwhile, in this study, only task performance was measured. This might have affected the outcome.

Theoretical Implications

Previous research in the field of personality and VR has been dominated by the topic of presence and immersion (Kober & Neuper, 2013; Sakuma et al., 2023). This study offered a novel perspective to the study of personality and performance, using a VR setting. It provided new insight into the relationship between personality and performance in the context of asphalt compaction. Moreover, it used an innovative research design towards personality and performance by utilizing a controlled environment (VR), which is distinct from previous studies on personality and performance that generally relied on workplace data, which might be influenced by situational factors in the workplace environment, organizational behaviour, and general workload (Kane, 1993). In addition, participants were asked perform tasks in profession that they did not voluntarily choose, and in a controlled environment, which may work to limit the influence of pre-existing attitudes or biases. The results in this study were similar to those in previous studies on personality and (job) performance in other contexts in that conscientiousness and neuroticism had noteworthy correlations with performance.

Practical Implications

This study suggested that personality can be used to aid in the selection and design of task allocation according to individual differences. For example, the HR department can use this

to identify candidates with high levels of conscientiousness and low levels of neuroticism for higher performance in a asphalt compaction context. Additionally, training and development programs can be tailored based on people's personality traits. For instance, individuals with high neuroticism may require different training strategies to overcome stress and anxiety. Moreover, various applications have used personality-targeted design in human-computer interaction (HCI) as an important factor in user modelling (Katifori et al., 2022). This means that using personality-targeted design in human computer interaction might have several benefits, such as improving the user's experience by tailoring the interaction to their individual characteristics and preferences.

Limitation and Future Research Recommendations

The study had several limitations. Firstly, the number of participants was limited to only 56 participants which limited the statistical power. The residuals for the 'quantity' data for both scenarios were not normally distributed. Therefore, the author had to rely on standard large-sample asymptotics for the statistical inference to be valid, which are likely to become reliable faster in multiple linear regressions than the repeated measure ANCOVA, which is why the author did both, reaching the same conclusions. Secondly, none of the participants had experience with asphalt compaction or driving a road roller. Bouvet et al., (2001) reported that asphalt compaction is a difficult task to begin with. Road roller operators need to memorize the number of passes performed, make strategic decisions about speed, trajectory, and be aware of colleague operations (Bouvet, 2001; Miller et al., 2008). This complexity further increases when performing the compaction in cold and rainy weather. People without experience may not be able identify the complexity, let alone the additional complexity introduced by different weather conditions. This might be why complexity did not affect task performance in any significant way

in this study. Thirdly, the factor analysis of the personality instrument did not recognise some traits as isolated factors, which may have resulted in the traits not being perfectly separable, as shown by the correlation found between openness to experience and agreeableness (.36), as well as extraversion and neuroticism (.2).

For future research it is suggested to explore the relationship between personality and task performance as a function of complexity with participants who have experience in asphalt compaction. Such participants might be able to better differentiate the level of complexity. As argued in this study, personality needs to be considered to maximize training effectiveness. However, future research is needed to investigate and validate whether using different training strategies for each trait, especially conscientiousness and neuroticism, can indeed increase performance.

Conclusion

This study found a noteworthy association between neuroticism and conscientiousness on the one hand, and quality performance measures on the other hand (under a sunny-warm, low-complexity scenario). However, overall, it can be concluded that complexity was not found to be a factor in the relationship between personality and task performance in various VR scenarios. Ultimately, the findings of this study can be used to improve training tools based on personality factors, with further study needed, and to create more personalised and engaging VR environments.

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Appendix

Quantity Indicator

Table 1

Quantity Indicator of Asphalt Compaction Task in VR

No.	Indicator	Reasoning	Description	Point Criteria
1	Number of compaction (passes)	The number of compaction influenced the level of compaction in road areas. Under compaction will reduce the stability and strength of the pavement due to the appearance of many voids. In contrast, over compaction cause the mixture to become unstable and produce the danger of flushing (Miller, et.al 2008).	• Under compaction indicated number (passes) 1-2 • Good Compaction indicated with number (passes) 3-5 • Over compaction indicated over number (passes) 6	Under-compaction and over-compaction passes did not count.

