

MASTER

Safety-related appraisals of night time environments do different road users focus on different parts of the environment?

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Safety-related appraisals of night time environments: Do different road users focus on different parts of the environment?

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identity number 0739960

in partial fulfilment of the requirements for the degree of

**Master of Science
in Human-Technology Interaction**

Supervisors:
dr. ir. Antal Haans
Leon van Rijswijk, MSc.

The only thing we have to fear is fear itself.
Franklin D. Roosevelt (1882 - 1945)

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Koen Olijve

Abstract

As modern innovations attempt to reduce crime rates, fear of crime also becomes a topic of interest. Innovations, such as reduced or dimmed road lighting, may have a positive environmental impact, but unintentionally also affects perceived personal safety; this feeling of safety affects a large group of individuals and their social behaviour. By gaining a better understanding of how safety appraisals are formed, urban environments, including intelligent lighting, can be designed to improve perceived personal safety.

Moving through the world, one evaluates the situation, scanning the environment for potential threats. Prospect-refuge theory predicts that safety judgements are influenced by aspects of the environment. If an environment offers a good overview (prospect) and offers little options for potential attackers to hide (concealment), it is perceived as safer. At night, perceived personal safety may correlate with the available lighting distribution as this might influence prospect and concealment. Previous findings (Haans and de Kort, 2012) demonstrated that pedestrians prefer light in their direct surroundings over more distal areas. Interestingly, participants judged prospect and perceived personal safety to be highest when only their direct surroundings were illuminated. This is contradictory to expectations that individuals prefer environments with a high overview in the distance, and could indicate perceived personal safety is primarily evaluated in the directly surrounding area. The current study investigates the road user's focus of attention on the environment, to better understand the area used in safety appraisals. The *theory of spatial navigation and appraisal* states that a road user's focus of attention is primarily one's immediate environment and this area is used to form safety judgements. The immediate environment, which is dynamic and varies between factors such as mode of transportation, is the primary source of threats one is attentive to. By determining the size and shape of this environment, this study contributes to a better understanding of the process of safety appraisal.

The immediate environment one is attentive to, as predicted by the current study, is dependent on the road user's action radius and velocity. For different road users, the source of potential threats is expected to differ, and as a

consequence the user's focus of attention on the surroundings. Pedestrians are expected to have a relatively shorter immediate environment one is attentive to, compared to cyclists, who focus further ahead on the road.

Based on the specifications of one's immediate environment, it was expected that pedestrians, when making safety judgements, would respond quicker to changes in the foreground of an image of an outdoor night time environment, in comparison to cyclists. Vice versa, cyclists were expected to detect changes in the middle-ground of an image in comparison to pedestrians. A change-blindness experiment was performed to test whether people really are more attentive to this immediate environment. Participants were asked to detect changes a scene and the reaction time was recorded. The changes could occur in one's alleged immediate environment or outside this area. Participants ($n=60$) were divided over two roles, pedestrians or cyclists. They were instructed to detect changes in a fixed set of urban sceneries. Changes in these images varied over three different levels of relative distance to the participant. Detection time was employed as an indication of the focus of attention of these road users.

Results showed that in both road user conditions, changes in the background were detected quicker compared to changes in the foreground or middle-ground. Contradictory to the expectations, no significant differences were found between the pedestrians and cyclists and their corresponding area of attention. Even though the hypotheses could not be confirmed, the safety evaluations indicated a difference between cyclists and pedestrians; extended research is needed to accurately identify the environmental area relevant in safety appraisals. This study has shown that the differences were not as expected, or could not effectively be induced in a lab study.

This study is a step towards a better understanding of perceived personal safety and the differences between pedestrians and cyclists in the formation of safety appraisals. Further research is needed to gain more understanding this process, in order to create urban environments that contribute to a higher perceived personal safety.

Chapter 1

Introduction

While moving through the world, one's focus of attention changes, focussing on different elements in the environment. This focus of attention determines how one feels in this situation, looking for potential threats and evaluating the situation, especially at night. Illuminating the area in focus of attention may help to better evaluate the situation and therefore influences one's perceived personal safety. The exact mechanisms behind this process are still fairly unknown. This study investigates the difference in focus of attention between two types of road users, cyclists and pedestrians, and their safety appraisals of night time environments in an attempt to better understand what influences perceived safety at night.

