The Relationship Between Situational Awareness and Attention Networks of Roller Operators in Virtual Reality

Master Thesis

Silvana Lorenzo Cervera

Educational Science and Technology
Faculty of Behavioural Management and Social Sciences
University of Twente

First Supervisor: Dr. Ilona Friso -van den Bos
Second Supervisor: Dr. Bas Kollöffel

Keywords: situational awareness, attention networks, alerting network, orienting network, and conflicting network

February 8th, 2024

ACKNOWLEDGEMENT

The development of this thesis has been a great challenge, and I would like to extend my utmost appreciation to my supervisors, Dr. Ilona Friso van-den Bos, and Dr. Bass Kollöffel, for their invaluable guidance, feedback, and unwavering support throughout the completion of this project. Their expertise and insights have been instrumental in completing this research endeavour. Their guidance has played a pivotal role in enhancing the research quality and shaping the direction of this study. I am truly indebted to their assistance, which has been the cornerstone of my academic growth and development.

I would also like to express my profound gratitude to Johan Hakkers for his invaluable assistance in data collection. His unwavering support and dedication have played a significant role in making this research possible. Additionally, I would like to extend my heartfelt appreciation to my family and friends for their constant encouragement and support throughout this arduous journey. Undoubtedly, their unwavering support has been instrumental in keeping me motivated and determined throughout the entire process. I am indebted to them for their unwavering support and encouragement, which has been invaluable in navigating my challenges.

Finally, I express my sincere gratitude to Yvonne Luyten-de Thouars, my study advisor during my academic journey at the University of Twente. Her support and guidance have been invaluable to me throughout my studies.

Table of Contents

List of Tables

List of Figures

ABSTRACT

Roller operators must pay attention to the elements in the environment to recognise them, stay safe, and avoid potential hazards. The ability to perceive and understand what is going on around them and to predict situations is called situational awareness (SA). Successfully fostering SA in a dynamic situation requires attention. Although the relationship between situational awareness and attention has been researched previously, the link between attention networks and situational awareness has not been researched before within the roller operators when compacting roads. This study aims to explore the relationship between attention networks and situational awareness in the context of road construction.

Thirty-seven participants took part in the attention network test (ANT) and participated in the VR simulation task. The VR environment allows them to complete a task in compacting roads and to measure their situational awareness. Participants' situational awareness was measured by using the SAGAT test at the end of the virtual reality task. A systematic procedure was utilised to investigate the topic. The first test applied was the attention network test to measure the efficiency of each of the networks of the participants, and the SAGAT test was applied to measure their situational awareness. The results of the Pearson correlation analysis showed a non-significant correlation between each of the attention networks and situational awareness. Furthermore, multiple linear regression analyses confirmed that there was a non-significant relationship between situational awareness levels and each of the attention networks. Additionally, general exploration of the attention networks and situational awareness showed no statistically significant relationship.

In conclusion, this study was an initial step in researching the association between the levels of situational awareness and attention networks (alerting, orienting, and conflicting) of roller operators in VR. Moreover, it demonstrates that VR is a safe environment for training and the simulation of complex tasks. Lastly, further research is essential to confirm the connection between these cognitive processes and the effect of attention networks on situational awareness.

Keywords: situational awareness, attention networks, alerting network, orienting network, and conflicting network.

INTRODUCTION

Situational awareness is key to safety in the workplace. Take, for example, roller operators on a road construction site. They should pay attention and always be aware of their surroundings to avoid potential dangers and stay safe. This concept is well-known as situational awareness (SA), which means recognising the elements in the current situation, understanding the relevant elements or circumstances, and anticipating the possible variations in this dynamic environment (Endsley, 1995). A construction setting is a dynamic environment that involves operators, machines, and numerous components that are constantly changing (Jaafar et al., 2020).

Attention is an essential factor for processing information, i.e., the relevant elements or circumstances (Wickens et al., 2013). Endsley (1995) argues that how individuals allocate their attention can generate some difficulties in perceiving different elements at the same time. Simultaneously, multiple sources and processes contribute to the allocation of attention to specific elements in the environment. In the brain, some sources are at the foundation of the attentional processes, and these are called attention networks. The attention networks support individuals' capacity to be alert towards the elements in the environment, to direct attention to specific elements, to prioritise attention to their task and to ignore distractors (Posner & Petersen, 1990).

The possible connection between attention networks and situational awareness might be established at the perception level of SA. Individuals identify relevant elements through their senses for just a few seconds (Best, 1995; as cited in Wickens et al., 1997). Then, when individuals notice elements around them, they react immediately to them (Posner & Petersen, 1990). Simultaneously, individuals might need to pay attention to recognising the elements around them (Posner, 1980). This process provides support to the first level of SA: perceiving the elements of the environment.

Moreover, when individuals try to understand the situation, there might be a conflict between their newly perceived information and integrating it with this information into their prior knowledge. The conflicting system might support individuals’ resolution between these connections and guide them in considering the most suitable way to integrate the information (Norman & Shallice, 1986a). Thus, comprehending the situation might require support from the conflicting system that is active in individuals.

So, attention networks might be fundamental for the development of situational awareness. Individuals become aware of elements in their surroundings when they focus their attention on them. This shows a link between attention and SA. However, this behaviour of becoming aware is an outcome of complex attentional processes known as attention networks. No study has investigated attention networks and their relationship with situational awareness. This study aims to fill that gap by establishing a relationship between the observed behaviour of the individuals, and SA. As a result, it can be hypothesised that attention networks are likely linked to SA.

The study aims to explore the possible relationship between situational awareness and attention networks, providing valuable information for the understanding of both cognitive processes in the context of the road construction sector. In this study, virtual reality (VR) was observed as being a tool that facilitates a realistic, yet safe environment for roller operators on construction sites (Voordijk & Vahdatikhaki, 2020). The SAGAT test is used to assess the participants' situational awareness and the Attention Network Test (ANT) short version assesses the attention network's effectiveness (Fan et al., 2005).

This study will help to understand the link between attention networks (alerting, orienting, and conflicting) and SA. This knowledge can be used to enhance the efficiency of attention networks and situational awareness in the construction sector. With this understanding, roller operators might be more able to distribute their attention to essential elements and use VR technology as a training tool.

THEORETICAL FRAMEWORK

Situational Awareness

Situational awareness is defined as the perception of the elements in the environment, understanding the perceived elements in the situated environment, and anticipating how these elements can change in the environment (Endsley, 1995). For instance, when roller operators recognise the humidity, the speed of the wind, and the temperature of the asphalt, they use this information to compact the asphalt before it cools down, foresee weather variations like the drop in temperature, cloud formation, and speed of the wind, and take actions to anticipate the changes and not affect the process of compacting.

According to Endsley (1995), there are three levels of situational awareness: perception of the elements in the environment, comprehension of the current situation, and projection of the future status.

Level 1: Perception of the Elements

The perception of the elements is the recognition of the elements, characteristics, and status that are relevant in the environment. There is no interpretation of the perceived elements at this level (Endsley, 1995). For instance, roller operators might perceive elements like the temperature of the asphalt, humidity, the lights of the control panel, and so on.

Level 2: Comprehension of the Current Situation

This level involves the individuals using the perceived relevant information (level 1). This level extends beyond being aware of the elements in the context; individuals understand the present elements, give meaning to the current situation, and gain a bigger picture of the current environment (Endsley, 1995). For instance, roller operators use the perceived elements from level 1 (e.g., asphalt temperature and speed of the wind) and then integrate this information to compact the asphalt properly, considering that the asphalt cools down rapidly.

Level 3: Projection of the Future Status

The ability to project the future status of the environment is based on the perceived elements and understanding of relevant information (levels 1 and 2). This level refers to an individual's capability to predict what will happen shortly in the environment (Endsley, 1995). For instance, roller operators can identify changes in the environment by noticing cloud formation, an increase in humidity, and a drop in temperature. These changes allow them to anticipate further changes in the environment in a very short time. This knowledge and time enable them to make informed decisions that will not negatively impact the process of compacting.

Situational Awareness Global Assessment Technique

The Situational Awareness Global Assessment Technique is well-known as the SAGAT test. It was created to measure situational awareness for tactical aircraft and tactical bomber aircraft (Endsley, 1988a, 1990a). This test is used during the development of the task of the participants, and it includes a set of questions related to the three levels of situational awareness: the perception of the elements, comprehension of the current situation, and projection of the future status.

The Role of Attention in Situational Awareness

Previous studies have demonstrated how air traffic controllers focus their attention on processing information in real-life situations. To determine how well these operators understood their surroundings, a modified version of the SAGAT test (Endsley, 1988a) was employed. Additionally, SATORI (Situation Assessment Through the Re-creation of Incidents) was used to recreate the work environments where errors occurred while performing tasks (Endsley & Rodgers, 1996).

The results of the study revealed substantial issues in the attention and situational awareness of air traffic controllers (Endsley & Rodgers, 1996). Controllers correctly reported 67.1% of current aircraft on average, with a mean distance inaccuracy of 9.6 miles, indicating probable inattention or passive viewing of the aircraft. The accuracy of detailed aircraft information, such as call signs, varied, with the numeric element recorded accurately just 38.4% of the time. While higher-level knowledge, such as recognising separation difficulties, performed well (86.2%), awareness of anticipated sector changes was lower (63.5%). Controllers needed help to appropriately estimate weather effects (39.3%) and monitor completed control assignments (23.2%). It might be argued that participants might fail to recall specific details about each aircraft (Level 1 SA) but prioritise understanding the situation.

Prior studies showed that individuals retain relevant information on Level 1 of situational awareness aspects, which can be effectively recalled (Endsley, 1990a). This method of assessment is likely to represent the allocation of attention by participants across different sources of information (Fracker, 1990, as cited in Endsley & Rodgers, 1996).

The results demonstrated the importance of the distribution of attention to make effective decisions and emphasised the compromises that controllers make while distributing their attention across various aircraft and sources of information. Although attentional allocation techniques are mostly successful, some mistakes might arise from an absence of situational awareness (Endsley & Rodgers, 1996).

In conclusion, this research might contribute to the present study by providing a basis for understanding how operators distribute their attention across different sources. Likewise, Endsley (1995b) argues that the distribution of attention in the perception level of SA shows some difficulty for individuals to perceive different elements at the same time. In addition, assessing each attention network provided detailed information about the allocation of attention by individuals concerning situational awareness.

Another study explored the role of attention in situation awareness, specifically in the field of air-to-air combat situations, with a specific emphasis on FFN (friend, foe, and neutral) awareness and spatial awareness among fighter pilots (Fracker, 1989). The study showed the relevant role of a limited-capacity attentional system in sustaining situational awareness throughout complex tasks. These results are also aligned with some theories about the limited capacity of attention that are still relevant (Kahneman, 1973; Navon & Gopher, 1979; Norman & Bobrow, 1975; Wickens, 1980, 1984b; as cited in Fracker, 1989). The results contributed to the current debate over attentional capacity and its consequences for situational awareness in difficult tasks (Hirst & Kalmar, 1987; Navon & Miller, 1987; Navon, 1984; as cited in Fracker, 1989).

Hence, the research contributed to the present study by emphasising the importance of attention allocation in situational awareness. Likewise, Endsley's theoretical framework explains how individuals direct their attention and contribute to the perception level and further ones (Endsley, 1995). Moreover, each part of the attention system can be assessed using the attention networks (Posner & Petersen, 1990).

The Attention Networks

The previous section has shown that the distribution of attention in the environment is relevant for situational awareness (Endsley & Rodgers, 1996). In addition, attention allocation was recognised as another essential process that contributes to the situational awareness of operators (Fracker, 1989). Likewise, attention allocation involves various cognitive processes that contribute to situational awareness. Thus, these processes can be assessed through attention networks, which can be divided into three networks that support attention (Posner & Petersen, 1990).

The attention system is complex and has various aspects; however, it relies on its networks in the brain, which are well-known as attention networks (Posner & Petersen, 1990). Each network has a unique function to support the attention system: alerting, orienting, and conflicting. To examine each of the networks, the next sections will provide detailed explanations of the contributions of each network.

Alerting Network

The alerting network generates a change in the internal state to get ready for perceiving an element. The alert state is essential for achieving good performance during tasks requiring higher cognitive processes (Posner & Petersen, 1990). The alerting network can be classified into two types of alertness (Posner, 1975): phasic alertness and tonic alertness.

Phasic alertness involves the individual responding immediately to a warning signal in the environment. For instance, when a flashing red light appears in the control panel, roller operators become aware, and they respond immediately to the signal.

Tonic alertness involves controlling the vigilance of the individual over some time without an element or signal in the environment. For instance, roller operators maintain their vigilance on the control panel that provides information for the compacting task.

Orienting Network

The orienting network implies selecting and focusing attention on a specific element in the environment (spatial location) or internal information retained in memory (Posner, 1980). For instance, roller operators direct their attention towards the control panel of the paver machine to get information to manage some essential indicators.

The orienting network involves two types of orienting (Posner, 1980): overtly and covertly.

Overt orienting involves individuals shifting attention through the physical movement of the eyes and head. For instance, if roller operators see a red light in the control panel, they direct their attention to it because they know something is happening.

Covert orienting involves the focus of attention without any physical movements (eyes or head). For instance, roller operators may effectively focus attention on specific information without compromising movements.

Conflicting Network

The conflicting network becomes active when individuals need to solve problems that tend to interfere with their principal tasks and avoid distractors (Norman & Shallice, 1986a). For instance, roller operators are compacting asphalt; suddenly, a text is incoming, so roller operators' conflict network of attention prioritises their tasks, inhibiting the distractor.

The model of conflicting control is based on the presence of several cognitive processing sub-systems (Norman & Shallice, 1986a). The first level of control is achieved through contention scheduling. It utilises previously learned patterns or principles to structure thoughts and behaviours. It functions similarly to having pre-existing information or a set of instructions that direct behaviour and thought (Newell and Simon, 1972; as cited in Norman &

Shallice, 1986a). Once chosen, a schema remains active until it accomplishes its aim or is interrupted by a competing schema or higher-level control.

The mechanism for contention scheduling is analogous to routine selection. When confronted with a novel or highly competitive situation that demands conflicting control, a supervisory attentional system is activated. This supervisory attentional system facilitates further inhibition or activation of the right schema (Norman & Shallice, 1986a). In contrast to the contention-scheduling mechanism includes competition between subsystems, the supervisory attentional system provides an understanding of the general environment and the objectives of the individuals.

This section has described the functions of each of the attention networks and their importance in the attention system. Additionally, the attention networks have their own test to measure each of the attentional processes, and in the next section, the ANT test will be described.

The Attention Network Test

The Attention Network Test (ANT) was created to evaluate the effectiveness of the alerting, orienting, and conflicting attention networks in a computerised task (Fan et al., 2002). The ANT is an integrated task that incorporates both the flanker task (Eriksen & Eriksen, 1974) and the spatial cueing task (Posner, 1980).

This task involves displaying the objective (target) in the centre, surrounded by several non-target stimuli providing information about the conflicting information and responses (Eriksen & Eriksen, 1974). The participants need to choose during the test between the different left or right arrows, depending on their direction.

There are three types of flankers (Eriksen & Eriksen, 1974): neutral, congruent, and incongruent. The congruent stimulus is called the compatible mode because the direction of the non-target and target stimuli is the same. The incongruent stimulus is called the incompatible mode. The direction of the non-target stimulus and the target stimulus are opposite. Thus, selecting an appropriate answer is more difficult than the congruent stimulus. The neutral stimulus is characterised by its trajectory being neither identical to the target stimulus nor the opposite.

The spatial cue task is designed to assess the covert orienting of attention, which refers to the shift of attention without physical movement such as the eyes or head (Posner, 1980), and during the spatial cue task, participants are provided with signs that predict the probable location of an objective stimulus on a screen. The objective of the spatial cue task is to comprehend how humans may efficiently and swiftly redirect their focus to the expected position, relying on these signals even in the absence of obvious or apparent motion. The ANT test has been used in the past to find out how efficiently attention networks work in complex environments like the road construction sector (Mohammadpour et al., 2016) and during driving tasks (Choi et al., 2019).

Previous Studies Related to the Attention Network Test

A previous study investigated the relationship between the attentional control of construction workers and their capacity to perceive safety risks on construction sites (Mohammadpour et al., 2016). The first step of the research involved administering a questionnaire to assess the participants' work experience and safety knowledge. Subsequently, the ANT was conducted to analyse the efficiency of the construction workers' attention networks (Fan et al., 2002). In addition, an experiment was also conducted using photos of potential dangers in the environment to assess the ability of workers to recognise safety hazards. Likewise, the photos were developed based on OSHA safety training resources to cover workplace safety hazards.

The results of the study showed that when individuals know about safety, they also notice additional risks, and this showed the importance of having prior knowledge in identifying possible hazards. Previous research displayed that workers who did not have sufficient training or understanding of their activities could not be expected to identify and handle all possible risks related to their work, nor could they be depended upon to successfully navigate and prevent potential accidents (Abdelhamid & Everett, 2000).

Furthermore, they demonstrated that individuals whose responses were faster could recognise more safety hazards than individuals whose responses were slower. This result is aligned with the definition of the alerting network, which is the state of being alert and responding immediately to elements (Posner & Petersen, 1990).

Hence, this study provided a basis for using the ANT test, particularly in the construction field (Mohammadpour et al., 2016). This reinforces the relevance of the ANT as an instrument for assessing attention networks, especially at construction sites (Fan et al., 2002). Moreover, it emphasised the differences in the assessment of the networks of attention, like the alerting network, which can generate a rapid response to hazards.

Another study was conducted to investigate the relationship between attention networks and driving performance in older adults (Choi et al., 2019). A simulation driving task was applied using a driver simulator (STISIM Drive® 3, Systems Technology, Inc.). The attention network test was also applied to measure each of the attentional functions (Fan et al., 2002).

The results of the study displayed that the executive network of attention is the most relevant predictor for driving performance and is related to crashes in critical situations. This result was aligned with previous research on the correlation between individuals' inhibitory control and the executive network, as well as crash hazards (Daigneault et al., 2002). Moreover, the alerting and orienting networks were not associated with crash risks. Therefore, the results of the study and the current study on situational awareness and attention networks show some similarities. The research measures the attention networks of individuals, utilising the ANT in a complex system like driving (Choi et al., 2019). Additionally, the ANT is a fundamental tool in research for assessing each of the attention functions of individuals (Fan et al., 2002). Consequently, this might provide significant insights regarding how these networks impact complex activities, like in the present study in the road construction field.