Quality Indicator

Table 2

The Quality Performance Score of The Asphalt Compaction in VR

No.	Indicator	Reasoning	Description	Point Criteria
1.	Adequate speed	The high speed of the road roller will be faster in initiating cracks, creating gaps and ripple in compaction, while low-speed road rollers lead to permanent asphalt pavement degradation (rutting) (Prokopev et al., 2021; Rum Harnaeni et al., 2018, *Guide to Asphalt Compaction*, 2012). The maximum efficiency speed for the road roller is 5km/h (Brakey, 1998)	• The road roller operates with speed not faster than 5 km/h. • The operator drives the road roller with stable speed (do not make sudden speed changes)	• The speed during one track is between 4-6 km/h and being constant for 60% of the trip
2.	Right angle (40 degree)	Prior to moving in another direction, the road roller	• Brief stop before	• Stop for 2-3

	and technique when moving to another track	must stop. It is crucial to stop gradually and turn slightly so that its wheels are not at right angles to the direction of travel during the stop. The wheels at the right angles to the direction of travel can cause roller marks and be challenging to roll out. Any scuffing or shoving of the hot mix asphalt material must be minimized during the change direction (Roberts et al., 1996).	moving to a new track • The steering angle is approximately 40 degree (no sharp angle)	seconds prior moving to a new track • The steering angle is between 30-60 degree
3.	Driving reverse on half of the track	Compaction should be done by driving forward and backwards (reversely). However, it is important not to stop and reverse in the same area because	• Look back (rear mirror) and drive back smoothly to the next track.	• Check rear mirror or over the shoulder

		the mat can become distorted and bumped (*Guide to Asphalt Compaction*, 2012). Thus, the operator should reverse on half the track creating a new track which would be half width further than the previous one.	• The next track should be half a drum's width further than the previous one	• New track is half durum further
4.	Not standing still on the asphalt pavement too long	Anytime a road roller stops and parks on a fresh asphalt layer, the drums or tires will dent the mat (*Guide to Asphalt Compaction*, 2012). Therefore, it is necessary not to stop too long on the hot asphalt layer.	• Road roller should not stand on hot asphalt longer than 3 seconds	• Stand on hot asphalt no longer than 3 seconds
5.	Don't steers while standing still	A power steering gouge will result if the road roller is steering while not in	• The steering wheel should not be steer	• No steer movement when the

	motion. An area of pavement will become compacted due to this action. The surface would become bruised or lacerated due to the kneading and grinding caused by the tires moving on their bias against the asphalt. (Guide to Asphalt Compaction, 2012).	away when the road roller is not on motion.	road roller is standing still

Personality Questionnaire

1. I am the life of the party. (E1)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
2. I sympathise with others' feelings. (A1)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
3. I get chores done right away. (C1)
   - Strongly disagree
   - Disagree
   - Neutral

- Agree
- Strongly agree

4. I have frequent mood swings. (N1)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
5. I have a vivid imagination. (O1)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
6. I don’t talk a lot. (E2)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
7. I am not interested in other people’s problems. (A2)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
8. I often forget to put things back in their proper place. (C2)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
9. I am relaxed most of the time. (N1)
   - Strongly disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly agree
10. I am not interested in abstract ideas. (O2)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

11. I talk to a lot of different people at parties. (E3)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
12. I feel others' emotions. (A3)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
13. I like order. (C3)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
14. I get upset easily. (N3)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
15. I have difficulty understanding abstract ideas. (O3)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
16. I keep in the background. (E4)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
17. I am not really interested in others. (A4)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
18. I make a mess of things. (C4)
    - Strongly disagree

- Disagree
- Neutral
- Agree
- Strongly agree

19. I seldom feel blue. (N4)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree
20. I do not have a good imagination. (O4)
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

VR Background Questionnaire

Name

Email

Age

Gender

- Male
- Female
- Non-binary / third gender
- Prefer not to say

How many times have you used virtual reality technology?

- 0 times
- 1-3 times
- 4-6 times
- More than 6 times