1.1 Perceived personal safety

Perceived safety has become an important topic of research as it directly affects many people in their daily life (Evans and Fletcher, 2000). In their survey conducted in England, Evans and Fletcher (2000) showed that perceived vulnerability and perceived ability to protect oneself against crime has a major influence upon fear of crime. Especially participants answering that they might be unable to cope with the consequences of being a victim of a crime, personal or property, scored high on fear of crime. This perceived safety can have an impact on individuals' social behaviour and might limit them to go out at night. As a result, the indirect effects may extend into social interactions. The environment should therefore be designed to reduce the fear of crime and create a situation that is both safe and also perceived as being safe.

Physical versus perceived safety

Safety can be divided into physical safety or perceived safety, based on the context. *Physical safety* can be interpreted as being afraid to fall, trip over objects or other ways to be physically harmed; *perceived personal safety* is

defined as a person's immediate sense of security, and an absence of anxiety of becoming victimized, when travelling through a particular environment (Blöbaum and Hunecke, 2005; Haans and de Kort, 2012). The current study focusses on perceived personal safety, making road users feel safe and willing to go out at night. The research setup attempts to eliminate the aspect of fear of physical danger, by letting participants stay at one place.

1.2 What influences perceived personal safety?

The human visual system is driven by expectations of the environment. To map the path of the eye while walking over a sidewalk, Davoudian and Raynham (2012) fitted participants with an eye-tracking device and monitored their behaviour while crossing a street in night or day. They concluded that approximately 50% of the time, pedestrians are looking at the footpath, approximately 0.8 to 1.0 seconds ahead. The second largest influencer were other people and the recognition of their body language.

Gap of knowledge

Research on what influences perceived personal safety is still rather limited. As shown in research by Davoudian and Raynham (2012), approximately 50% of the time the eyes focus on the sidewalk while walking. Which environmental aspects influence this percentage and steer our eyes is still uncertain. As an example, does mode of transportation, by increasing the velocity, influence one's gaze to maintain an approximately 1 second focus on the road ahead? By determining which environmental cues are important in the safety appraisal process, the environment can assist in increase perceived personal safety.

Scientific relevance

By understanding what affects perceived personal safety, urban environments can be designed to reduce fear of crime and enable people to safely go out at night. Innovations that reduce the environmental impact, such as dimmed or dynamic road lighting, unintentionally influence perceived personal safety. To successfully improve the urban environment, minimizing the ecological impact, more understanding of the safety appraisal process is needed.

1.3 Focus of the current study

The current study focusses on understanding what influences our perceived personal safety in urban environments. A study by Haans and de Kort (2012) examined perceived personal safety when different areas surrounding a pedestrian were illuminated, and how this effect is mediated. Participants reported a higher prospect and experienced higher perceived personal safety when the

area directly surrounding the participant was illuminated. The compared areas, either directly surrounding the participant or in the distance, are not the correct areas to study for threat appraisals, causing unexpected results. The current study predicts that the area of focus is dependent on factors such as time day, velocity and mode of transportation. Since Davoudian and Raynham (2012) has shown that pedestrians focus on the area to cover within approximately 1 second, the area in which treat appraisals occur will also be much smaller. The current study attempts to identify the focus of attention of pedestrians in comparison to cyclists in urban environments, to better understand in which area threat appraisals occur.

Outline

The next chapter describes the related work to urban safety, dynamic road lighting and personal space, and provides a theoretical framework. A new theory is formulated to combine recent findings with accepted theories. Chapter 3 provides the research question and explains how this is tested. The methodology and results are described thereafter in Chapters 4 and 5 respectively. The final chapter, Chapter 6, discusses these outcomes and suggest some future implications and leads for future research.

Chapter 2

Theoretical framework

In order to study the area of the environment on which people focus their attention while making safety appraisals, the fundamental theories and related work in urban safety and personal space are important. This section discusses these theories and how they relate to the current study. A theoretical framework is provided for the new theory of perceived spacial safety, which will be tested within this study.