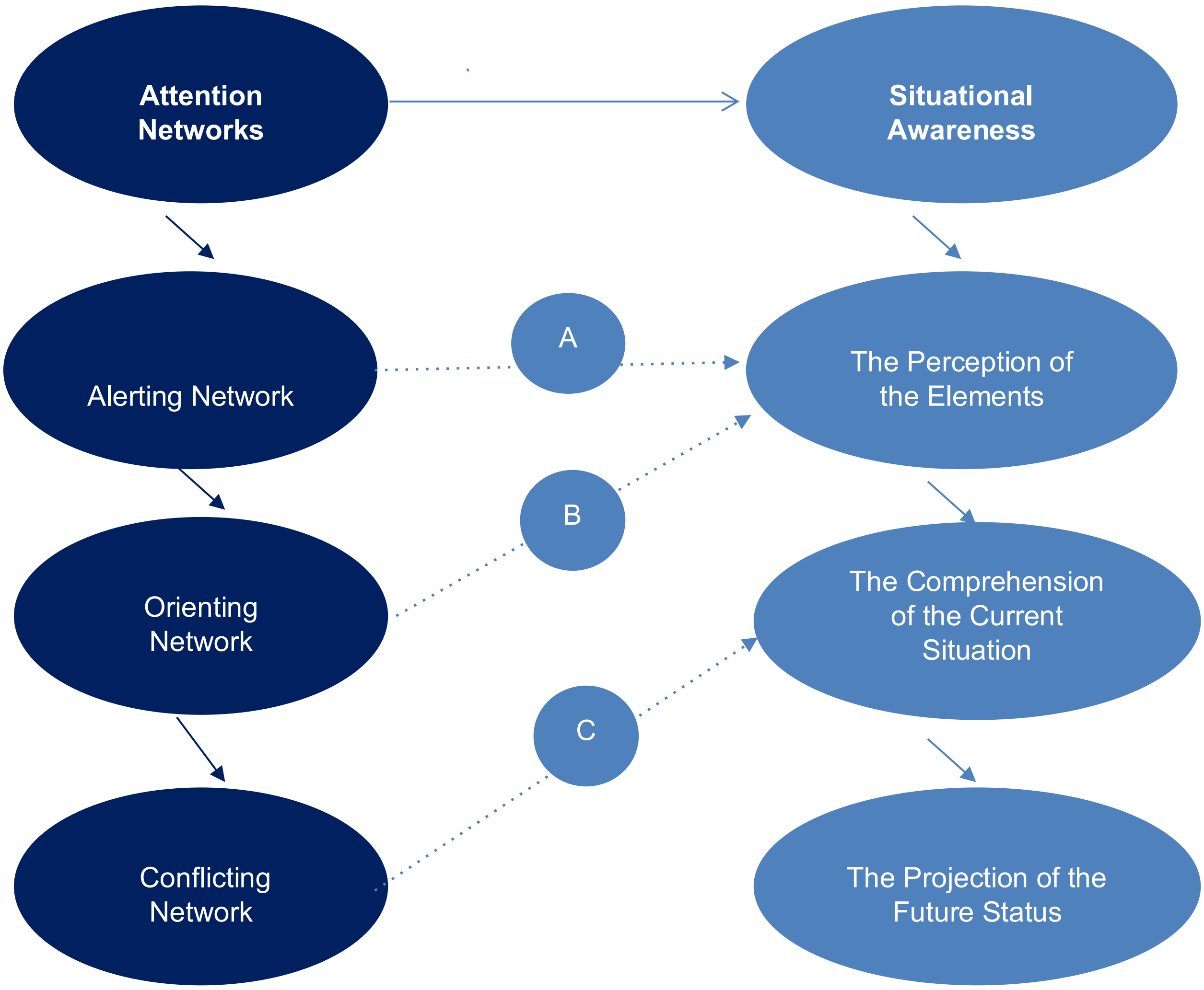
In conclusion, this section has summarised the significant role of the attention network test in assessing the efficiency of individuals' attention networks in the road construction field (Mohammadpour et al., 2016). Overall, the findings enhance our comprehension of the elements that impact hazard perception in construction workers, highlighting the significance of safety information, training, and the effectiveness of attention networks. On the other hand, the study on the driving task simulation in older individuals contributed to our knowledge of attention networks and how they affect driving performance. It also provided unique insights into the function of the executive network in anticipating collision hazards (Choi et al., 2019). Thus, the next chapter will address the possible relationship between attention networks and situational awareness.

Exploring the Possible Relationship between Situational Awareness and Attention Networks

In the section that follows, it will be argued that there is a possible link between attention networks and situational awareness. The attention networks are one of the most important networks in the brain. Its networks involve being alert, directing attention to the sensory elements, resolving conflicts between tasks, and prioritising them (Posner & Petersen, 1990). Conversely, situational awareness is described as the ability to recognise the relevant elements in a dynamic environment. This equips the roller operators to comprehend and interpret the situation accurately and, as a result, foresee the changes in the dynamic environment and predict them (Endsley, 1995). Thus, relating these models might reveal insights into how the attention networks of the roller operators might be linked to situational awareness (see Figure 1).

Figure 1

Possible Link Between Attention Networks and Situational Awareness



Note. This Figure depicts the possible link between situational awareness and attention networks, and it is based on the theoretical frameworks offered by Posner (1990) for attention networks and situational awareness (Endsley, 1995).

Exploring the Role of the Alerting Network in Situational Awareness

Role of the Alerting Network in the Perception of Elements. In this section, the first discussion is about the possible relationship between the alerting network and the perception of the elements, the first level of SA. This discussion might reveal some new insights into these cognitive processes.

In the perception level of SA, the elements might be acquired through the senses and briefly held in the sensory memory for a limited period, typically only a few seconds (Best, 1995; as cited in Wickens et al., 1997). These elements are registered in the sensory store, where particular characteristics are detected, such as colour, shapes, etc. (Neisser, 1967; Treisman & Paterson, 1984). Then, through the focus of attention, the elements with the most prominent characteristics will be processed, making it possible to attain the perception level of SA. Additionally, research by Posner & Petersen (1990) underlines the important role of the alerting network. They state that the alerting network generates rapid responses to the elements to process the most relevant information. A high level of alertness results in rapid reactions, but also in increasing errors, as cited in Posner & Petersen (1990).

The potential relationship between the perception level and the alerting network might be evident in the rapid response of the alerting state to the elements in the environment. Thus, this evidence showed that the alerting network may be related to the perception level of SA.

Role of the Alerting Network in Comprehending the Current Situation. The section below describes the possible relationship between the alerting network and the second level of SA, the comprehension level.

The comprehension level relies on the first level and is primarily influenced by the information stored in working and long-term memory (Endsley, 1995). Likewise, long-term memory structures, like the mental models, play an important role. They are defined as essential processes for creating descriptions, explanations, and anticipations of the states that become essential (Rouse & Morris, 1985). Conversely, the alerting network responds rapidly to the elements in the environment to process the relevant information (Posner & Petersen, 1990). The high alertness in individuals can lead to rapid responses, yet also an increase in mistakes.

In conclusion, comprehension relies on the first level of SA and on the intervention of more complex factors and processes to get meaning from the situation. At this level, the alerting network has nothing to react to as it already perceives these elements at the first level. Hence, the comprehension level of SA might not be directly related to the alerting network.

Role of the Alerting Network in the Projection of Future Status. As the preceding section shows no relationship between the alerting network and the comprehension level of SA, this section is focused on discussing the possible relationship between the alerting network and the projection level of SA.

The projection level relies on the first and second levels of SA, and it also involves more complex processes (Endsley, 1988b, 1990a, 1995). Working memory has a very important role because it keeps track of current conditions, anticipated future conditions, the rules used to derive future conditions from the current ones, and the actions that are suitable for future conditions (Wickens, 1984; as cited in Endsley, 1995). Long-term memory structures, play a fundamental role in understanding and projecting future states without overloading working memory (Endsley, 1995).

The operators' goals, which are regarded as ideal states of the system, guide attention via a decision-making process that proceeds from the top down (Casson, 1983; as cited in Endsley, 1995). Furthermore, the focus on attention determines how the operator interacts with the environment around them, and over time, what they see is compared to a mental model-based projection they hold (Endsley, 1995).

The projection level requires complex processes rather than responding immediately to the elements in the environment, as there are no elements to react or respond to. The alerting network is in charge of generating rapid reactions to environmental elements (Posner & Petersen, 1990). Thus, the alerting network may not be directly connected to the projection level of SA.

To conclude this section, the literature has shown the relationship between the alerting network and the perception level of SA, and the most relevant aspects were addressed.

Exploring the Role of the Orienting Network in Situational Awareness

Role of the Orienting Network in the Perception of Elements. The previous section concludes the discussion of the alerting network and its correlation with the three levels of SA. In this section, the focus shifts to the possible correlation between the orienting network and the perception of the elements when essential information is addressed.

Endsley's theoretical framework emphasises the relevance of how individuals direct their attention, influencing not just the perception of elements but also the other stages (Endsley, 1995). In the context of road construction, roller operators might shift their attention to the temperature monitor and then to the control panel to verify information. The orienting network refers to directing attention to certain elements in the environment and searching for memory structures in the brain (Posner, 1980). The alerting network involves a shift of attention and the physical movement of the eyes and head.

The possible relationship may be at the beginning of the development of the perception level of SA. When individuals react to the elements in the environment, thereby activating the alerting network, they also might need to direct their attention to different locations. Likewise, Endsley's' theoretical framework emphasises the importance of directing attention at the perception level. This information might be in line with Posner's orienting network.

Posner's orienting network emphasises that individuals direct their attention to perceive elements in the environment. So, roller operators notice a flashlight in the control panel and respond immediately by shifting their attention towards the elements in their surroundings. Hence, there is some evidence that the orienting network might be related to the perception level of SA.

Role of the Orienting Network in the Comprehension of the Current Situation. This section explores the link between the orienting network and the perception level of SA. The comprehension level is built up at the first level of SA. The comprehension level is built up on the first level of SA. This level involves different complex processes like working memory, long-term memory, schemas, pattern matching, and individuals' expertise (Endsley, 1988a, 1990a; Endsley & Garland, 2000).

The orienting network directs individuals' attention to the elements in the environment (Posner, 1980). The shift of attention involves a turn of the head and movement of the eyes towards elements in the environment.

In summary, the comprehension level relies on the first level of SA and involves various complex processes (Endsley, 1995). During the development of the comprehension level, there might not necessarily be a shift of attention. Conclusively, the comprehension level might not be directly related to the orienting network of attention.

Role of the Orienting Network in the Projection of Future Status. Despite a limited association between the orienting network and the comprehension level of SA. Nonetheless, there is a possibility of gaining new insights into the orienting network and its potential connection with the projection level of SA.

At the projection level, various processes like working memory, long-term memory, expertise, schemas, attention, and mental models play an essential role (Endsley, 1988b, 1990a, 1995). In the case of a road construction site, expert roller operators rely on their experience to build effective long-term memory structures that help them see patterns quickly and make decisions more easily (Endsley, 1995). Mental models and schemas are essential, as they enable professionals to comprehend and predict future states without exceeding their working memory capacities (Rouse & Morris, 1985).

In conclusion, the projection level relies on both the first and second levels of SA (Endsley, 1995). The projection level of SA does not interact with elements in the environment. Conversely, the orienting network directs attention to the sensory elements in the environment (Posner, 1980). Thus, this suggests that the orienting network might not be related to the projection level of the future status of SA.

This section has attempted to provide a summary of the literature relating to the orienting network and all the levels of SA, with strong evidence for a relationship between the orienting network and the perception level of SA.

Exploring the Role of the Conflicting Network in Situational Awareness

Role of the Conflicting Network in the Perception of Elements. The focus of this section is on the possible correlation between the conflicting network and the perception level of SA. As previously explained, different processes play a role, such as sensory memory, attention, and working memory, at the perception level (Endsley, 1995). Unlike this, the conflicting network manages the task conflicts and sets priorities between different tasks (Norman & Shallice, 1986a).

This utilises contention scheduling for resolving conflicts between schemas that are active simultaneously and avoiding conflicts. The activation values and inhibition are used in the contention scheduling to prevent incompatible tasks and encourage the cooperative use of common structures. Likewise, the supervisory attentional system works as an extra control structure by manipulating activation values (Norman & Shallice, 1986a).

In summary, at the perception level of SA, individuals recognise the elements in the environment without using schemas. Nonetheless, the conflicting network framework supports managing and resolving conflicts between multiple tasks. Accordingly, the conflicting network works independently of the perception level of SA. Thus, there is a lack of correlation between both processes.

Role of the Conflicting Network in the Comprehension of the Current Situation. This section addresses the relationship between the conflicting network and the comprehension level of SA. The comprehension level encompasses the interpretation and comprehension of the information that has been perceived, and it is primarily influenced by the information stored in working and long-term memory (Endsley, 1988). Working memory, a crucial factor in cognitive processes, plays a major role in storing information for active processing (Wickens, 1992; as cited in Endsley, 1995).

Moreover, long-term memory structures play a strategic role in escaping the limits of working memory in dealing with these cognitive processes. Schemas are also relevant in cognitive processes because they provide an organised framework for understanding information, especially in those that involve complex systems and states (Bartlett, 1932; Mayer, 1983; as cited in Endsley, 1995).

The conflicting network, as observed by Norman & Shallice (1986a), helps in managing task conflicts and determining priorities between different tasks. It also uses contention scheduling to resolve conflicts between multiple schemas that are active simultaneously to prevent conflicts during performance. The supervisory attentional system also provides additional control by manipulating activation values to regulate attention (Norman & Shallice, 1986a).

In conclusion, the link between the comprehension level of SA and the conflicting network may arise from the role of the schemas that hold the memory and are used in the understanding of the situation. The conflicting network assists in managing and resolving conflicts between multiple schemas in memory or tasks (Norman & Shallice, 1986a). Accordingly, a possible relationship is evident between the comprehension level and the conflicting network.

Role of the Conflicting Network in the Projection of Future Status. This section displays a possible correlation between the conflicting network and the projection of future status, the third level of SA. The projection level of the future status relies on the first and second levels of SA and compromises a larger variety of cognitive processes to anticipate the changes in the environment. Likewise, various factors and processes like working memory, expertise, as well as long-term memory, mental models, and pattern matching have an important role in the development of the projection level (Endsley, 1988b, 1990a, 1995).

The conflicting network is responsible for managing task conflict and avoiding distractors. However, its model utilises contention scheduling to resolve conflicts that may arise when multiple schemas are active simultaneously, ensuring smooth performance (Norman & Shallice, 1986a). Additionally, the system utilises activation values and inhibition to prevent incompatible tasks and promote cooperative use of common structures, and the supervisory attentional system provides additional control by manipulating activation values to regulate attention (Norman & Shallice, 1986a).

In conclusion, the projection level extends beyond the management of conflicts and priorities in real time to predict what may happen shortly. Besides, the conflicting network involves task resolution, inhibits incompatible tasks, and controls the attention of individuals. This involvement with schemas is not exclusive to the conflicting network. Thus, the conflicting network may not be related to the projection level of SA.

This chapter has demonstrated the possible correlations between each of the attention networks and each of the levels of situational awareness. Three possible correlations were found between the alerting network and the perception level of SA, the orienting network and the perception level of SA, and the conflicting network and the comprehension level of SA. Hence, the next chapter will establish the hypotheses based on the previous literature.

Research Questions and Hypotheses

Endsley's theoretical framework emphasises the relevance of situational awareness for operators, especially in a dynamic environment (Endsley, 1995). Endsley also developed a test called SAGAT for measuring situational awareness (Endsley, 1988b, 1990b). Besides, multiple cognitive processes contribute to situational awareness. Particularly, attention is one of the processes that have a significant role in situational awareness, as earlier studies demonstrated (Endsley & Rodgers, 1994; Fracker, 1989).

Posner states that attention networks can measure individuals' efficiency through their three networks: alerting, orienting, and conflicting (Posner & Petersen, 1990). Moreover, the

ANT test was developed to assess each of the attention networks, i.e., the attention network was applied in the context of road construction (Mohammadpour et al., 2016) and in a driving task simulation (Choi et al., 2019).

Thus, the possible link between situational awareness and attention networks is likely evident in the first levels of situational awareness (see Figure 1). During the development of the first level of SA, the alerting network might generate a rapid response to the elements in the environment (relation A). Concurrently, the orienting network may contribute to allowing the individuals to direct their attention to them (relation B), and the conflicting network enables individuals to resolve task conflict and inhibit distractors (relation C).

The study investigates roller operators' attention networks and situational awareness relationship, revealing how the alerting network responds to elements, orients attention, and task conflict resolution of individuals. It supports the research model with hypotheses H1, H2, and H3, analysing the relationship between these cognitive processes (see Figure 1).

The main research question is: *What is the association between attention networks (alerting, orienting, and conflicting) and the three levels of situational awareness (perception, comprehension, and projection) of roller operators in VR?*

The following hypotheses were formulated based on the theoretical framework:

*Roller operators' attention networks efficacy (alerting, orienting, and conflicting) is assumed to be positively related to situational awareness.

H1: Roller operators' alerting network efficacy is assumed to be positively related to the perception level of situational awareness.

H2: Roller operators' orienting network efficacy is assumed to be positively related to the perception level of situational awareness.

H3: Roller operators' conflicting network efficacy is assumed to be positively related to the comprehension level of situational awareness.

METHOD

Research Design

This study was based on basic and correlational research using quantitative methods. In this case, two tests were applied to get information about the variables in the study: the Attention Network Test and the Situational Awareness Global Assessment Technique.

Participants

This study included fifty-four male students enrolled in a road construction engineering programme at a vocational school. The results showed that, on average, students were in the first year of the programme (M = 1.22, SD = 0.42). Likewise, the ages of the participants ranged from 16 to 19 years old, and on average, they were 17.3 years old (M = 17.3, SD = 0.88). Most of the participants had a work activity concurrent with their studies (M = 3.98, SD = 0.66). Regarding virtual reality (VR) experiences, the results showed that participants compacted asphalt on average 2.07 (M = 2.07, SD = 0.89) and about 2.39 times on average; they did not compact frequently outside of the virtual reality environment (M = 2.39, SD = 0.86).

Thirty-seven participants completed the virtual reality task and the SAGAT test. However, only 36 cases were included in the data analysis. Due to the existence of an outlier, the data on the participant was removed from the statistical analysis. The participant's performance on the ANT was initially within the usual range in the practice trial, but further tries showed changes, including negative results within the orienting and conflicting networks. The assessment of the participant's trial showed that he did not complete any incongruent trial, which did not coincide with the previous ANT practice trials.

Instruments

Demographic Questionnaire

The demographic questionnaire consisted of ten questions, and it was completed online using Microsoft Forms to get general information about the students. The anonymous questionnaire gathered general information about the students, such as their characteristics, age, gender, education, work experience, experience compacting in VR, and experience compacting outside of VR, as shown in Appendix B.