2.1 Urban safety

In his book *The experience of landscape*, Appleton (1975) discusses the Habitat Theory, describing that certain conditions of the environment are seen as aesthetically pleasing when they support biological survival. The purpose of this theory is to establish a connection between the aesthetic pleasure induced by an environment and the ability of that environment to meet biological needs (Loewen et al., 1993) such as food and shelter.

Prospect-Refuge theory

The Prospect-Refuge Theory builds on this theory, discussing how the environment can provide protection to human beings and offer options to escape from predators, such as animals or thieves. In essence, it comes down to a quote from Konrad Lorenz ‘...to see without being seen’ (Appleton, 1975, p.69). According to Appleton, the ability to see (prospect) without being seen (refuge) increases perceived personal safety and consequently the aesthetic pleasure felt in an environment (Loewen et al., 1993).

Concealment and Escape

Although Appleton's theories were originally based on landscapes and paintings, they have henceforth been successfully applied in social science studies, explaining human behaviour and the source of fear arising from the design of the physical environment. However, often the elements prospect and refuge are insufficient to completely describe the effect on perceived safety. Areas with a wide view, such as an open space, provide good prospect, but have relatively low refuge capabilities. Vice versa, a refuge option also provides shelter for potential enemies, a paradox named refuge ambiguity (Loewen et al., 1993). Loewen et al. (1993, p.325) proposed to extend the prospect-refuge theory to include access to potential help as refuge option, even if it does not actually conceal the prey from the gaze of the hunter. This creates a distinction between physical refuge and social refuge (i.e., escape).

Nasar et al. (1993) confirmed that, in addition to limited prospect and blocked escape, also concealment is of significant influence to the perceived personal safety of a typical campus environment. Moreover, to a high prospect and refuge, a potential victim would prefer an area which offers no possibilities for attackers to hide, in other words, which has a low concealment. They measured concealment by the number of features that could hide someone and measured prospect by dividing the size of each hiding feature by its distance from the next heavily used path (Blöbaum and Hunecke, 2005, p.468).

The prospect-refuge theory as most commonly used in environmental psychology today, and also in the current study, contains four primary concepts. Prospect is the overview in a given situation, expose replaced refuge as a less ambiguous term to indicate one's exposure to the world. Additionally, concealment is the number of hiding places for a potential attacker, escape is the number of escape paths, including social refuge where other people might offer assistance in the situation. If all these elements are present in the environment, the situation is often perceived as safe.

The prospect-refuge theory in practice

Fisher and Nasar (1992) tested the prospect-refuge theory on a campus and the paths students took. They concluded that students are more likely to choose a different path if the short path was dark and offered places for offenders to hide (i.e., low prospect and high concealment). To test this, Loewen et al. (1993) showed slides to college students and let them grade the perceived personal safety of these images. Independent judges categorised the elements of the pictures, including presence of light, openness of the space and access to real refuge. If all elements (light, open area and access to refuge) were present, the area was rated significantly safer than with one or more elements not present. The high-visibility (i.e., light present) had the strongest influence on the perceived personal safety. Areas that provide both prospect and low

concealment were rated safer than with one or none of these two present, with prospect as strongest influencer. Therefore, presence of light, as it provides prospect and interacts with all other variables, was identified as the single most important variable to this effect on safety (Loewen et al., 1993, p.329). This shows the importance of road lighting on perceived safety, as explained by the prospect-refuge theory.

Because the study by Loewen et al. (1993) was performed in a lab using slides, it was replicated by Blöbaum and Hunecke (2005) in a field experiment. The study identified the environmental factors, both physical and personal, influencing perceived personal safety. Most impacting factors were the feeling of entrapment (escape), the presence of sufficient lighting and good prospect. These factors facilitate anticipation of danger, as well as the possibility to escape. Lighting seems to be especially relevant in situations with a low-level of entrapment, whereas concealment seems to be especially relevant in settings containing a high level of entrapment. Keeping in mind that lighting is often regarded as the easiest physical feature that could be improved in a given situation, a change of lighting conditions may become relevant in settings already offering possibilities of escape. A place containing a high level of entrapment might not significantly profit from a change of lighting (Blöbaum and Hunecke, 2005, p.481).

Affective Theory

Ulrich, among others, claims that the prospect-refuge theory by Appleton is a too simplified version to fully explain the interaction between human-beings and their environment. Ulrich (1983) proposed the Affective Theory which states that emotional responses to landscapes occur before cognitive information processing (Lothian, 1999). These responses are not controlled cognitive responses, but immediate and unconscious responses that influence attention and subsequently conscious processing and behaviour.

Both Appleton's prospect-refuge theory and Ulrich's Affective Theory have good support from studies (Lothian, 1999). However, the usefulness of the Affective theory in predicting landscape preferences in perceived personal safety is limited. Rather, it focuses on the positive effects that landscape can play on emotional states of well being (Lothian, 1999).

Information Processing Theory

Kaplan and Kaplan applied an information processing approach to landscape aesthetics to explain the interactions between human-beings and the environment. They hypothesized that the perceptual process involves extracting information from one's environment (Lothian, 1999). Contrary to Ulrich's

Affective theory, this is a conscious process and in turn affects a person's emotions. An aesthetically pleasing environment has to be understandable, but at the same time offer elements to attract and involve the viewer to explore. The Kaplans identified four predictor variables, two of which (coherence and legibility) help one understand the environment and the other two (complexity and mystery) encourage its exploration (Kaplan, 1987).

The Information Processing Theory by the Kaplans is successful in explaining personal landscape preferences, it is however not applicable in a field situation to evaluate landscapes. Unlike Appleton's prospect-refuge theory, it cannot be readily applied in the field (Lothian, 1999). Even though the prospect-refuge theory is a (too) simplified version, it is the best available theory in explaining urban safety. In accordance with (Haans and de Kort, 2012), it will serve as the basis for explaining perceived personal safety in the current study.

Gender differences

Researchers often assume a difference in gender for risk perception (Gustafson, 1998; Fisher and May, 2009; Holland and Hill, 2007). In their meta-study, Gustafson (1998) analysed various studies into risk perception and how they use gender influences, and their influence on other factors. Often, the gender differences are left unexplained. Women and men may perceive the same risks differently, they may perceive different risks, and they may attach different meanings to what appear to be "the same" risks (Gustafson, 1998). Due to education, stereotyping or expectations, risk may be interpreted differently between men and women. In a different study, Fisher and May (2009) tested if male and female college students also use different environmental cues to evaluate the risk of a situation. They concluded that these cues are not gendered and are therefore the same for men and women. The most important cues to evaluate the safety of a given situation were related to lighting and foliage, which could be interpreted as lower prospect (Fisher and May, 2009). Holland and Hill (2007) tested the influence of age and gender on one's tendency to cross the street. There was only a minimal effect of gender in one of the two situations in the age group 25-59.

There are also studies that confirm a difference in safety related results between men and women. Loewen et al. (1993) found a difference in perceived safety between men and women in urban environments, especially when the number of escape options decreased. A study by Blöbaum and Hunecke (2005) supports these findings. Entrapment had the highest impact on perceived safety; this was significantly influenced by the lighting present. Lighting and good prospect are important for enabling the anticipation of danger as early as possible (Blöbaum and Hunecke, 2005). The authors concluded that many of these factors are influenced by gender stereotyping.

As research is often contradictory, the current study is open to both male and female participants, these will be equally divided over the conditions to ensure that no gender effect will have an influence.

2.2 Environmental cues

Improving perceived personal safety

By better understanding the environmental cues that influence perceived personal safety, the scenario can be improved. Research (Fisher and Nasar, 1992; Loewen et al., 1993; Blöbaum and Hunecke, 2005) has shown the importance of light in the evaluation of a landscape. Adding more light could positively influence a scenario; however, we need to consider not only how much lighting pedestrians need in order to feel safe, but also where it should strike (Haans and de Kort, 2012). Minimizing the ecological costs of light, both in energy usage and impact on animal night life, will require a careful implementation of such a light setting.

When sensitively deployed, road lighting could lead to a reduction of crime and fear of crime, and increased pedestrian street use after dark (Painter, 1996). As light provides both prospect, as a road user one can see further ahead, it also limits concealment. By effectively illuminating the area in which threat appraisals occur, the road user's perceived personal safety increases. Eindhoven University of Technology studies innovative road lighting designs and recent studies (Kort et al., 2010) have shown that these influence perceived safety and should be studied further.