VR Environment for Compacting Task

The virtual reality environment was used to replicate the authentic scenario of compacting asphalt. The participants used a head-mounted display, joystick, and steering wheel to actively participate in the task inside the virtual reality environment. The VR task aimed to compact asphalt using software, a joystick, and a steering wheel to control a roller machine. All the instructions before starting the VR task are shown in Appendix C.

At the beginning of the task, the participants had preparatory training where they were provided with specific information about the compacting task (Appendix E). The compacting task lasts 7 minutes (420”) approximately. The VR setting has overcast weather and a 12ºC virtual environment temperature, and it involves 72 asphalt rows. Also, the utilisation of ZOAB asphalt type and a layer thickness of 5. This information was important to their preparation for their virtual asphalt-compacting experience so they could control the VR task. After the compacting task was done, the participants answered questions about it.

Situational Awareness Global Assessment Technique

The Situation Awareness Global Assessment Technique developed by Endsley for evaluating situational awareness is widely recognised as one of the most used methods for directly assessing the level of situational awareness. In this case, a set of questions from the SAGAT test for compacting asphalt was developed to assess the level of situational awareness in VR (Raestrup, 2023). The SAGAT test for assessing situational awareness involved twelve questions (Appendix F), considering a set of four questions for each level of SA.

The test involved the three levels of situational awareness, which were introduced in the following way: perception, comprehension, and projection. The test includes 12 questions, and each level of SA includes four questions, and each correct answer will provide a percentage per question. These are some examples of the questions included in the SAGAT test: How many times have you already compacted the indicated area? Which side of the asphalt is the high side? The whole test is shown in Appendix F.

Previous studies have measured the internal consistency of the three levels of the SAGAT test using Cronbach's alpha (Hultin et al., 2019). Results from multiple studies have shown that the internal consistency of the SAGAT test is over the acceptable threshold of 0.767, indicating a reliable test (Coolen et al., 2019). In one study, the reliability of the SAGAT test was measured using Cronbach's alpha, and the results showed a score of 0.767 (Hogan et al., 2006).

Overall, Cronbach's alpha is a reliable method for measuring the internal consistency of the SAGAT test, and previous studies have shown that the test has generally high internal consistency. Further, for the interpretation of the results, Cronbach’s alpha threshold or cut-off as an acceptable value is 0.7 or 0.6 (van Griethuijsen et al., 2015). Thus, based on previous studies that applied the SAGAT test, Cronbach's alpha was used to examine the reliability of the SAGAT test. The findings showed ($\alpha = 0.25$) based on the analysis of the 12 questions of the test. This result proved that the internal consistency of the test was low. Additionally, an individual assessment of the reliability of each of the levels of the SAGAT test was assessed to verify the internal consistency. There were diverse results for each level: For level 1 (perception), Cronbach’s alpha was -0.15, for level 2 (comprehension level), it was 0.42, and for level 3 (projection level), it was 0.67. Therefore, these results showed that the internal consistency of the perception level had a negative result, which might have influenced the total results for the reliability of the SAGAT test.

The Attention Network Test

The attention network test involves 30 minutes (Fan et al., 2002). However, a short version of only 12 minutes was considered to assess the participants' networks. This ANT short version involves a 120-day trial to get the information from each of the attention networks. The test began with a preliminary explanation of the different tasks, followed by a practice round and feedback showing how each response was assessed. To complete the task, the participants pressed key E if the central arrow pointed to the left and key I if the central arrow pointed to the right. The task incorporated flankers in different directions as targets (congruent or incongruent), as shown in Appendix D.

This study applied the ANT short version, which includes three conditions: no cue, centre cue, and spatial cue (Fan et al., 2005). The spatial cue can be positioned either below or above the central cross and consistently indicates the location of forthcoming target arrays. The flanker conditions are classified: the first one is the neutral target, encompassing scenarios with either no flankers or the presence of mere lines devoid of arrowheads; the second one is congruent, wherein the flanking arrows align in the same direction as the target; the third is incongruent, where they point in the opposite direction.

The subtraction technique is applied in the Attention Network Test (ANT) to measure the attentional networks. The alerting network is calculated by subtracting the average reaction time (RT) of right responses with no cue from correct responses with a central cue.

The orienting network is calculated by subtracting the average reaction time with a central cue from the average reaction time with a spatial cue, proving their ability to direct attention to specific elements.

The conflicting network is calculated by subtracting the average reaction time in incongruent flankers from the average reaction time in incongruent conditions, indicating participants' ability to resolve conflicts and prioritise their tasks. Thus, the results will provide information using a correct interpretation of each attention network.

The interpretation of the Attention Network Test relies on the reaction times (RT) and accuracy data that are relevant to understanding how the attention networks work (Fan & Posner, 2004). In the alerting network, larger alerting scores may indicate trouble keeping awareness in the absence of a signal, which may be seen in younger individuals.

In the orienting network, larger reaction times for orienting may suggest difficulties disengaging from the centre cue, but higher effort may indicate better orienting. Lastly, the interpretation of the conflicting score is based on the difference between incongruent and congruent response times. When error rates match, interpretation is simple; however, differences in reaction times and error rates may indicate different task techniques rather than differences in conflict skills.

In previous studies, the ANT reliability was measured using split-half reliability (MacLeod et al., 2010). Moreover, in another study, the psychometric properties of performance on a modified version of the ANT were analysed on healthy adults, and the reliability was measured using the split-half method (Ishigami et al., 2016). Likewise, the split-half was applied in this study to measure the internal consistency of the ANT. Split half reliability has some conditions in which the negative results cannot be interpreted, therefore the inversion of negative scores could help to assess the reliability of the results (Steinke & Kopp, 2020). The ANT results were Cronbach's alpha (-1.15), Guttmann split-half coefficient (r = .047) and Spearman-Brown split-half coefficient (r = .066). Before assessing the reliability of the test, the raw data was revised and excluded from single trials with negative ratings. This step was crucial since it ensured the test's reliability evaluation was accurate.

After the analysis of without some negative results, Cronbach's alpha (α = 0.21) was relatively low and showed a limited internal consistency of the test. In addition, the second part of Cronbach's alpha showed good internal consistency. Spearman-Brown result was (r = 0.298) a modest improvement in reliability. Guttmann split-half coefficient (r = 0.22) showed a moderate level of internal consistency.

Procedure

The first step was to inform the University of Twente's Ethics Committee about the research and request permission to gather the data. Before beginning the study, informed consent was provided to the participants to inform them of the study protocols, rights, and obligations. Then the participants had the opportunity to express their concerns about the study.

The tests were carried out over two days to gather the data from June 2023, from 8:00 a.m. to 12:00 p.m. A presentation was displayed to the participants, and the information was delivered in Dutch (Appendix B). Moreover, the demographic survey was provided in the Dutch language. The ANT was obtained from a website and installed on the PCs at the vocational school's laboratory; the ANT instructions were in English, while the virtual reality task was in Dutch.

Before starting with the ANT test, the participants were instructed through a presentation explaining each of the tests (Appendix D) and were asked to focus on the task. The participants were instructed again at the beginning of the test and also had a short trial practice. Then, they sat down and maintained a certain distance from the screen computer, and they used the keyboard (E, I) and the mouse to choose the position of the arrows during the 120 trials, divided into 3 blocks of trials involving 12 minutes.

After the ANT test was completed, the participants were asked to complete the VR compacting task (Appendix E). Three VR simulators were utilised to complete the task and assess the participants' situational awareness, and the task took approximately 7 minutes. The last element of the work compromised the SAGAT test, which was used after the compacting task was completed for the students since it was more convenient for them. The participants responded to a series of 12 questions that involved their levels of SA (Appendix F).

Statistical Analyses

The findings of this study were analysed using IBM SPSS 28, a tool used to assess the relationship between situational awareness and attention networks (alerting, orienting, and conflicting) among road compacting engineers at a vocational school in the Netherlands. To address some broad questions about the participants, descriptive statistics of the variable’s measures were utilised. The reliability analysis was used to confirm the validity of the tests over time and in various settings. Furthermore, multiple linear regression analysis can be used to determine whether multiple independent variables (alerting, orienting, and conflicting) have any influence on a single dependent variable (situational awareness), shedding light on the most influential variables driving the outcome of interest.

RESULTS

Table 1 shows the descriptive statistics and correlations for situational awareness (perception of the elements, comprehension of the current situation, and projection of the future status) and attention networks (alerting, orienting, and conflicting).

Descriptive Statistics and Correlations

Table 1

Descriptive Statistics and Correlations for Situational Awareness and Attention Networks

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Situational Awareness	53.00	12.91	-						
2. Perception	46.53	17.06	.37*	-					
3. Comprehension	50.69	24.99	.74**	.09	-				
4. Projection	61.81	23.52	.59**	-.21	.11	-			
5. Alerting	17.67	40.22	.06	-.08	.13	.01	-		
6. Orienting	39.44	68.47	.33*	-.01	.24	.30	-.42*	-	
7. Conflicting	110.81	154.83	.22	.24	.10	.07	.12	-.04	-

Note. $N = 36$

*. $p < 0.05$ (2-tailed).

**. $p < 0.01$ (2-tailed).

Relationship between Situational Awareness and The Attention Networks

Exploring the relationship between situational awareness (perception, comprehension, and projection) and attention networks (alerting, orienting, and conflicting) using multiple linear regression. The dependent variable in each regression analysis was each one of the levels of situational awareness.

Table 2

Results of Multiple Linear Regression Analysis for Examining the Relationship Between Situational Awareness and Attention Networks

Coefficients	*B*	*SE*	β	*t*	*p*	95% CI	
						LL	*UL*
(Constant)	46.712	3.096		15.087	<.001	40.405	53.019
Alerting	.068	.056	.211	1.206	.237	-.047	.182
Orienting	.081	.033	.429	2.460	.019	.014	.148
Conflicting	.017	.013	.206	1.292	.205	-.010	.044

Note. *N* = 36

Dependent Variable: Situational Awareness. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The regression analysis displayed that the regression model assessing the effect of attention networks on situational awareness was not statistically significant [F (3, 32) = 2.644, *p* = 0.066]. However, the model explained 19.9% of the variance in situational awareness (R^2 = .199), providing valuable information on the influence of attention networks. Individual analysis of each network, the alerting network *B* = 0.068 (*t* = 1.206, *p* = 0.237) demonstrated a lack of significance in the relationship with situational awareness. The orienting network with a *B* = 0.081 (*t* = 2.460, *p* = 0.019) showed a positive and significant relationship with situational awareness. Conversely, the conflicting network with a *B* = 0.017 (*t* = 1.292, *p* = 0.205) did not reach statistical significance in the relationship with situational awareness. The Durbin-Watson test displayed a value of 1.627 and a significant autocorrelation among the residuals. While the model did not reach statistical significance, the orienting network showed a positive relationship to situational awareness. These results suggested further research within the context of the study.

Table 3

Results of Multiple Linear Regression Analysis for Examining the Relationship between Perception Level of Situational Awareness and Attention Networks

Coefficients	*B*	*SE*	β	*t*	*p*	95% CI	
						LL	*UL*
Constant	44.877	4.405		10.188	<.001	35.905	53.850
Alerting	-.054	.080	-.127	-.675	.505	-.217	.109
Orienting	-.013	.047	-.052	-.278	.783	-.108	.082
Conflicting	.028	.019	.255	1.488	.147	-.010	.067

Note: N = 36

Dependent Variable: Perception. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The results of the regression analysis showed that there was not enough evidence to support the efficacy of attention networks on the perception level of situational awareness. The main effect was not statistically significant [F (3, 32) = 8.26, p = 0.55], but it did explain 7.2% of the variability in the perception level of situational awareness (adjusted R^2 = -.015). Analysing each one of the predictors revealed that the alerting network showed a negative and non-significant relationship to the perception level of SA, as shown by B = -0.054 (t = -0.675, p = 0.505). Similarly, the orienting network showed a negative and non-significant association with the perception level of SA, with B = -0.013 (t = -0.278, p = 0.783). According to B = 0.028 (t = 1.488, p = 0.147), the conflicting network also showed a non-significant relationship with the perception level. The Durbin-Watson test showed a value of 1.93, indicating a significant autocorrelation between the residuals.

Table 4

Results of Multiple Linear Regression Analysis for Examining the Relationship between Comprehension Level of Situational Awareness and Attention Networks

Coefficients	*B*	*SE*	β	*t*	*p*	95% CI	
						LL	*UL*
Constant	41.138	6.249		6.583	<.001	28.409	53.867
Alerting	.167	.114	.268	1.468	.152	-.065	.398
Orienting	.130	.066	.357	1.964	.058	-.005	.265
Conflicting	.013	.027	.083	.497	.623	-.041	.068

Note. N = 36

Dependent Variable: Comprehension. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The regression analysis revealed that the attention networks did not provide enough evidence to support the relationship between attention networks on the comprehension level of SA, which was not statistically significant. The main effect was not statistically significant [F (3, 32) = 1.580, p = 0.213]. While the main effect did not meet the threshold for significance, the model was responsible for 12.9 % of the variance in the comprehension level of SA (adjusted R^2 = .047). Further analysis of each of the predictors displayed that the alerting network had a positive and non-significant association with the comprehension level of SA, B =.167 (t = 1.468, p = .152). Particularly, the orienting network B = .130 (t = 1.964, p = .058) was slightly above the standard threshold of significance, but the relationship with the comprehension level of SA was not statistically significant. The conflicting network B =.013 (t =.497, p = .623) displayed a non-significant relationship with the comprehension level of SA. The results of the Durbin-Watson test displayed a value of 1.49, indicating the presence of autocorrelation between the residuals. While the model did not reach statistical significance between attention networks and the comprehension level of SA, the p - value of the orienting network was slightly above to the standard threshold for significance. This result suggests the need for additional research within the context of the study.

Table 5

Results of Multiple Linear Regression Analysis for Examining the Relationship between Projection Level of Situational Awareness and Attention Networks

Coefficients	B	*SE*	*β*	*t*	*p*	95% CI	
						LL	*UL*
Constant	54.123	5.920		9.142	<.001	42.064	66.181
Alerting	.091	.108	.156	.848	.403	-.128	.310
Orienting	.127	.063	.370	2.023	.052	-.001	.255
Conflicting	.010	.025	.063	.377	.709	-.042	.061

Note. *N* = 36

Dependent Variable: Projection. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The regression analysis showed that the relationship between attention networks and the dependent variable projection level was not statistically significant. The main effect was not statistically significant [F (3, 32) = 1.419, *p* = 0.255], explaining 11.7% of the variance in the projection level (adjusted R^2 = .035). According to the analysis of the predictors, the alerting network with a value of *B* = 0.091 (*t* = 0.848, *p* = 0.403) did not show a statistically significant relationship with the projection level of SA. Conversely, the orienting network with a value of *B* = 0.127 (*t* = 2.023, *p* = 0.052) displayed a non-statistical significance relationship with the projection level of SA, despite the *p*-value being slightly above the threshold standard. The conflicting network with a value of *B* = 0.010 (*t* = 0.377, *p* = 0.709) did not have a statistically significant relationship with the projection level of SA. Additionally, the Durbin-Watson test showed a value of 1.957, which confirmed significant autocorrelation among the residuals. While the model did not reach statistical significance between attention networks and the projection level of SA, the *p*-value of the orienting network was slightly above the threshold standard for significance, further study is needed to evaluate its potential significance. This finding indicates the need for more investigation in the context of the study.

DISCUSSION

Interpretation of Findings

The study findings indicate that there is no significant correlation between the levels of situational awareness and each of the attention networks. The results confirmed that none of the alerting, orienting, or conflicting attention networks are connected to situational awareness and its levels (perceiving the elements, understanding the present situation, and projecting the future status). Therefore, some explanations for non-significant results are discussed based on the theoretical models.

Roller Operators' Attention Networks Efficacy (alerting, orienting, and conflicting) is Assumed to be Positively Related to Situational Awareness

This first analysis supports a general exploration of the relationship between situational awareness and attention networks, and this was not hypothesised: Roller operators' attention network efficacy is positively related to situational awareness. The results showed that the attention networks were not statistically significantly positively related to situational awareness. The non-significant results between the attention networks and SA might have several reasons. Most likely, the multilinear regression analysis showed that the relationship was not statistically significant. However, previous research supports the relationship between attention and situational awareness in complex systems (Endsley & Rodgers, 1996; Fracker, 1989).

Multiple linear regression analysis displayed that there is no relationship between attention networks and situational awareness. The attention networks are not related to situational awareness. One of the limitations is the small sample size, and consequently, the results cannot be generalised to a larger population (Drew et al., 2014a). Likewise, the sample size affects the statistical power because it does not allow the rejection of the null hypothesis or the detection of true effects in the study (Cohen, 1988). Therefore, the study failed to fulfil the necessary criteria to attain statistical power due to the inadequate reliability of the sample size, a small effect size, and the absence of meaningful results.

Individuals' alerting network allows them to react immediately to the highly relevant elements (Posner & Petersen, 1990). These elements appear at the first level of situational awareness and might be recognised through the activation of the alerting network. In the context of a construction site, roller operators react immediately to a red flashing light that might appear in the control panel of the roller machine. Nonetheless, the results displayed that there is no link between situational awareness and the alerting network.

The results of the orienting network showed a statistically significant association with situational awareness. These findings indicated that variations in the orienting network, which is a part of attentional processes, might be significantly associated with shifts in situational awareness. The findings provided a significant understanding of the functioning of the orienting network and how they influenced situational awareness within the particular subject being studied. Furthermore, a previous study states that at the perception level, there is a necessity to direct attention not just towards perceiving and processing stimuli within a given context but also towards the later stages of decision-making and executing action (Endsley, 1995). This means that orienting attention is necessary and fundamental in the process of accomplishing situational awareness. Additionally, this implies that improving the orienting network might potentially lead to positive outcomes like increasing and enhancing situational awareness in various fields.

The conflicting network displayed a non-statistically significant association with situational awareness. Nonetheless, existing literature explains that the conflicting network might be related to the comprehension level of SA. This aligns with the process of resolving conflicting schemas in individuals via the integration of newly acquired information with pre-existing knowledge (Norman & Shallice, 1986a). Furthermore, it is essential to note that situational awareness involves different levels and processes (Endsley, 1995) beyond the involvement of the conflicting network. Nevertheless, the lack of correlation between these cognitive processes was confirmed in the multiple linear regression analysis.

Moreover, how attention is distributed might influence the perception of individuals and consequently having some difficulties perceiving various elements at the same time (Endsley, 1988a, 1995; Endsley & Garland, 2000). The orienting network might influence situational awareness at the beginning of the perception level, where individuals might direct their attention to the elements in the environment. Additionally, Posner states that the orienting network guides attention to the elements in the environment (Posner, 1980). This means that the individuals shift their attention from one location to another to recognise the elements around them, an action called overt orienting.