Changing the urban setting

The impact on perceived safety of changes such as installing (intelligent) dynamic road lighting should be studied carefully, as its influence may not be directly clear at start but difficult to reverse. Road lighting was installed to increase the safety and perceived safety on the road, changing it too hasty may counteract this use. Road lighting provides light to all road users, including pedestrians, influencing their perceived safety. In particular to those vulnerable to or fearful of personal attacks, roadway lighting is essential for experiencing safety and the freedom to go out at night (Kort et al., 2010).

Previous research (Osch, 2010; Haans and de Kort, 2012), conducted at Eindhoven University of Technology, tested the influence of intelligent dynamic road lighting on perceived personal safety. The effect of three different lighting scenarios was compared for pedestrians' perceived safety and possible mediators based on prospect-refuge theory.

By manipulating the lighting dynamically in a Wizard of Oz experiment* an intelligent road lighting system was simulated. Pedestrians had to walk down a street in different scenarios and each time at the end answered a questionnaire about their experiences. This questionnaire measured perceived personal safety, as well as possible mediators prospect, concealment and escape. There were three different conditions in which participants had to walk: a spot light scenario, in which the participant's immediate surroundings are illuminated, a dark spot scenario, in which distal parts of the environment were illuminated and a control condition. The total light level was constant over all conditions. For an image of the three scenario's, see Figure 2.1.

Based on Appleton's prospect-refuge theory, individuals are expected to prefer an environment in which they can see potential threats, without being too exposed. In other words, to see without being seen. Since in the dark spot condition these conditions are emphasized, the authors expected was this would be perceived as safest. In the dark spot, the participant is in the dark and therefore difficult to see, i.e. has a high refuge, but can see everything that happens in the distance, i.e. has a high prospect.

Results (Osch, 2010; Haans and de Kort, 2012) have shown that there is an influence of the road lighting distribution on perceived safety. However, the dark spot was perceived as least safe, over the light spot and control condition. Participants indicating have a higher prospect in the light spot condition. In other words, the area in which they looked for potential threats was better illuminated in the light spot condition compared to the dark spot condition, contrary to expectations.

The study was repeated in a Virtual Reality (VR) environment (Nab and Thomassen, 2012), where participants wore a VR-helmet and can move their

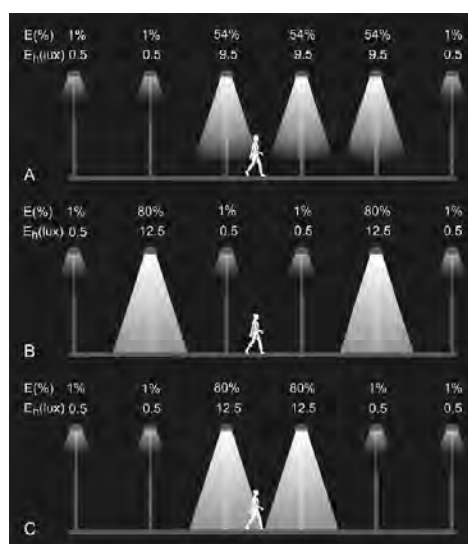


Figure 2.1: The three different lighting scenarios from the original study by Van Osch; A is the control condition, B the dark spot condition and C the light spot condition.

*A Wizard of Oz experiment is a method in which participants interact with a - what is to be believed to be - interactive system, but which is actually being operated by the experimenter.

head - they cannot move physically in any direction. Their task was similar to the original study, participants had to evaluate safety and mediators from images displayed on their helmet. Results from this study show comparable conclusions to the study in the field, also in this study the light spot condition was rated safer in comparison to the dark spot condition.

The current studies investigate the area used by pedestrians and other road users to evaluate potential threats. Which area of the environment is important to illuminate in order to feel safe? Does this area differ between different road users?

2.3 Categorizing the space around us

Introduction into personal space

To know which area is used to evaluate threats, the space around an individual needs to be described. This space can be described in many different terms, distances and shapes, depending on the field of research. Philosophers, mathematicians, physicists, psychologists and many more, each describe the space differently depending on their focus. Most commonly, the space is described as a mathematical concept, using the geometric system, with the Euclid as the most typical choice (Turvey, 2004).

Another approach describes the space in a less abstract and objective manner, but focusses on the physiological and psychological concept of space; how our brain interprets the world around us. Examples of this are the theories by Kant and Gestalt psychologists (Turvey, 2004).

A third and less commonly used concept of space is to describe it in biological and ecological terms, defining properties of space that are to be found at the interface of animal and environment where their respective properties are complementary (Turvey, 2004). For the purpose of this study, all three concepts are required to describe the space around us: we need to know the objective properties, how the space is interpreted and how we react to it.

This section discusses the major views on (personal) space and how different approaches can lead to differently sized, shaped and interactive space. From these views, the theory of perceived spacial safety is formulated.

Hall's view on personal space

Zoologist Hediger (Hediger et al., 1950) studied the animals in the zoo where he worked and described how various animals interacted with animals of the same and different species. In addition to the individual's territory, identified by a plot of ground, each animal is surrounded by a series of bubbles or irregularly shaped balloons that serve to maintain proper spacing between individ-

uals. Hediger has identified and described a number of such distances which appear to be used in one form or another by most animals (Hall, 1969, p.10). For animals of different species approaching each other, there is a flight and a critical distance, different for each animal. Approaching an animal is only possible up to the *flight distance*, at which the animal will flee. Approaching even further, one enters the *critical distance*, the narrow band between the flight and attack distance, where the animal will no longer flee but rather follow the approaching man. For animals of the same species, Hediger defined two zones which differ greatly between contact and non-contact animals, these zones are personal and social distance. *Personal distance* is the normal spacing that non-contact animals maintain between themselves and others. *Social distance* varies greatly between different animals and situations, but is the distance at which social animals are in touch with each other (Hall, 1969, p.14).

The studies from Hediger inspired Edward T. Hall to extend this research to the interaction among people. Based on interviews and observations he identified four different distances in the interaction between people (Hall, 1969, p.116). These distances are briefly summarized[†] as follows (Hall, 1969; Gifford, 1997; Bell et al., 2001):

- Intimate distance: 0 cm till 45 cm
The presence of the other person is unmistakable and may at times be overwhelming because of the greatly stepped-up sensory inputs. (Hall, 1969, p.116)
Touch, smell, heat et cetera are the primary modes of communication.
- Personal distance: 45 cm till 1 m (approximately)
This distance is a protective bubble that the individual maintains between itself and others. (Hall, 1969, p.119)
Verbal communication, in combination with visual feedback, is the basis for communication in this distance.
- Social distance: 1 m till 3.5 m
Regular distance for communicating, without the need to speak louder or lower one's voice.
Minimal sensory input, not possible to touch, but visual and normal voice communication are still possible.
- Public distance: more than 3.5 m
In this area, the other is outside the circle of involvement. Regular communication is not possible.

[†]The interested reader is referred to (Hall, 1969) for an extensive description of these areas.

Subtle shades of meaning are lost, therefore (loud) verbal communication, combined with exaggerated non-verbal communication is only possible.

Hall was not the only one studying personal space; however, different approaches lead to a different division of the space around us.

Neurological approach to personal space

Based on neurological studies, Grüsser (1983) divided the directly perceived space into the two major regions of *personal* and *extra-personal space*. Personal space contains the space of the self (ego space), which is experienced by the “inner senses” within the limits of the body space. Extra-personal space was further subdivided into grasping space and instrumental grasping space, near-distant action space, far-distant action space, and the visual background (such as the sky) (Grüsser, 1983; Daum and Hecht, 2009). This division depends on the contribution of the different sensory and motor modalities to object recognition and space perception. Based on studies with lesion-patients and area-7 neurons in rhesus monkeys - related to spatial control of arm movements - Grüsser concludes that there are different neuronal mechanisms responsible for the perceptual and motor operations, related to the different compartments and are dominated by different brain structures (Grüsser, 1983).