In previous studies, the relationship between attention and situational awareness was assessed using a different model, and the results showed that attention allocation and distribution are relevant to situational awareness (Endsley & Rodgers, 1996; Fracker, 1989). In comparison to the previous studies, this study is focused on measuring each of the attentional processes (alerting, orienting, and conflicting) related to situational awareness.

This study begins a preliminary general inquiry into the relationship between attention networks and situational awareness. It demonstrated that there was no statistically significant relationship between attention networks and SA. Despite that no link was found between these cognitive processes, this result provides a foundation for future research in this field considering a larger sample size. This result serves as a critical stepping stone for additional in-depth research into the complex interaction between attentional processes and situational awareness, opening opportunities for advances in our understanding of cognitive processes in dynamic situations.

Cronbach's test measured the internal consistency of the SAGAT test (α = 0.25), which means that the internal consistency of the test was low. However, an additional step was taken to assess the reliability of each level using Cronbach's alpha.: For level 1 (perception), Cronbach's alpha was -0.148, for level 2 (comprehension level), it was 0.42, and for level 3 (projection level), it was 0.67. These results showed that the internal consistency of the perception level had a negative result, which might have influenced the total results for the reliability of the SAGAT test. It might be possible some inconsistencies in the responses of the participants which lead to some negative results in the test. Therefore, the negative results in the perception level of SA might have contributed to the weak reliability of the test, considering that the other levels' results showed moderate reliability.

On the other side, to measure the internal consistency of the ANT, the split-half method was applied. In the first part, Cronbach's alpha (α = 0.21) was relatively low and showed a limited internal consistency between the results of the test, Spearman-Brown result was (r = 0.30), and Guttmann split-half coefficient (r = 0.22) showed a moderate level of internal consistency.

The theoretical framework of situational awareness provides a conceptual understanding of how directing attention contributes to the broader concept of situational awareness (Endsley, 1995). According to Posner & Petersen (1990), orienting attention guides the direction of the attention to the elements around them. Despite the relationship between situational awareness and attention networks was not statistically significant, the existing literature supports the connection between attention and SA (Endsley, 1995; Posner, 1980; Posner & Petersen, 1990). This combination of gathered data and theoretical understanding supports the possible connection of the orienting network in enhancing situational awareness. Further research is needed to get deeper insights into this possible relationship.

Roller Operators' Alerting Network Efficacy is Assumed to be Positively Related to the Perception Level of Situational Awareness.

The first hypothesis states that the roller operators' alerting network effect is positively related to the perception level, which is the first level of SA. Nonetheless, the results showed that there was no statistically significant relationship between the alerting network and the perception level of SA. There may be several reasons why the alerting network did not have a significant impact on the perception level of SA.

Multiple linear regression analysis explained that the relationship between the alerting network and the perception level of SA was not evident in this study. The results displayed that the predictors of the study did not show a significant effect on the perception level of SA. Most likely, the limited sample size contributed to the lack of statistical power (Cohen, 1988). This means that the amount of statistical power depends on parameters such as the size of the sample, the magnitude of the effect, and the level of significance (Cohen, 1988). Given the circumstances of this research, the limited number of participants is likely to have reduced the statistical strength, making it inadequate for detecting significant correlations. The sample size might not provide enough representation to generalise the results (Drew et al., 2014a). Therefore, it is necessary to consider a larger group of participants to enhance the robustness and applicability of the findings.

Moreover, some of the participants expressed their thoughts about the Attentional Network Test, indicating that it was long, repetitive, and boring. This information is aligned with previous research, indicating that cognitive tasks, especially those that require continuous awareness and effort, may lead to mental fatigue and this is like tasks that do not require an immediate reaction (Smith et al., 2019). For instance, the cognitive task applied in this study required that the participants focus and respond immediately pressing a key. Thus, it can be inferred that the participants felt exhausted and bored with the task. Moreover, tasks demanding focusing but including a limited quantity of information may induce more fatigue in comparison to tasks with higher demands (Lorist and Faber, 2011; as cited in Smith et al., 2019).

Additionally, during the analysis of the ANT data, it was brought to attention that an outlier had been identified. Upon further investigation, it became apparent that this participant's results were significantly inconsistent with the rest of the data set. As such, this outlier was flagged for review and further examination to determine any potential anomalies or errors that may have contributed to the deviation (Barnett & Lewis, 1978). The results showed repetition in the conflicting network (congruent responses). As the participant did not provide any incongruent responses, it was not possible to complete the subtraction and obtain the result of the conflicting network. As a result, the participant was deemed an outlier, and their results were excluded to maintain the reliability of the results.

The possible link between the perception level of SA and the alerting network might be based on how individuals process and respond to elements in the environment. The alerting network allows individuals to respond immediately to the elements to process the relevant information (Posner & Petersen, 1990). Posner argues that individuals respond immediately when performing a task because of the alerting network, but also explains that this response works in a specific way (Posner, 1978; as cited in Posner & Petersen, 1990).

According to Posner & Boies (1971), when individuals perform a task, the alerting state affects them, prompting them to respond immediately to the elements around them. Nonetheless, depending on the conditions of the elements, individuals might respond to the elements in the environment. In a situation where elements are not visible or easily observed, it is important to make the warning or alert signal prominent or conspicuous to draw attention and transmit the relevant information. Unlike when elements are easy to recognise, it can increase the possibility of errors in the information because of the faster responses. The practical relevance of this theoretical framework becomes evident when it is applied to the specific setting of road construction. For instance, roller operators manage the roller machine that involves different elements like the temperature of the asphalt, the speed of the wind, and the control panel displaying a flashing light, so roller operators react immediately to verify what is happening.

The results provided by this study cannot be directly compared with earlier studies due to the fact that the relationship between the alerting network and the perception level of SA. This subject has not been researched before. Comparing this study to previous ones, this one used the attention network test to verify the efficiency of each of the attention networks (alerting, orienting, and conflicting) and the SAGAT test to see how aware the participants were of their surroundings.

Nevertheless, prior studies showed the role of attention in situational awareness. The first study showed the importance of the distribution of attention in situational awareness (Endsley & Rodgers, 1996). Another study showed how the allocation of attention influences situational awareness (Fracker, 1989). Therefore, a relationship between attention and situational awareness might be considered based on the literature and previous research on the role of attention and situational awareness (Endsley & Rodgers, 1996; Fracker, 1989). However, the present study is focused on a deeper analysis of each of the attentional processes and situational awareness. Consequently, the lack of connection between these cognitive processes was unexpected in this study.

Existing literature shows that there might be a link between the alerting network and the perception level of SA because the alerting network reacts immediately to the elements in the environment. Nonetheless, the results of this study did not have a statistically significant relationship with the perception level of SA, and it did not have enough statistical power to confirm the results. Even though the results are not conclusive, they encourage further exploration of the subject to get deeper insights into this complex subject in study.

Roller Operators' Orienting Network Efficacy is Assumed to be Positively Related to the Perception Level of Situational Awareness

The H2 stated that orienting network efficacy is positively related to the perception level of SA. Nonetheless, the results showed that the orienting network was not statistically significantly related to the perception level of SA. The non-significant results between the orienting network and perception level of SA might have several reasons. Most likely, the multilinear regression analysis showed that the relationship was not significant. Moreover, the low statistical power is an obstacle to providing significant insights into the relationship between the orienting network and the perception level of SA.

Multiple linear regression analysis displayed that the relationship between the orienting network and the perception level of SA may not be evident in this study. The H2 hypothesised that the orienting network efficacy is assumed to be positively related to the perception level of SA. Likewise, the results showed that there was not a statistically significant relationship between the orienting network and the perception level, the first level of SA. The most likely reasons for the results that were not statistically significant are like those for the first hypothesis, which looked at the link between the alerting network and situational awareness of individuals.

Nevertheless, relying on the perception level of SA, individuals might perceive the elements in their environment through various sensory modalities. Individuals might respond to them through the alerting network that might enable them to respond quickly to environmental elements (Posner & Petersen, 1990). Likewise, individuals orient their attention to recognise the sensory elements in the environment (Posner, 1980).

In the complex dynamics of the attentional processes, overt orienting takes a prominent role in the orienting network exerting influence on perception level by coordinating physical movements. Overt orienting generates head or eye movements towards an element in a specific situation (Posner, 1980), which allows the exploration of the environment. Additionally, individuals can enhance the priority for processing the element by shifting attention covertly without visible physical movement, which means that individuals can process the information easily.

An experimental study of the orienting network revealed information on how individuals direct their attention (Posner, 1980). The results showed a limited benefit from an empty field, but if individuals direct their attention to the wrong location, the processing of the information target might take longer. This means that the cues are relevant for orienting attention effectively to different elements in the environment and revealing information on how individuals direct their attention (Posner, 1980). The results showed a limited benefit from an empty field, but if individuals direct their attention to the wrong location, the processing of the information target might take longer. This means that the cues are relevant for effectively orienting attention to different elements in the environment.

Endsley's theoretical framework suggests that how individuals direct their attention is not only important for perceiving elements but also contributes to other stages of situational awareness (Endsley, 1995). This theoretical framework is aligned with Posner’s theory of the orienting network, wherein individuals are in practical workplaces like road construction sites. For instance, roller operators might direct their attention to recognising the relevant elements like the temperature of the asphalt and signals in the control panel of the roller machine.

As discussed earlier in this section, this study explores the complex connection between the orienting network and the perception of the elements, the first level of SA. As far as it is known, previous research has not examined these connections in this complex and constantly changing environment. In comparison to the earlier studies, this study examines how each of the networks works with situational awareness. Nonetheless, earlier studies showed how attention has a role in the distribution of attention and how individuals allocate attention in situational awareness (Endsley & Rodgers, 1996; Fracker, 1989). Hence, a relationship between attention and situational awareness has a basic background considering the previous literature. Likewise, the lack of correlation between the orienting network and situational awareness was unexpected in this study.

Although previous literature displays some relationship between the orienting network and the perception level of SA, the current study did not show statistically significant results. Hence, further research considering a larger sample size which can support the statistical power is recommended to get conclusive results.

Roller Operators' Conflicting Network Efficacy is Assumed to be Positively Related to the Comprehension Level of Situational Awareness

According to the third hypothesis, roller operators' conflicting network efficacy is positively related to the comprehension level of SA. Nonetheless, the results of the study showed that a conflicting network did not have a statistically significant impact on the comprehension level of SA. The lack of significance in the relationship between the conflicting network and the comprehension level of SA has led to some arguments.

Multiple linear regression analysis showed that the conflicting network efficacy was not linked to the understanding of the current situation, which is the second level of SA. One of the limitations is the lack of statistical power that influences the results of the study (Cohen, 1988). These results cannot be conclusive because the sample is not large enough to generalise the results (Drew et al., 2014a).

The comprehension level involves the active processing of the perceived elements that are stored in working memory. Additionally, long-term memory helps to provide new context and overcome the limitations of working memory by using its schemas or mental models to help understand the situation (Endsley, 1995). This level process entails the active processing of perceived elements that are stored in the working memory. This necessitates overcoming constraints in working memory by providing new context from long-term memory. This is essential to understanding the situation through schemas, or mental models. Additionally, the conflicting network manages task conflicts and prioritizes different tasks (Norman & Shallice, 1986a). Furthermore, to avoid performance conflicts between active schemas, it uses contention scheduling to resolve conflicts.

Furthermore, activation values and inhibition are used in the contention scheduling to prevent incompatible tasks and encourage the cooperative use of common structures. Additionally, the supervisory attentional system works as an extra control structure by manipulating activation values to provide attentional control (Norman & Shallice, 1986a). Applying this attentional control to the schemas in the horizontal thread organisation affects the choice of actions in an indirect way. Hence, the conflicting network framework assists in managing and resolving conflicts between multiple schemas or tasks at the second level of situational awareness, when understanding is essential for the development of situational awareness. In a practical workplace, roller operators compact asphalt, and when a conflict with another task can occur, the individuals' conflicting networks prioritise the relevant one and inhibit the distractors.

The present study introduces a primary exploration of the conflicting network and comprehension level of SA considering that there is no earlier research on this topic. The relationship between the conflicting network is supported by literature. However, the results demonstrated that there is no link between them. In the current study, the attention networks can provide information on how each of the networks of the attention system works at the comprehension level of SA. As mentioned previously, the role of attention was assessed in previous studies using a different model, and the results showed that attention allocation and attention distribution have a significant role in situational awareness (Endsley & Rodgers, 1996; Fracker, 1989).

Although the existing literature supports the relationship between attention networks and situational awareness. The results of the hypothesis showed that the comprehension level of SA and the conflicting network did not have statistical significance. Consequently, it should be recommended to explore this relationship in a new study to get a profound understanding and confirm if there is a relationship with a larger sample size.

Rollers Operators' Attention Network Efficacy is Assumed to be Positively Related to the Projection Level of Situational Awareness

Previous hypotheses were formulated to get insights into the possible link between each of the attention networks and the levels of situational awareness. Nonetheless, an additional exploration of the possible link between the projection level of SA and attention networks was assessed. Furthermore, it is relevant to emphasise that this additional hypothesis was not formulated in the main research, but it was considered because the projection of the future status is the last level to acquire SA. Based on the findings, it can be concluded that there exists no statistically significant correlation between the attention networks and the level of SA projection.

The multilinear regression analysis displayed the relationship between the attention network and the projection level of SA was not statistically significant. The non-significant results might have some reasons. Most likely, the same reasons that were explained in the first hypothesis on the relationship between the alerting network and the perception level of SA.

Projecting the future status is built up on the first and second levels of SA (Endsley, 1995). Moreover, this level involves various processes like working memory, long-term memory, mental models, expertise, attention, and the goals of individuals (Endsley, 1988a, 1995, 2001). This projection level of SA was explored with each of the attention networks, and the literature supports the relationship with some of the attention networks. Nonetheless, the multiple linear regression analysis displayed and confirmed no relationship between the cognitive processes.

The projection level relies on the first and second levels of SA and, based on them, makes predictions of the near future; and there are no elements in this level (Endsley, 1995). Conversely, the alerting network reacts immediately to elements, and as mentioned previously, at this level there are no elements to recognise (Posner & Petersen, 1990). In a practical scenario, roller operators project the possible changes in the environment. They make connections between the perceived elements and the understanding of the current situation to forecast possible changes and not affect the compacting process. Thus, the piece of evidence shows that the projection level works independently and that there is a lack of correlation to the alerting network.

The orienting network involves directing attention to elements, in the environment which might generate physical movement of the eyes and the head; on the other hand, the projection level does not include elements in the environment (Posner, 1980). This level aims to anticipate possible changes in the environment. In a practical context, roller operators forecasting the variation in the environment might not need to direct their attention to elements in the environment. Hence, the projection level may not be related to the orienting network.

As discussed previously, the projection level involves the first and second levels of SA and various complex processes (Endsley, 1995). Conversely, the conflicting network provides conflict resolution between task conflicts, allowing individuals to focus on the relevant task (Norman & Shallice, 1986a). In the high-pressure environment of a construction site, the ability to anticipate changes is vital for roller operators. But it takes more than only completing tasks; it requires a range of cognitive processes to stay on top of things and that is why it is important to recognise that this cognitive process does not only involve task resolution.

Previous studies have shown the link between situational awareness and attention (Endsley & Rodgers, 1996; Fracker, 1989). Nevertheless, there is no previous research on the association between attention networks and situational awareness. In comparison to previous research, this study focuses on analysing each of the attention networks and their relationship with the levels of SA. This established a base for future research to address this gap in the literature and get even more insights on this topic.

The evidence presented in the results shows that attention networks and the projection level of SA are not linked. This is consistent with what existing studies have suggested: that these cognitive processes are not associated with each other. However, to gain more comprehensive insights, it is imperative to conduct further research with a larger sample size.

Emphasising this point will help us uncover new and valuable insights regarding the relationship between attention networks and the projection level of SA.

Limitations

This study has some limitations. First, the sample was homogeneous in terms of gender and characteristics, raising questions about its generalisability to a more diverse population. A small sample is acceptable if the sample size is homogenous (Drew et al., 2014b). However, samples in Behavioural Science require a larger population for the appropriate generalisation of the results. Therefore, this means a larger sample size is necessary to enhance the accuracy and generalisation of the findings.

The statistical power of this study is low, which means that the null hypothesis cannot be rejected (Cohen, 1988). The study did not meet the parameters required to achieve statistical power, which is a result of the reliability of the sample size, a small effect size, and no significant findings. The significance criteria are well known as the Type I error. It indicates the level of evidence for the existence of the phenomenon, or the possibility of incorrectly rejecting the null hypothesis (Cohen, 1988). This implies that the significance can reject the null hypothesis in this case that there is no relationship between situational awareness and attention networks.

Failing to reject a false null hypothesis is an instance of a Type II error in statistical analysis. It occurs when the test fails to identify an effect that is present. Thus, despite the existence of an effect, erroneously adopt the null hypothesis, which states that there is no effect (Cohen, 1988). Furthermore, the size of the sample always affects how reliable it is. There are fewer errors and more trust when the sample size is larger. This link makes sense: getting more accurate results raises the likelihood of finding a real effect in a large amount of variation. It is very important in research to understand the connection between sample size and statistical power, which means being able to find real effects.

The effect size indicates the proportion of the population that exhibits the phenomenon in question or the extent to which the null hypothesis is rejected (Cohen, 1988). The absence of a phenomenon is consistently indicated by the null hypothesis, which states that the effect size is zero, irrespective of how it is represented in a study. As a result, the hypotheses did not show statistically significant effects and the additional and general analysis of the attention networks and situational awareness did not reach a statistical significance, therefore is necessary to be cautious with the interpretation of these results.

The Attention Network Test (ANT) was administered in a laboratory environment rather than on an individual basis. The ANT test is a versatile instrument that can assess adults, children, and animals. This test can be conducted in groups or individually (Fan et al., 2002). Additionally, in another study, the test was individually applied to children in a controlled place (Rueda et al., 2004). In this study, due to limited time and space availability, the data was gathered in a group, that may affect the results with external distractors in the same space.

During the development of the test, maybe the presence of external distractions influences the task performance of the participants, which can be a limitation for the results. Nonetheless, previous research on internal and external distractors demonstrated that the number of internal distractors in comparison to the other distractors was reduced to the presence of a speech as opposed to when there was no speech. This information is consistent with findings from prior studies, which propose that when faced with external distractions that require attentional resources, individuals tend to increase their dedication and focus on the current task (Hughes et al., 2013; Hughes & Marsh, 2020). Additionally, previous studies demonstrated that there exists empirical evidence indicating that task performance is negatively related to the presence of external distractions during task execution (Stawarczyk et al., 2011; Stawarczyk & D'Argembeau, 2016; Unsworth & McMillan, 2014). Despite external distractors, the literature suggests that they may not be a drawback.

Theoretical Implications

This study breaks new ground by examining the interplay between situational awareness and attention networks, an area of research that has not been investigated in compacting tasks in VR. This study works on a gap between situational awareness and attention networks, combining both the compacting task in the VR environment, the SAGAT test, and the attention network test to measure each of the attentional processes. Previous studies have utilised the ANT test in combination with VR tasks to assess attention processes (Choi et al., 2019; Shimi et al., 2021). By integrating appropriate tests with the compacting task in virtual reality and the assessment of situational awareness, this study attempts to reveal the intricate understanding of cognitive processes within this practical field, like the construction site.

The use of virtual reality (VR) settings for training is both cost-effective and safe, reducing the risks for roller operators working on construction sites. VR helps individuals learn useful skills in a controlled environment that is similar to the real world by engaging them in designed virtual scenarios. This way of training supports them develop the skills they need to be successful as roller operators (Voordijk & Vahdatikhaki, 2020). In addition, virtual reality has potential benefits for learning, and it can be incorporated into the educational system for design and construction fields (Alizadehsalehi et al., 2019). VR technology facilitates a realistic environment in the construction fields, and this allows individuals to interact with a virtual model and process of construction (Sampaio et al., 2005).

Practical Implications

This research suggests that situational awareness and attention networks can be used to support roller operators who work in a complex environment. The ANT was applied to measure the attention networks of construction workers related to safety-related risks in a real construction environment in previous research (Mohammadpour et al., 2016), in driving task simulation (Choi et al., 2019), and in VR goalkeeping tasks (Shimi et al., 2021). Therefore, this means that the attention network test could be applied to measuring attentional processes in complex environments.

Despite the results of the attention networks, training attention could contribute to improving the attention networks and how these can contribute to their situational awareness. Nonetheless, there are some techniques for training attention. There is evidence that mindfulness meditation may cause changes in brain areas associated with attention, emotion control, and self-awareness (Tang & Posner, 2009). Hence, mindfulness can train attention and maintain it for a specific time. Physical activity like aerobics might provide benefits to individuals, especially in different areas of the brain and their mental processes (Hillman et al., 2008).

Future Research

First, it is recommended to conduct further research on situational awareness and attention networks using a larger sample size. This will increase the likelihood of the statistical power of the study, making it more likely to detect any real effects within the results (Cohen, 1988). A higher statistical power increases the chances of detecting a real effect, while a lower statistical power reduces the chances of detecting such an effect between the attention network and situational awareness results (Cohen, 1988; Liu, 2013).

Second, the ANT test is flexible and can be administered to different groups of patients, including children, adults, and animals like monkeys (Fan et al., 2002). This means that the ANT test can be applied to different groups of people. In another study, the ANT test was applied individually in a controlled environment in the presence of a researcher (Rueda et al., 2004). In this study, the attention network test was conducted using the short version of the ANT in a laboratory and controlled by the presence of a researcher (Fan et al., 2005). However, in this case, it would be more appropriate to conduct the test individually because it ensures the focus of the participants in the test.

Third, a new version of the VR setting might be implemented with the ANT and the SAGAT tests in the same scenario. Earlier research had implemented and adapted the cue condition of Posner in a VR environment (Soret et al., 2019). The use of visual or auditory signals in virtual reality efficiently directs individuals' attention, resulting in enhanced information processing. This means that VR can be effective for training and assessing one of the attentional processes. Virtual reality is suitable for creating training environments, particularly for practical activities like construction sites (Azimi et al., 2018; Webel et al., 2013; as cited in Soret et al., 2019).

CONCLUSION

The relationship between each of the levels of situational awareness (perception, comprehension, and projection) and the three attention networks (alerting, orienting, and conflicting) did not show a statistical significance. Additionally, a general analysis of situational awareness and attention networks was considered, and it revealed a non-significant relationship. Nonetheless, the individual analysis of the attention networks showed a particular relationship between the orienting network and situational awareness. It is noteworthy that this relationship was not included in the hypotheses in the current study. Moreover, an additional exploration of the attention networks and projection level was analysed, and the results showed a non-significant positive relationship between these cognitive processes. Nevertheless, further research is required to substantiate the results of the subject in the study and confirm the possible relationship between situational awareness and the orienting network with a larger sample.

The present study constitutes an initial investigation into attention networks and situational awareness. Nonetheless, the current results are inconclusive on account of their low statistical power. Due to the intricate nature of the subject matter under investigation, additional research is imperative to achieve a more comprehensive understanding. Expanding the range of participants is crucial to obtaining novel insights and enhancing the generalizability of future findings in this field. Besides, incorporating a general hypothesis into future research on situational awareness and each of the attention networks. Furthermore, situational awareness and each of the three attention networks should be evaluated separately again.

This study demonstrates the valuable contribution of VR, as it supports the training of roller operators in a dynamic environment in a safe environment and also assesses the compacting task in VR. Nonetheless, it would be beneficial to create an integrated model that considers the compacting setting and explores and assesses the relationship between situational awareness and attention networks. This could provide new insights into the scope of the study.

REFERENCES

Abdelhamid, T. S., & Everett, J. G. (2000). Identifying root causes of construction accidents. *Journal of Construction Engineering and Management*, *126*(1), 52–59. https://doi.org/10.1061/(asce)0733-9364(2000)126:1(52)

Alizadehsalehi, S., Hadavi, A., & Huang, J. C. (2019). Virtual reality for design and construction education environment. *AEI 2019: Integrated Building Solutions - The National Agenda - Proceedings of the Architectural Engineering National Conference*, 193–201. https://doi.org/10.1061/9780784482261.023

Barnett, V., & Lewis, T. (1978). Introduction. In *Outliers in Statistical Data* (pp. 1–16).

Choi, H., Kasko, J., & Feng, J. (2019). An attention assessment for informing older drivers' crash risks in various hazardous situations. *Gerontologist*, *59*(1), 112–123. https://doi.org/10.1093/geront/gny079

Cohen, J. (1988). The concepts of power analysis. In *Statistical power analysis for the behavioural sciences.* (pp. 1–17). Lawrence Erlbaum Associate.

Coolen, E., Draaisma, J., & Loeffen, J. (2019). Measuring situation awareness and team effectiveness in pediatric acute care by using the situation global assessment technique. *European Journal of Pediatrics*, *178*, 837–850. https://doi.org/10.1007/s00431-019-03358-z

Daigneault, G., Joly, P., & Frigon, J. Y. (2002). Executive functions in the evaluation of accident risk of older drivers. *Journal of Clinical and Experimental Neuropsychology*, *24*(2), 221–238. https://doi.org/10.1076/jcen.24.2.221.993

de Souza Almeida, R., Faria-Jr, A., & Klein, R. M. (2021). On the origins and evolution of the Attention Network Tests. In *Neuroscience and Biobehavioral Reviews* (Vol. 126, pp. 560–572). https://doi.org/10.1016/j.neubiorev.2021.02.028

Drew, C., Hardman, M., & Hosp, J. (2014a). Participant Selection and Assignment. In *Designing and Conducting Research in Education* (pp. 81–108). https://doi.org/10.4135/9781483385648

Drew, C., Hardman, M., & Hosp, J. (2014b). Participant selection and assignment. In *Designing and Conducting Research in Education* (pp. 81–108). https://doi.org/10.4135/9781483385648

Endsley, M. R. (1988a). Design and evaluation for situation awareness enhancement. *Proceedings of the Human Factors Society Annual Meeting*, *32*(2), 97–101. https://doi.org/10.1177/154193128803200221

Endsley, M. R. (1988b). Situation awareness global assessment technique (SAGAT). *IEEE Proceedings of the National Aerospace and Electronics Conference*, 789–795. https://doi.org/10.1109/NAECON.1988.195097

Endsley, M. R. (1990a). A methodology for the objective measurement of situation awareness. In *Situational Awareness in Aerospace Operations (AGARD-CP-478)*.

Endsley, M. R. (1990b). Predictive utility of an objective measure of situation awareness. *Proceedings of the Human Factors Society Annual Meeting*, 41–45. https://doi.org/10.1177/154193129003400110

Endsley, M. R. (1995). Towards a theory of situational awareness in dynamic systems. *Human Factors*, *37*(1), 32-64. https://doi.org/10.1518/001872095779049543

Endsley, M. R. (2001). Designing for situation awareness in complex systems. *Proceedings of the Second International Workshop on Symbiosis of Humans, Artifacts and Environment*, 1–14.

Endsley, M. R., & Garland, D. J. (2000). Theoretical underpinnings of situation awareness: A critical review. *Mahwah, NJ: Lawrence Erlbaum Associates.*, *1*(1), 3–21.

Endsley, M. R., & Rodgers, M. D. (1994). Situation awareness information requirements analysis for en route air traffic control. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *38*(1), 71–75. https://doi.org/10.1177/154193129403800113

Endsley, M. R., & Rodgers, M. D. (1996). Attention distribution and situation awareness in air traffic control. *Proceedings of the Human Factors and Ergonomics Society, 1*, 82–85. https://doi.org/10.1177/154193129604000216

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*(1), 143–149. https://doi.org/10.3758/BF03203267

Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *NeuroImage*, *26*(2), 471–479. https://doi.org/10.1016/j.neuroimage.2005.02.004

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. https://doi.org/10.1162/089892902317361886

Fan, J., & Posner, M. (2004). Human attentional networks. *Psychiatrische Praxis, Supplement*, *31*(2), 210–214. https://doi.org/10.1055/s-2004-828484

Fracker, M. L. (1989). Attention allocation in situation awareness. *Proceedings of the Human Factors Society Annual Meeting*, *33*(20), 1396-1400. https://doi.org/https://doi.org/10.1177/154193128903302007

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: Exercise effects on brain and cognition. In *Nature Reviews Neuroscience* (Vol. 9, Issue 1, pp. 58–65). https://doi.org/https://doi.org/10.1038/nrn2298

Hogan, M. P., Pace, D. E., Hapgood, J., & Boone, D. C. (2006). Use of human patient simulation and the Situation Awareness Global Assessment Technique in practical trauma skills assessment. *Journal of Trauma - Injury, Infection and Critical Care*, *61*(5), 1047–1052. https://doi.org/10.1097/01.ta.0000238687.23622.89

Hughes, R. W., Hurlstone, M. J., Marsh, J. E., Jones, D. M., & Vachon, F. (2013). Cognitive control of auditory distraction: Impact of task difficulty, foreknowledge, and working memory capacity supports duplex-mechanism account. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(2), 539-553. https://doi.org/10.1037/a0029064

Hughes, R. W., & Marsh, J. E. (2020). When is forewarned forearmed? predicting auditory distraction in short-term memory. *Journal of Experimental Psychology: Learning Memory and Cognition*, *46*(3), 427-442. https://doi.org/10.1037/xlm0000736

Hultin, M., Jonsson, K., Härgestam, M., Lindkvist, M., & Brulin, C. (2019). Reliability of instruments that measure situation awareness, team performance and task performance in a simulation setting with medical students. *BMJ Open*, *9*(9), 1–10. https://doi.org/10.1136/bmjopen-2019-029412

Ishigami, Y., Eskes, G. A., Tyndall, A. V., Longman, R. S., Drogos, L. L., & Poulin, M. J. (2016). The attention network test-interaction (ANT-I): reliability and validity in healthy older adults. *Experimental Brain Research*, *234*(3), 815–827. https://doi.org/10.1007/s00221-015-4493-4

Jaafar, K., Elbarkouky, R., & Kennedy, J. (2020). Construction site layout optimization model considering cost and safety in a dynamic environment. *Asian Journal of Civil Engineering*, *22*(2), 297–312. https://doi.org/10.1007/s42107-020-00314-3

Liu, X. S. (2013). Statistical power. In *Statistical power analysis for the social and behavioral sciences. Basic and advanced techniques* (pp. 17–50). Routledge.

MacLeod, J. W., Lawrence, M. A., McConnell, M. M., Eskes, G. A., Klein, R. M., & Shore, D. I. (2010). Appraising the ANT: psychometric and theoretical considerations of the attention network test. *Psychometric and Theoretical Considerations of the Attention Network Test. Neuropsychology*, *24*(5), 637–651. https://doi.org/10.1037/a0019803

Mohammadpour, A., Asadi, S., & Karan, E. (2016). Determining the role of attentional control among construction workers in improving safety performance. *Construction Research Congress 2016: Old and New Construction Technologies Converge in Historic San Juan - Proceedings of the 2016 Construction Research Congress, CRC 2016*, 2793–2800. https://doi.org/10.1061/9780784479827.278

Neisser, U. (1967). Visual cognition. In *Cognitive Psychology* (pp. 13–158). Psychology Press Classic Editions.

Norman, D. A., & Shallice, T. (1986a). Attention and action: Willed and automatic human control of behavior. In *Attention to Action* (Issue 4, pp. 1–18).

Petersen, S. E., & Posner, M. (2012). The attention system of the human brain: 20 years after. In *Annual review of neuroscience* (Vol. 35, pp. 73–89). https://doi.org/10.1146/annurev-neuro-062111-150525

Posner, & Boies. (1971). Components of attention. *Psychological Review*, *78*(5), 391–408. https://doi.org/10.1037/h0031333

Posner, M. (1975). Psychobiology of attention. In *Handbook of Psychobiology* (pp. 441–479). Harcourt brace Jovanovich, Publishers.

Posner, M. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32*(1), 3–25. https://doi.org/10.1080/00335558008248231

Posner, & Petersen. (1990). The Attention system of the human brain. *Annual Review of Neuroscience*, *13*(1), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Raestrup, I. J. M. (2023). *Complementing german vocational training with VR training: investigating the effect of time pressure and stress on situation awareness and performance of construction trainees*. University of Twente.

Rouse, W. B., & Morris, N. M. (1985). On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin*, *100*(3), 349–363. https://doi.org/https://doi.org/10.1037/0033-2909.100.3.349

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040. https://doi.org/10.1016/j.neuropsychologia.2003.12.012

Sampaio, A. Z., Henriques, P., & Studer, P. (2005). Learning construction processes using virtual reality models. *Electronic Journal of Information Technology in Construction*, *10*, 141–151.

Shimi, A., Tsestou, V., Hadjiaros, M., Neokleous, K., & Avraamides, M. (2021). Attentional skills in soccer: Evaluating the involvement of attention in executing a goalkeeping task in virtual reality. *Applied Sciences*, *11*(19), 1–17. https://doi.org/10.3390/app11199341

Smith, M. R., Chai, R., Nguyen, H. T., Marcora, S. M., & Coutts, A. J. (2019). Comparing the Effects of Three Cognitive Tasks on Indicators of Mental Fatigue. *Journal of Psychology: Interdisciplinary and Applied*, *153*(8). https://doi.org/10.1080/00223980.2019.1611530

Soret, R., Charras, P., Hurter, C., & Peysakhovich, V. (2019). Attentional orienting in virtual reality using endogenous and exogenous cues in auditory and visual modalities. *Proceedings of the 11th ACM Symposium on Eye Tracking Research & Applications*, 1–8. https://doi.org/10.1145/3317959.3321490

Stawarczyk, D., & D'Argembeau, A. (2016). Conjoint influence of mind-wandering and sleepiness on task performance. *Journal of Experimental Psychology: Human Perception and Performance*, *42*(10). https://doi.org/10.1037/xhp0000254

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011). Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica*, *136*(3), 370–381. https://doi.org/10.1016/j.actpsy.2011.01.002

Steinke, A., & Kopp, B. (2020). RELEX: An Excel-based software tool for sampling split-half reliability coefficients. *Methods in Psychology*, *2*. https://doi.org/10.1016/j.metip.2020.100023

Tang, Y. Y., & Posner, M. I. (2009). Attention training and attention state training. In *Trends in Cognitive Sciences* (Vol. 13, Issue 5, pp. 222–227). https://doi.org/10.1016/j.tics.2009.01.009

Treisman, A., & Paterson, R. (1984). Emergent features, attention, and object perception. *Journal of Experimental Psychology: Human Perception and Performance*, *10*(1), 12–31. https://doi.org/10.1037/0096-1523.10.1.12

Unsworth, N., & McMillan, B. D. (2014). Similarities and differences between mind-wandering and external distraction: a latent variable analysis of lapses of attention and their relation to cognitive abilities. *Acta Psychologica*, *150*, 14–25. https://doi.org/10.1016/J.ACTPSY.2014.04.001

van Griethuijsen, R. A. L. F., van Eijck, M. W., Haste, H., den Brok, P. J., Skinner, N. C., Mansour, N., Gencer, A. S., & BouJaoude, S. (2015). Global patterns in students' views of science and interest in science. *Research in Science Education*, *45*(4), 581–603. https://doi.org/10.1007/s11165-014-9438-6

Voordijk, H., & Vahdatikhaki, F. (2020). Virtual reality learning environments and technological mediation in construction practice. *European Journal of Engineering Education*, *47*(2), 259–273. https://doi.org/10.1080/03043797.2020.1795085

Weaver, B., Bédard, M., McAuliffe, J., & Parkkari, M. (2009). Using the attention network test to predict driving test scores. *Accident Analysis and Prevention*, *41*(1), 76–83. https://doi.org/10.1016/j.aap.2008.09.006

Wickens, C., Gordon, S., & Liu, Y. (1997). An introduction to human factors engineering. *Human Engineering*, *7*(2), 145–181.

Wickens, Hollands, J. G., Banbury, S., & Parasuraman, R. (2013). Engineering psychology and human performance. In *Engineering Psychology and Human Performance* (pp. 1–201).

APPENDICES

Appendix A: Information Letter and Informed Consent

<u>Informatieblad voor onderzoek 'Het verband tussen aandachtsnetwerken en Situation Awareness'</u>

Doel van het onderzoek

Dit onderzoek wordt geleid door Silvana Lorenzo Cervera.

Het doel van dit onderzoek is om te onderzoeken of de mate waarin studenten zich bewust zijn van hun omgeving afhangt van aandacht.

Hoe gaan we te werk?

U neemt deel aan een onderzoek waarbij we informatie zullen vergaren door middel van computertaken: een taak over aandacht, en een taak over walsen in Virtual Reality.

Potentiële risico's en ongemakken

Tijdens deelname is er een kans dat de VR wat misselijkheid veroorzaakt. In dit geval is het belangrijk om direct te stoppen met het onderzoek.

Vergoeding

U ontvangt voor deelname aan dit onderzoek geen vergoeding.

Vertrouwelijkheid van gegevens

Wij doen er alles aan uw privacy zo goed mogelijk te beschermen. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen.