Division based on the used information sources

Cutting and Vishton (1995) stated that there are nine sources of information through which we perceive our natural environment: occlusion, relative size, relative density, height in the visual field, aerial perspective, motion perspective, binocular disparities, convergence and accommodation. These sources of information will not be extensively discussed; however, the interested reader is referred to (Cutting and Vishton, 1995) for more information. For each person there are three areas, of different size, that surround him or her. The different sources of information provide the observer with knowledge of the surroundings, depending on the area. These areas can be divided into personal space, action space and vista space (Cutting and Vishton, 1995):

Personal space This is the zone immediately surrounding the observer’s head, generally within arm’s reach and slightly beyond. It is a very intimate area. In this area, a number of information sources are used, but this number is smaller than in the other areas. Most importantly, also roughly in this order, are occlusion, retinal disparity, relative size, convergence, and accommodation.

Action space In this circular region, just beyond personal space, an individual's public actions take place. One moves quickly within this space and can talk without too much difficulty and can throw for example a ball to each other in this space. This space is also served by a different collection and ranking of sources of information. There are five: occlusion, height in the visual field, binocular disparity, motion perspective, and relative size. The size of this area is approximately 30m, after this the utility of disparity and motion perspective is too much declined.

In the original study by (Haans and de Kort, 2012), this area was illuminated in the light spot condition. Illuminating this area was perceived as safest by the participants of the study. In addition, prospect was highest in this condition, indicating that participants primarily used this area to evaluate the environment for potential threats.

Vista space Beyond the 30 m of the action space, very little information can be extracted from binocular disparity and other close-by sources of information, also an object's motion is considerably less salient than its displacement. The observer relies more on pictorial cues, such as occlusion, height in the visual field, relative size, and aerial perspective. In this area, we rely on monocular information cues and static sources of information.

In the original study (Haans and de Kort, 2012), this area was illuminated, up to approximately 60m. Illuminating this area while leaving the action space dark, as was done in the dark spot condition, was not perceived as safe as the light spot condition.

The light spot condition and dark spot condition in the study Haans and de Kort (2012) correspond to illuminating the action space and vista space respectively. Results showed that prospect was higher when only the action space was illuminated. The action space is the area which offers immediate threats to pedestrians, learned by experience or evolution, and therefore receives most attention when evaluating the environment. The current study states that the action and vista space are not the correct frames, but the area in which threat appraisals occur is even smaller, dependent on various factors such as mode of transport.

Goffman's *Umwelt* theory

Goffman (1971) explains in his book *Relations in Public* that there is a sphere around the individual where potential sources of alarm are found. He calls this the "Umwelt". In this area, the individual is alert for danger and also rates his or her danger by signs of threat in this area. The size of the *Umwelt* is different for different species. Typically, events that are further away (over hundred metres), are neither actual nor potential sources of immediate alarm. If one expects danger from outside the *Umwelt*, deliberate attention is required. The

Umwelt is not only different between species but also different for individuals and the task at hand. Goffman gives the example of a air traffic controllers. Even though they are in a small room, they are aware (using artificial tools to assist) of the air around them.

As we move, our surroundings move as well. As a result, some potential signs of alarm move out of effective range (as their sources move out of relevance) while others, which were out of range a moment ago, now come into it (Goffman, 1971, p.249). This surrounding follows the individual while he moves. The size and shape of this bubble also change. For example, on a busy sidewalk during the day, threats within ten meters are in one's direct attention. However, at night, in a quiet street, even a threat 257 meters away may be of interest.

2.4 Theory of spatial navigation and appraisal

The original study Haans and de Kort (2012) interpreted the vista space as the most important source of information at night. Information from this area is used to look for potential treats and therefore evaluate the situation. However, as shown in the results (Osch, 2010; Haans and de Kort, 2012), prospect was evaluated higher in the light spot condition, indicating the participants had all the necessary information to evaluate the scenario in the illuminated area. As Davoudian and Raynham (2012) has shown, pedestrians focus about 50% of their gaze on the sidewalk 0.8 to 1.0 seconds ahead, at a normal walking pace an area much smaller than the vista space.

The current study combines elements of Goffman's *Umwelt* theory with personal space and the moving action space to form a new theory of spatial navigation and appraisal. As Hall said: Man's perception of space is dynamic because it is related to action - what can be done in a given space - rather than what is seen by passive viewing (Hall, 1969, p.115). Individuals primarily use the area around them, as an evaluation for the situation in cases of immediate threats.