Voordat onze onderzoeksgegevens naar buiten gebracht worden, worden uw gegevens zoveel mogelijk geanonimiseerd, tenzij u in ons toestemmingsformulier expliciet toestemming heeft gegeven voor het vermelden van uw naam, bijvoorbeeld bij een quote.

In een publicatie zullen anonieme gegevens of pseudoniemen worden gebruikt. De formulieren en andere documenten die in het kader van deze studie worden gemaakt of verzameld, worden opgeslagen op een beveiligde locatie bij de Universiteit Twente en op de beveiligde (versleutelde) gegevensdragers van de onderzoekers.

De onderzoeksgegevens worden bewaard voor een periode van [10 jaar]. Uiterlijk na het verstrijken van deze termijn zullen de gegevens worden verwijderd of worden geanonimiseerd zodat ze niet meer te herleiden zijn tot een persoon.

De onderzoeksgegevens worden indien nodig (bijvoorbeeld voor een controle op wetenschappelijke integriteit) en alleen in anonieme vorm ter beschikking gesteld aan personen buiten de onderzoeksgroep.

Tot slot is dit onderzoek beoordeeld en goedgekeurd door de ethische commissie van de faculteit BMS.

Vrijwilligheid

Deelname aan dit onderzoek is geheel vrijwillig. U kunt als deelnemer uw medewerking aan het onderzoek te allen tijde stoppen, of weigeren dat uw gegevens voor het onderzoek mogen worden gebruikt, zonder opgaaf van redenen. Het stopzetten van deelname heeft geen nadelige gevolgen voor u of de eventueel reeds ontvangen vergoeding.

Als u tijdens het onderzoek besluit om uw medewerking te staken, zullen de gegevens die u reeds hebt verstrekt tot het moment van intrekking van de toestemming in het onderzoek gebruikt worden.

Wilt u stoppen met het onderzoek, of heeft u vragen en/of klachten? Neem dan contact op met de onderzoeksleider.

Silvana Lorenzo Cervera

S.a.lorenzocervera@student.utwente.nl - 0620171610

Voor bezwaren met betrekking tot de opzet en of uitvoering van het onderzoek kunt u zich ook wenden tot de Secretaris van de Ethische Commissie/ domein Humanities & Social Sciences van de faculteit Behavioural, Management and Social Sciences op de Universiteit Twente via ethicscommittee-hss@utwente.nl. Dit onderzoek wordt uitgevoerd vanuit de Universiteit Twente, faculteit Behavioural, Management and Social Sciences. Indien u specifieke vragen hebt over de omgang met persoonsgegevens kun u deze ook richten aan de Functionaris Gegevensbescherming van de UT door een mail te sturen naar dpo@utwente.nl.

Tot slot heeft u het recht een verzoek tot inzage, wijziging, verwijdering of aanpassing van uw gegevens te doen bij de Onderzoeksleider.

Door dit toestemmingsformulier te ondertekenen erken ik het volgende:

1. Ik ben voldoende geïnformeerd over het onderzoek door middel van een separaat informatieblad. Ik heb het informatieblad gelezen en heb daarna de mogelijkheid gehad vragen te kunnen stellen. Deze vragen zijn voldoende beantwoord.

2. Ik neem vrijwillig deel aan dit onderzoek. Er is geen expliciete of impliciete dwang voor mij om aan dit onderzoek deel te nemen. Het is mij duidelijk dat ik deelname aan het onder- zoek op elk moment, zonder opgaaf van reden, kan beëindigen. Ik hoef een vraag niet te beantwoorden als ik dat niet wil.

Naast het bovenstaande is het hieronder mogelijk voor verschillende onderdelen van

Het onderzoek specifiek toestemming te geven. U kunt er per onderdeel voor kiezen wel of geen toestemming te geven. Indien u voor alles toestemming wil geven, is dat mogelijk via de aanvinkbox onderaan de stellingen.

3. Ik geef toestemming om de gegevens die gedurende het onderzoek bij mij worden verzameld te verwerken zoals is opgenomen in het bijgevoegde informatieblad.	JA ☐	NEE ☐
	☐	☐

	☐	☐
8.Ik geef toestemming om de bij mij verzamelde onderzoeksdata te bewaren en te gebruiken voor toekomstig onderzoek en voor onderwijsdoeleinden.	☐	☐

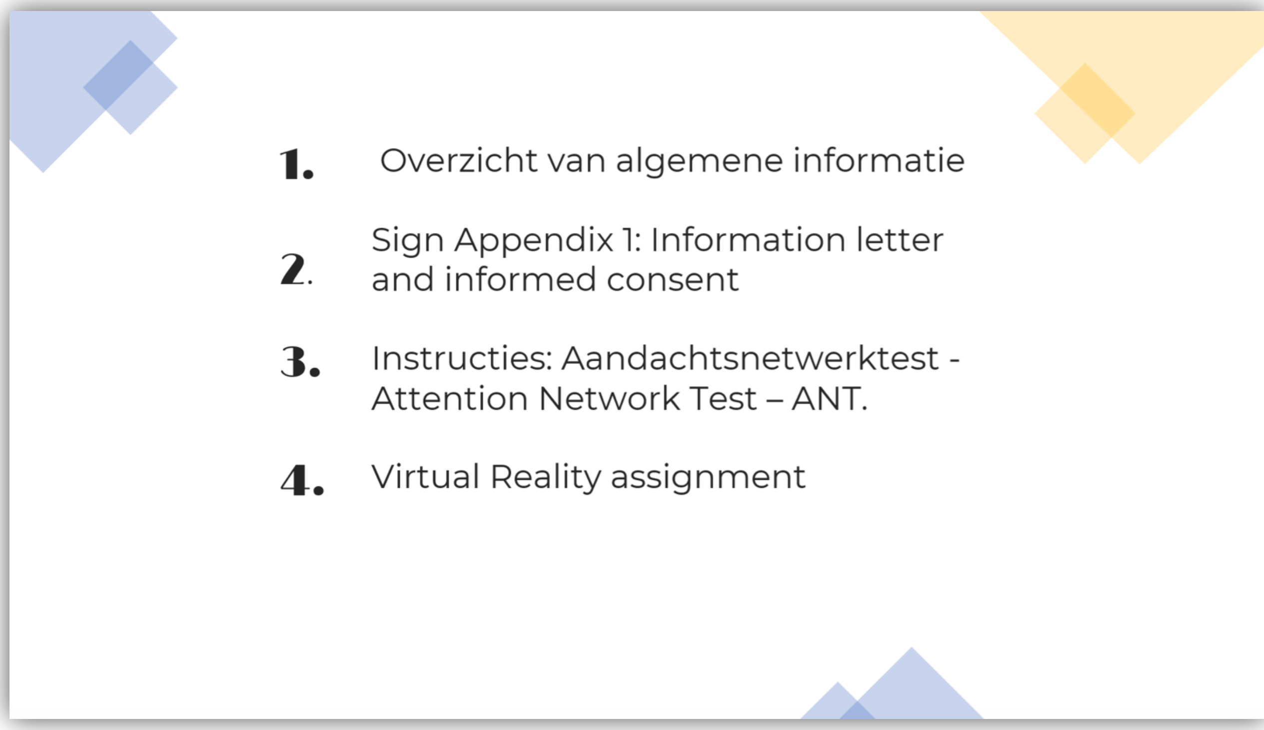
Naam Deelnemer: Naam Onderzoeker:

Handtekening:
Datum:

Handtekening:
Datum:

Appendix B: Presentation of the Instructions (SAGAT and ANT)

Before the commencement of the tests, a series of slides were presented to the participants, each of which contained explicit instructions to be adhered to. These instructions were designed to provide comprehensive guidance and clarity to the participants regarding the test requirements. Link: A-SA Protocol. pptx


1. Overzicht van algemene informatie
2. Sign Appendix 1: Information letter and informed consent
3. Instructies: Aandachtsnetwerktest - Attention Network Test – ANT.
4. Virtual Reality assignment

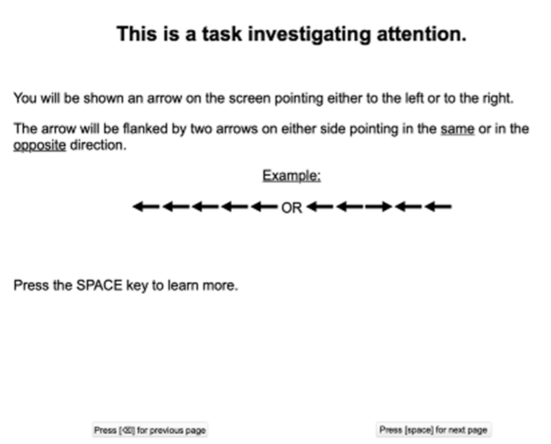

Consent Form
• Lees het formulier goed en vul het in als je mee wilt doen.
• Information letter and informed consent Informatieblad vo or onderzoek ‘Het verband tussen aandachtsnetwerken en Situation Awareness’.

Overzicht van algemene informatie

https://forms.office.com/e/uiMjwPGUgZ

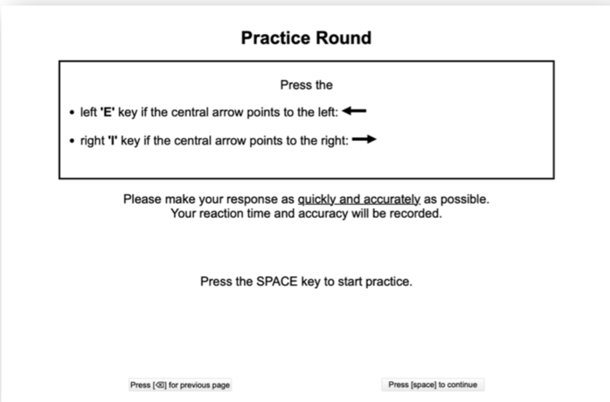
Attention Network Test (ANT)

- Please, you should focus on completing the Attentional Network Test.
- Read the instructions carefully.
- This test lasts 12 minutes.



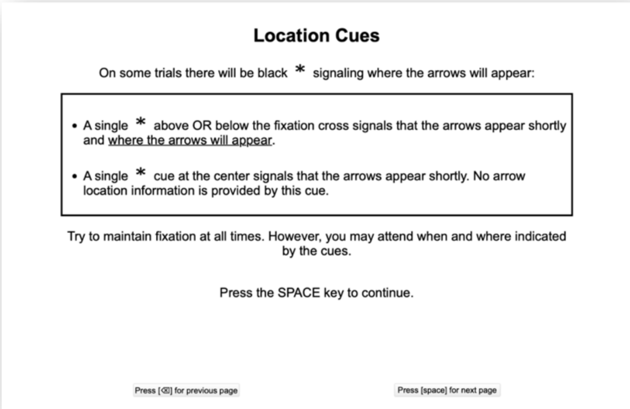
- De pijltjes die niet in het midden staan kunnen dezelfde of de andere kant op wijzen.
- Met deze pijltjes hoef je niets.

Attention Network Test (ANT)

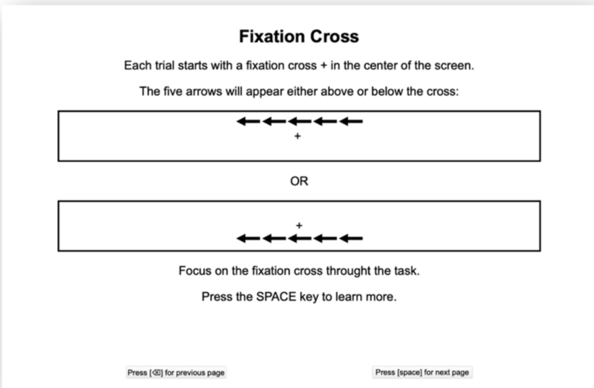


- Druk op **E** als de pijl in het midden naar links wijst
- Druk op **I (i)** als de pijl in het midden naar rechts wijst
- Werk zo snel mogelijk

Source: https://www.millisecond.com/download/library/ant



- Een * boven of onder het midden geeft aan waar de pijl verschijnt
- Een * in het midden geeft aan dat de pijl eraan komt maar niet waar
- Blijf goed kijken!



- Elke trial begint met een kruisje. De pijltjes verschijnen boven of onder het kruisje.
- Blijf geconcentreerd op het kruisje


Virtual Reality: stap voor stap
1. Vul je naam in, ga door
2. Klik op de vragen waar je antwoord op wilt
3. Kijk goed hoe je de virtuele wals bedient
4. Doe je best zo goed mogelijk te walsen
5. Blijf opletten
6. Beantwoord alle vragen aan het einde


Virtual Reality: stap voor stap
Roller Simulation 2.0
Welkom bij de virtuele walstraining. Het DOEL van deze training is om te leren hoe je dingen in je omgeving, zoals het weer, het asfalt en andere weggebruikers, goed in de gaten te houden zonder dat je vergeet wat je taak is. Aan het einde van de sessie krijg je wat vragen over wat je gezien en gedaan hebt. Let goed op, zodat je de vragen kunt beantwoorden.
Let op: Doe de VR bril nog niet op, leg deze naast je neer!
Config
Naam:
ID:
Ik ben er klaar voor


Virtual Reality: stap voor stap
Motor starten
Vooruit / Achteruit
THRUSTMASTER


Virtual Reality: stap voor stap
oratie snelheid
npassen
Sproeier snelheid
aanpassen


Virtual Reality: stap voor stap
Temp: 12
Time: 00:00
Spd: 0

Appendix C: Overview of General Information

This demographic questionnaire has only analysis purposes.

Overzicht van algemene informatie

Hi, Silvana. When you submit this form, the owner will see your name and email address.

1. E-mail:

Enter your answer

2. Hoe oud ben je?

Enter your answer

3. Wat is je geslacht?

- a. Man
- b. Vrouw
- c. Anders

4. Werk je naast je opleiding en stages?

- a. Nee
- b. Ja, parttime in de sector wegenbouw
- c. Ja, fulltime in de sector wegenbouw
- d. Ja, parttime in een andere sector
- e. Ja, fulltime in een andere sector

5. In welk jaar van je opleiding zit je?

- a. Eerste
- b. Tweede
- c. Derde

6. Hoe vaak heb je asfalt verdicht in VR?

- a. Nooit
- b. Zelden
- c. Soms
- d. Vaak
- e. Heel vaak

7. Hoe vaak heb je asfalt verdicht buiten VR?

- a. Nooit
- b. Zelden
- c. Soms
- d. Vaak
- e. Heel vaak

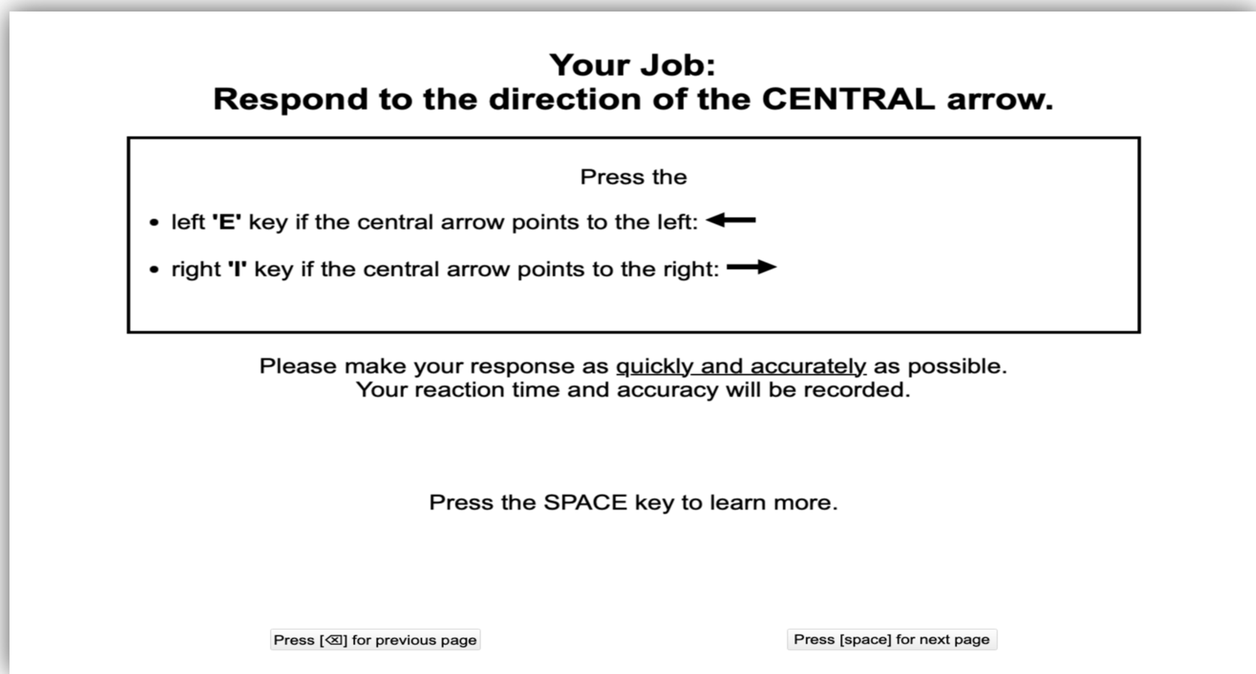
8. Ben je gediagnostiseerd met een psychische aandoening? Als het antwoord ja is namelijk:

Enter your answer

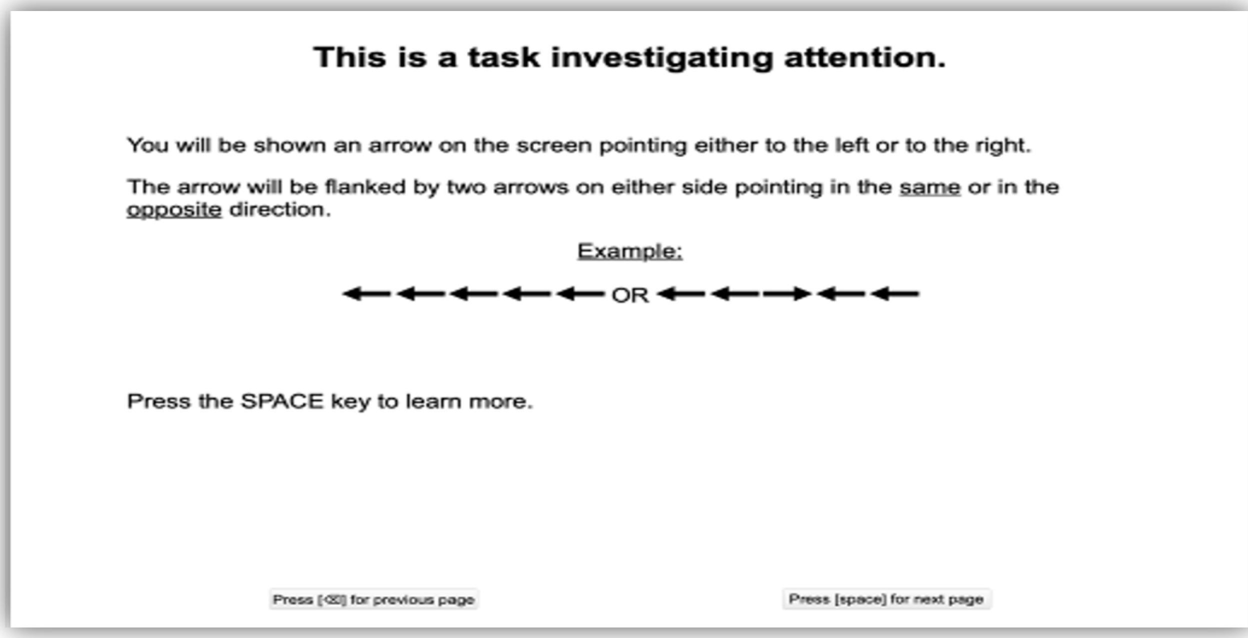
Submit

Appendix D: Attention Networks Test (ANT)

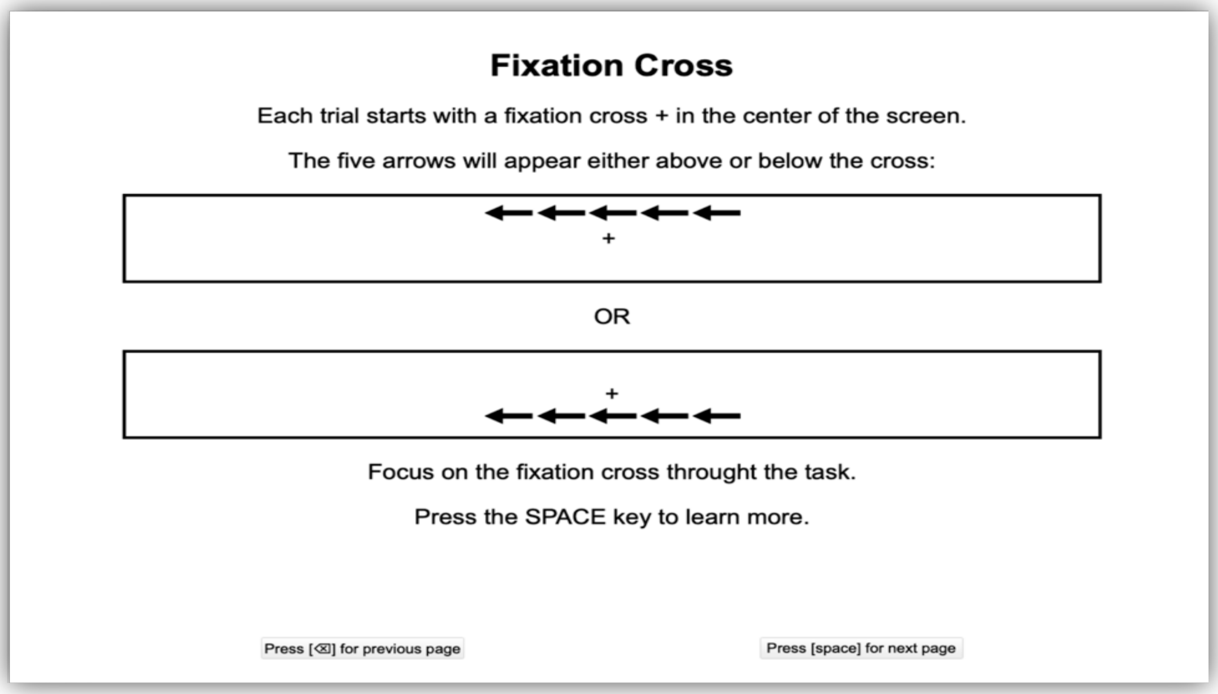
1. The participants are given instructions to respond to the left (E) and right (I) using specific letters.



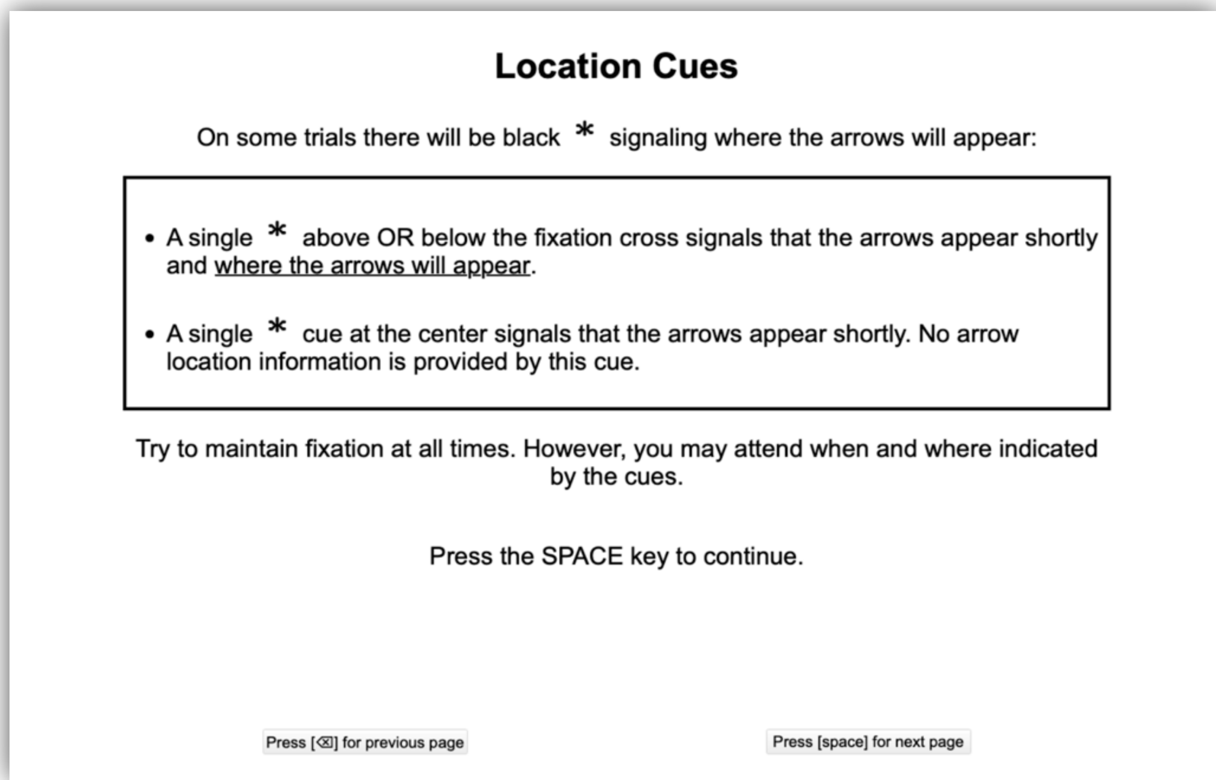
2. In this part of the test, the attention task investigation starts, and it involves three blocks with a total of 120 trials.



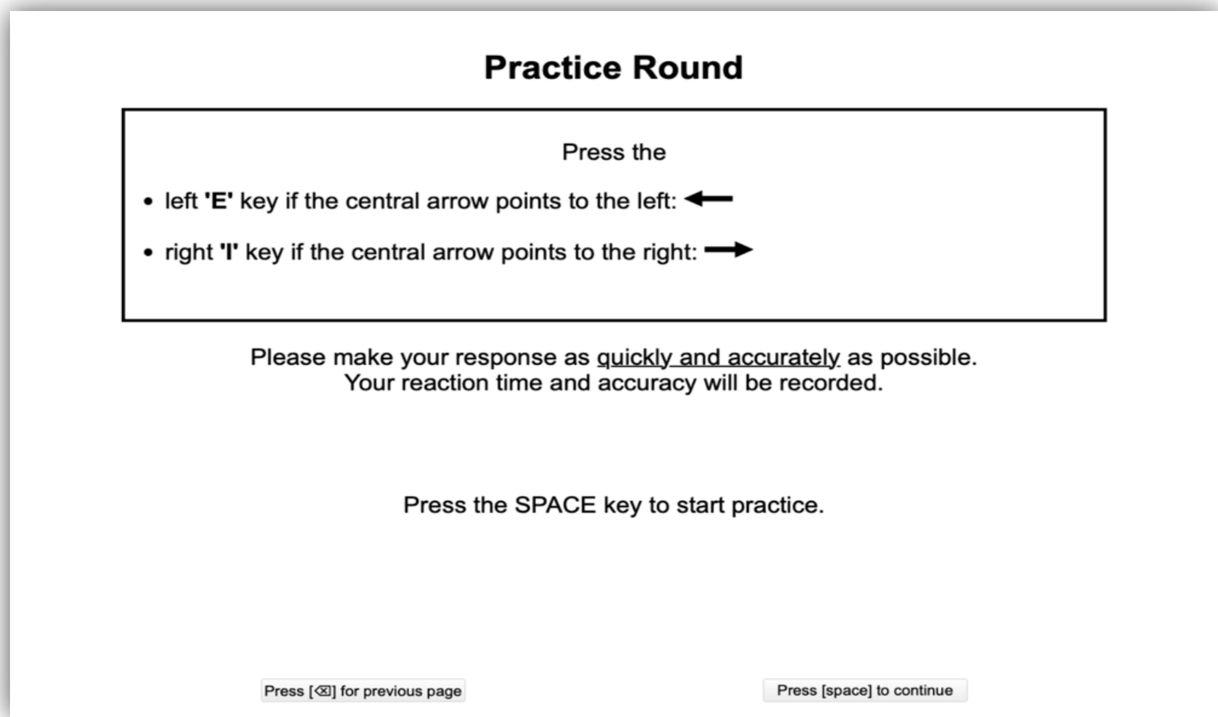
3. The fixation cross: the trials start with the fixation cross (+) in the centre of the screen.



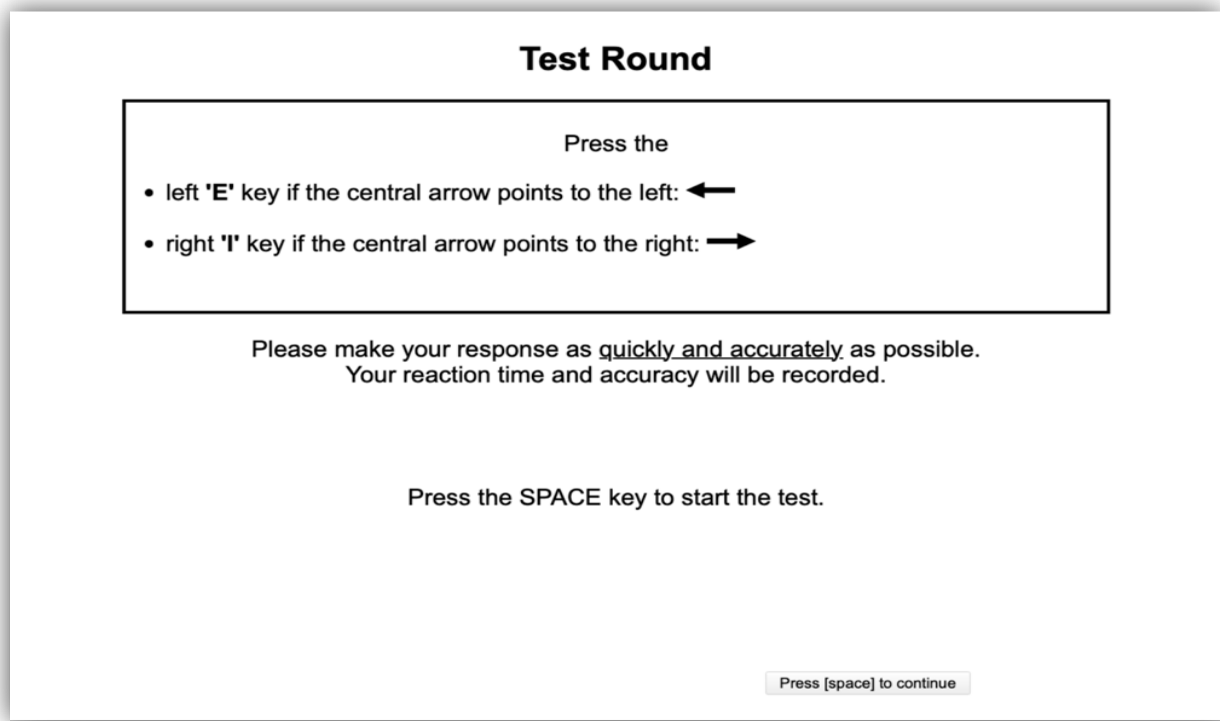
4. The location cues (*) show where the arrows will appear.



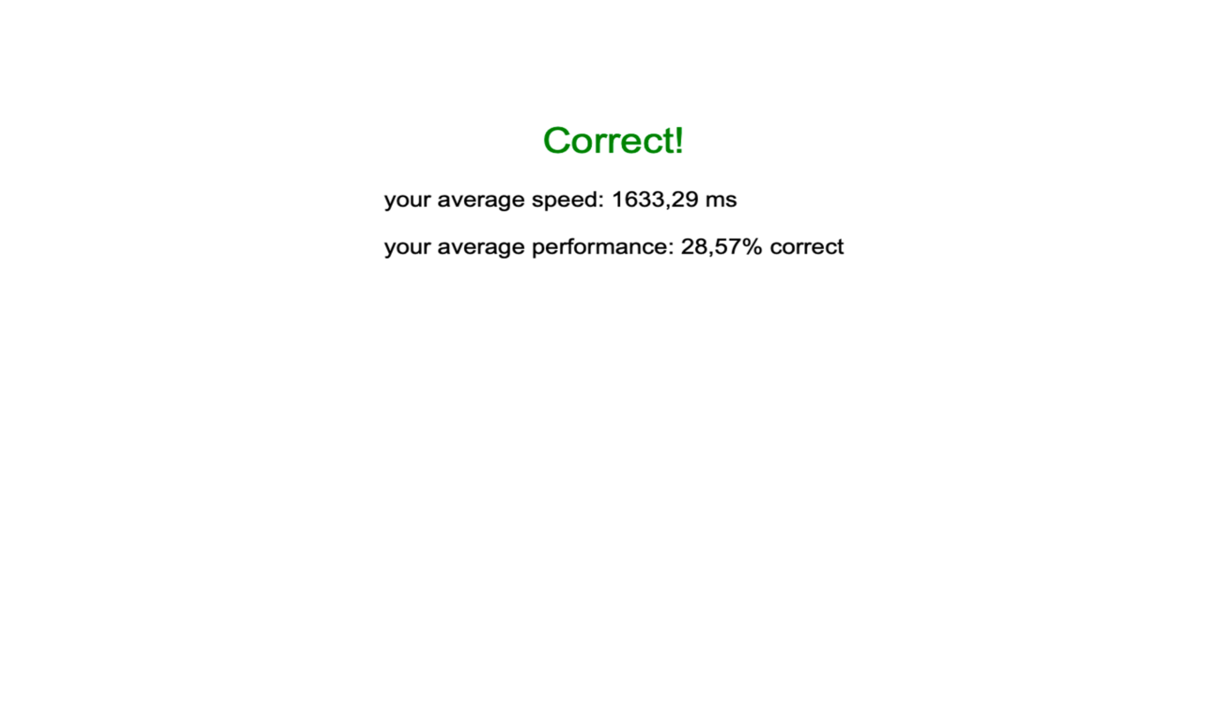
5. This is an example of the feedback in the practice round when the response is correct.



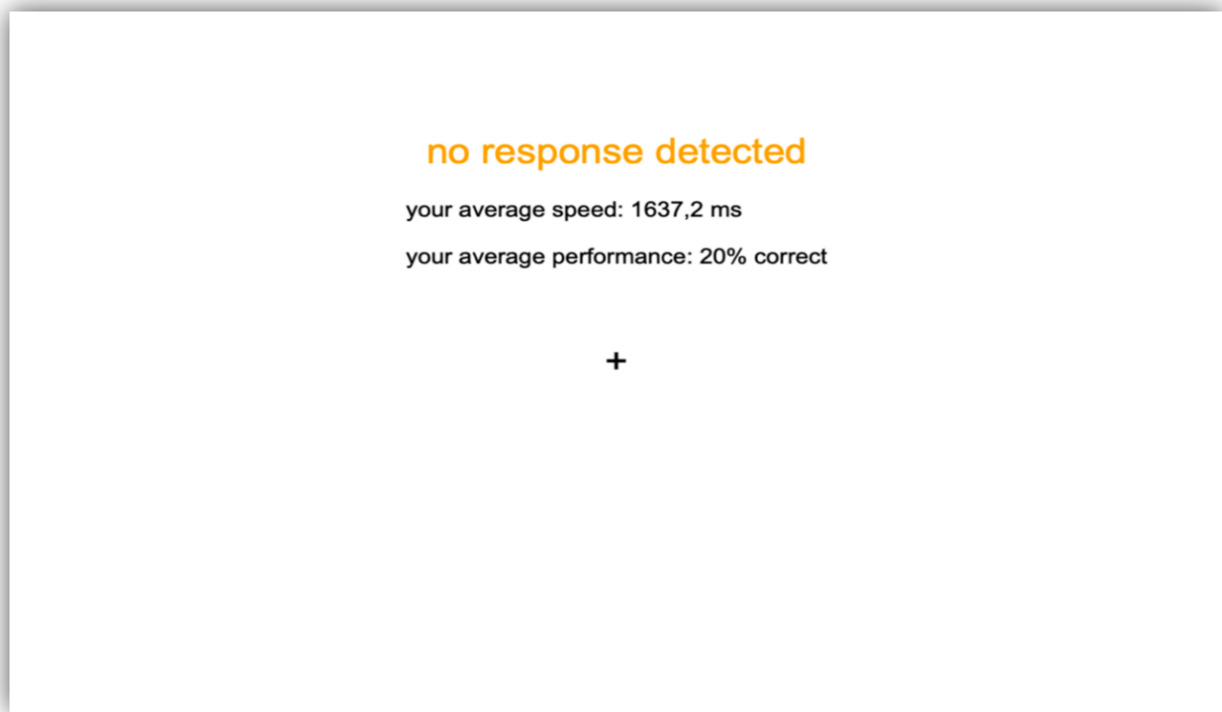
6. This shows the beginning of the test:



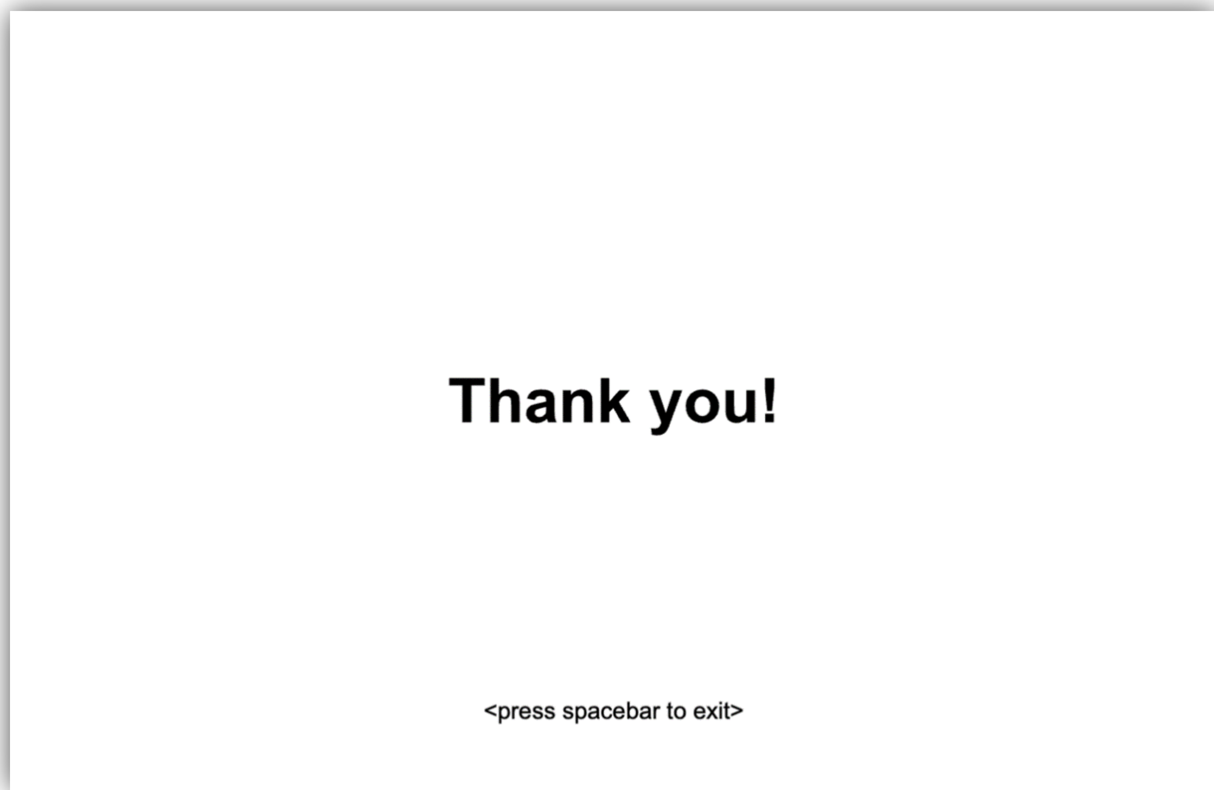
7. This is an example of a correct response from a participant.



8. This is an example of no detected response from the participant.



9. This is the end of the ANT test.

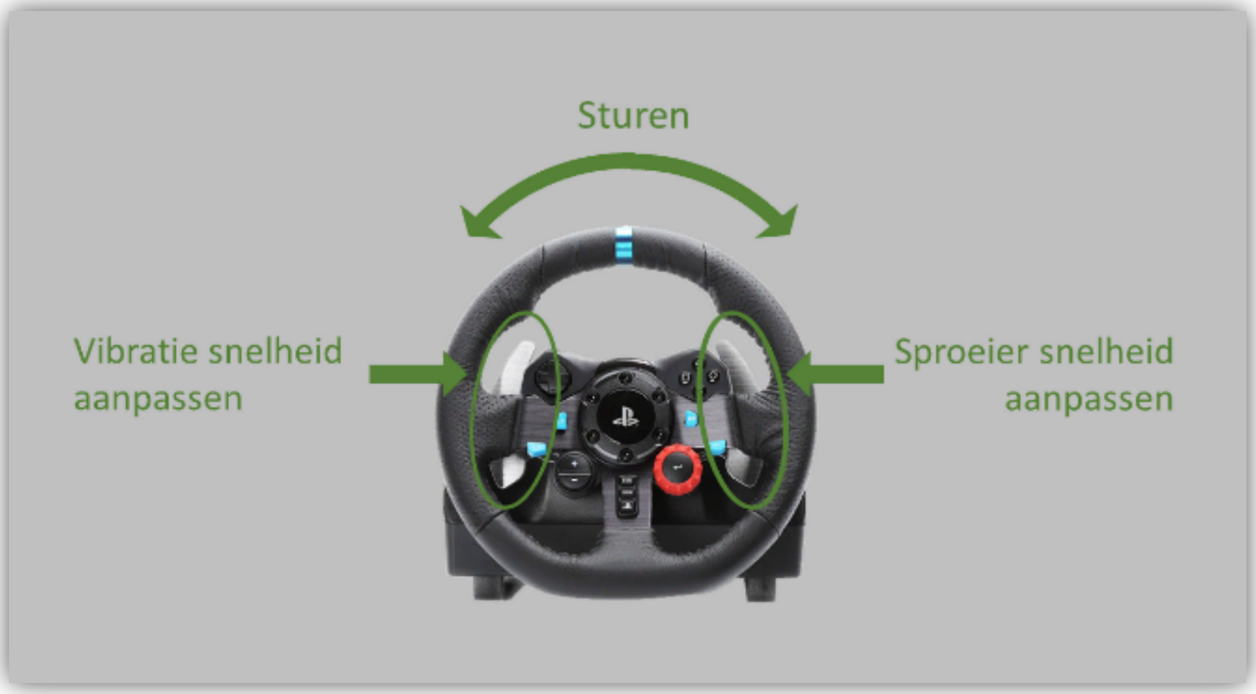


Appendix E: Compacting Task in Virtual Reality

The first part of the task involves instructions for learning to operate the environment. The participants must log in to get access to the instructions and get feedback before completing the task.

1. The joystick will help the participants to manage the task compacting.

3. The steering wheel supports the control of the roller machine.

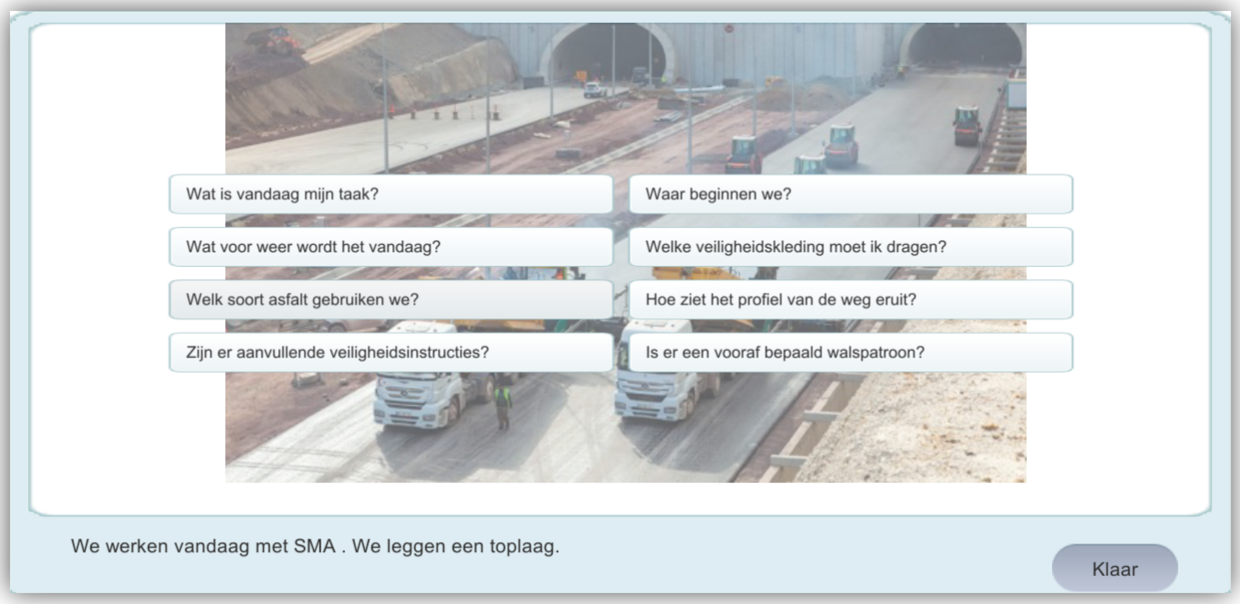


4. The participants interact with information related to the task before compacting the task in VR. Each question shows an answer at the bottom of the screen.


Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
Het is vandaag bewolkt maar er is weinig kans op regen. Het wordt ongeveer 12 graden.
Klaar


Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
We werken vandaag met SMA . We leggen een toplaag.
Klaar


Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
Het regent vandaag de hele dag een beetje. Het is rond de 5 graden.
Klaar


Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
We werken vandaag met SMA . We leggen een toplaag.
Klaar

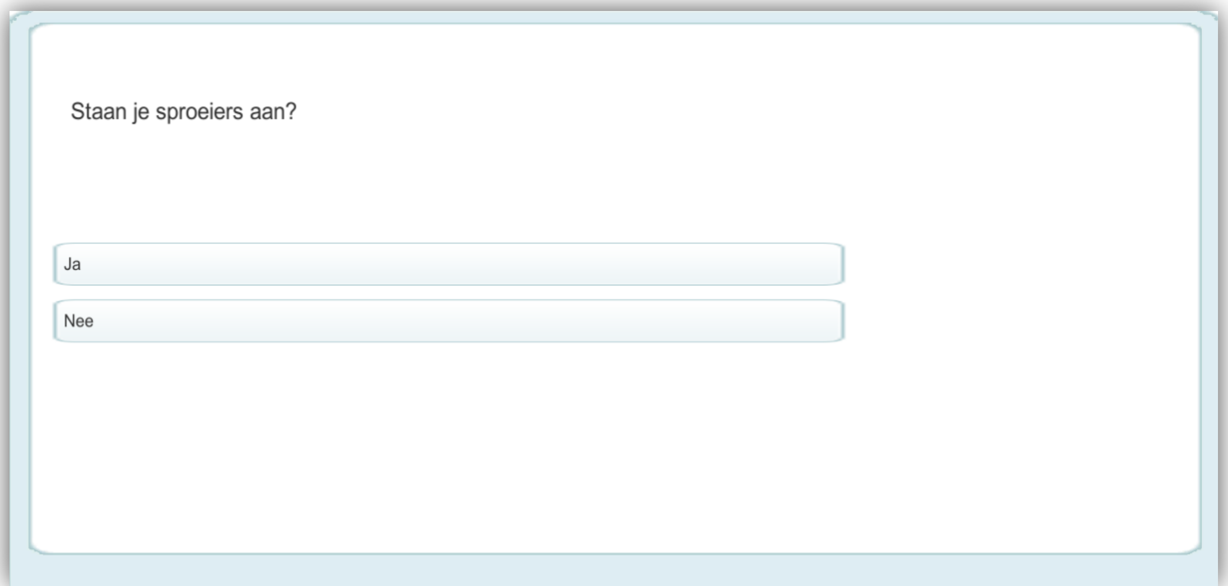

Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
Je draagt je standaard set met schoenen en jas. Je veiligheidshelm zet je op wanneer je niet op de wals zit.
Klaar

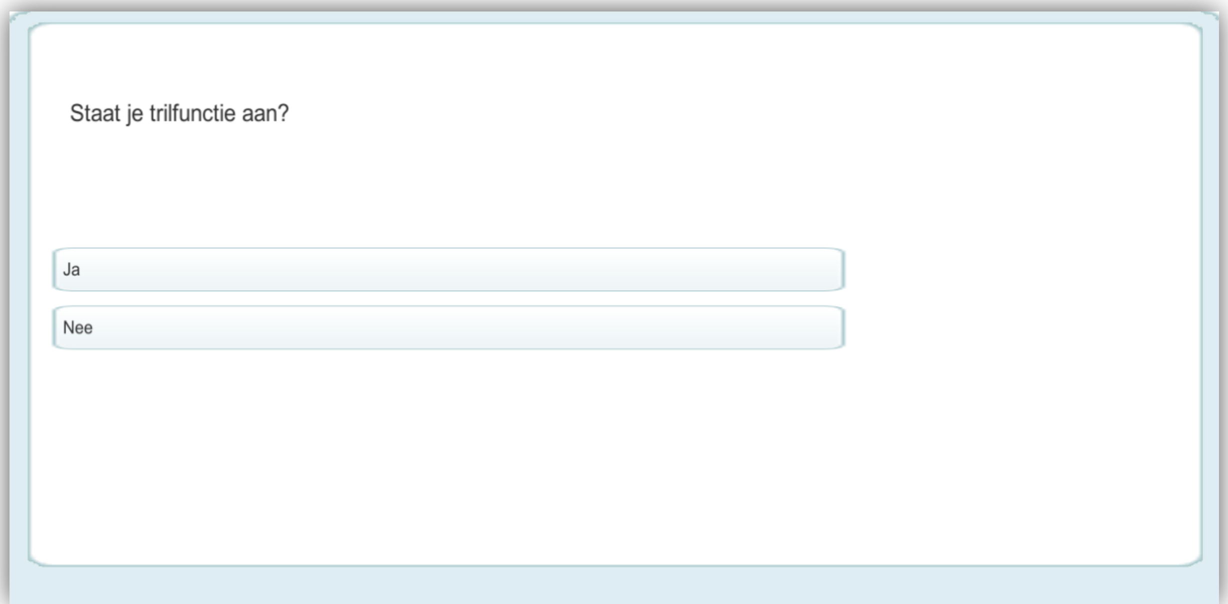

Wat is vandaag mijn taak?
Waar beginnen we?
Wat voor weer wordt het vandaag?
Welke veiligheidskleding moet ik dragen?
Welk soort asfalt gebruiken we?
Hoe ziet het profiel van de weg eruit?
Zijn er aanvullende veiligheidsinstructies?
Is er een vooraf bepaald walspatroon?
De hoge kant van het asfalt ligt in het midden van de rotonde. Ieder van de poten heeft een dakprofiel.
Klaar

5. After the brief information was displayed to the participants. They complete the compacting task in a VR environment. It shows the temperature and speed of the roller machine.

Appendix F: Situational Awareness Global Assessment

In this section, after completing the compacting task in VR, the participants respond to the twelve questions of the SAGAT test.





Moet je op dit moment rekening houden met ander verkeer in je werkgebied?

- Ja
- Nee

Welke invloed heeft het weer waarbij je aan het werk bent?

- Het is koud, dus ik moet dicht bij de asfaltafwerkmachine blijven
- Het is koud, dus ik moet een gemiddelde afstand van de asfaltafwerkmachine houden asfaltafwerkmachine
- Temperaturen zijn aangenaam, dus ik moet dicht bij de asfaltafwerkmachine blijven
- Temperaturen zijn aangenaam, dus ik moet een gemiddelde afstand van do asfaltafwerkmachine houden

Mag je de trilfunctie nu aanzetten?

- Ja
- Nee, het weer is er niet geschikt voor
- Nee, niet met dit type asfalt
- Nee, niet met de sproeiers aan

Hoe lang duurt het nog tot je watertank leeg is?

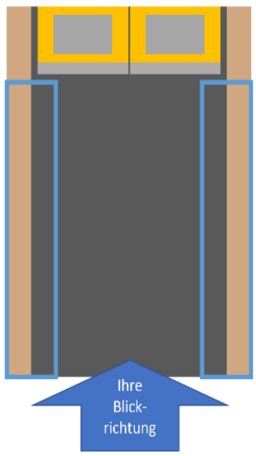
- Die is nu leeg
- Die zal snel leeg zijn
- Het duurt nog lang voordat die leeg is

Hoe lang duurt het nog tot je brandstoftank leeg is?

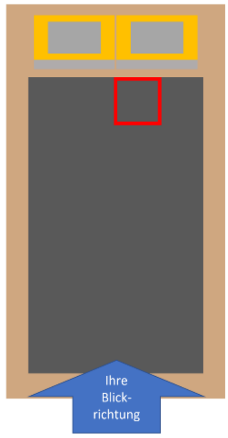
- Die is nu leeg
- Die zal snel leeg zijn
- Het duurt nog lang voordat die leeg is

Welke kant van het asfalt is de lage kant? Klik op een vak blauw.

- Het bovenste vak
- Het onderste vak



Hoe vaak moet je het aangegeven gebied nog walsen, denk je, om de juiste verdichting te bereiken?



- De verdichting is bereikt
- Nog een of twee keer
- Nog meer dan twee keer

Voorzie je veranderingen in het weer?

- Ik voorzie geen veranderingen
- Ik voorzie een regenbui, ik moet mijn afstand tot de machine verkleinen
- Ik voorzie een stijging van de temperatuur, ik moet mijn afstand tot de machine vergroten


Dit is het einde van de training. Wil je feedback geven op de simulatie of heb je vragen? Neem contact met ons op via onze website.
Druk op 'esc' op je toetsenbord om af te sluiten.

These are the questions of the SAGAT test in English.

Questions	Answers
1. How many times have you already rolled the indicated area?	A. 0 or 1 time B. 2 or 3 times C. More than 3 times [A] More than 3 times
2. Which side of the asphalt is the high side? Click on the blue box.	A. The left side B. The right side [A] The left side
3. Are your sprinklers on?	A. Yes b. No [A] Yes
4. Is your vibration turned on?	A. Yes B. No [A] No
5. Which compaction phase are you currently in?	A. Pre-compaction B. Elastic phase C. Final compaction [A] Pre-compaction
6. How does the weather affect where you are working?	A. It is cool, so I have to stay relatively close to the paver.

	B. It is cool, so I have to keep a good distance from the paver. C. It is hot, so I have to stay relatively close to the paver. D. It is hot, so I have to keep a good distance from the paver. [A] It is cool, so I have to stay relatively close to the paver.
7. Do you currently have to consider other traffic in your work area?	A. Yes B. No [A] No
8. Can you turn on the vibration function now?	A. Yes B. No, the weather is not suitable. C. No, not with this type of asphalt. D. No, not with the sprinklers on. [A] No, not with this type of asphalt
9. How long will it take for your water tank to be empty?	A. It is empty now. B. It will be empty soon. C. It will take a long time before it is empty. [A] It will take a long time before it is empty.
10. How long until your fuel tank is empty?	[C] It is empty now. It will be empty soon. It will be a long time before it is empty. [A] It will take a long time before it is empty

11. How many times do you think you need to roll the indicated area to achieve the correct compaction?	A. Compaction has been achieved. B. One or two more times C. More than two more times [A] More than twice
12. Do you foresee changes in the weather?	A. I do not foresee any changes. B. I foresee a rain show, I have to reduce my distance from the machine, I have to reduce my distance from the machine. C. I foresee an increase in temperature, I have to increase my distance from the machine. [A] I do not foresee any changes.