In the current study the space around us is divided into *immediate environment* and *distal environment*. The immediate environment is, similar Goffman's *Umwelt* theory, dynamic in shape and size. The size and shape of the area depends on factors such as mode of transportation, time of day, other individuals et cetera. Some sources of information may be outside the scope of interest, as experience or evolution has thought that these are less important. For an individual walking down a street the situation is different during the day compared to the same street at night. Cyclists and pedestrians have a different immediate environment since their mode of transportation differs and different elements of the environment are relevant to their perceived safety, as also depicted in Figure 2.2.



Figure 2.2: Schematic drawing showing the difference in immediate environment for pedestrians (left) and cyclists (right).

The current study states that to make a safety judgement, individuals are primarily attentive to environmental cues from the area which could offer immediate threat. In this immediate environment, threat appraisals are formed to evaluate the situation. The theory of spatial navigation and appraisal, which predicts a difference in this immediate environment between road users, is tested in an experimental setup.

Chapter 3

Research goal

To improve the feeling of safety of different road users, the mechanisms of safety appraisal need to be better understood. This study investigates the focus of attention of road users, i.e. one's immediate environment, and how this changes depending on their method of transportation. As predicted by the theory of spatial navigation and appraisal, one's immediate environment is dependent on the mode of transportation.

3.1 Illuminating the immediate environment

The original study by Haans and de Kort (2012) showed that, with respect to their sense of personal safety, participants preferred light in their direct surroundings (i.e., a spot light scenario) rather than on the more distant parts of the road (i.e., a dark spot scenario; as the road user is walking in relative darkness). This result is counter-intuitive to previous research in the field of urban safety, since in the spotlight condition participant indicated to feel safer, had a better view on potential attackers (prospect) and saw more options to escape. The vista space, illuminated in the dark spot condition, was expected to be the primary source of information to evaluate the environment.

The current study states that, to make a safety judgement, pedestrians are primarily attentive to environmental cues from the area which could offer immediate threat. This is comparable to Goffman's *Umwelt* theory and the notion of one's immediate environment. It is an area up to approximately 1 second in the distance, similar to the findings by Davoudian and Raynham (2012). In this environment, threat appraisals are formed, based on the environment's prospect, escape and concealment options. This immediate environment is not necessarily static; it is dependent on various factors of the subject, such as time of day, other road users and method of transportation.

3.2 Research set-up

The focus of attention for different road users was tested using a change-blindness paradigm. Previous research by Gajadhar (2006) has shown that this paradigm can be used to test different roles of road users and their focus of attention. Reaction time to notice a change in different parts of an image was recorded. This change detection differs depending on the type of road user and this role can be induced using an experimental set-up as shown by previous research (Gajadhar, 2006). Changes in areas to which one is most attentive to will be detected quicker, since this is in one's focus of attention. A significant difference in response time is therefore an indication of difference in focus.

3.3 Hypotheses and testing

The current study investigates if different road users have a different focus on the environment to form safety appraisals. Tested is whether two types of road users, pedestrians and cyclists, focus on different parts of the environment, as these offer potential immediate threats to them. The study aims to answer the following research question:

Research Question *“Do cyclists and pedestrians have different immediate surroundings (to which one is attentive) and does this influence their perceived safety of the environment?”*

Hypothesis 1: Changes in the foreground and middle-ground detected faster than in the background.

Hypothesis 2: Cyclists detect changes faster in the middle-ground, in comparison to pedestrians.

Hypothesis 3: Pedestrians detect changes faster in foreground, in comparison to cyclists.

Chapter 4

Method

The current section describes the methodology, procedure and all used materials and settings to perform the experiment. This experiment is designed to answer the research question and confirm or deny the accompanying hypotheses.

4.1 Design

The current study uses a two by three between-subject design. The manipulations vary in relative location on the screen: either at the foreground, at middle-distance or in the background. Differences in reaction time to detect these changes are an indication of the focus of attention of the different road users. Expected is that changes in the foreground, which is the hypothesized immediate environment of the pedestrian, are detected quicker by pedestrians compared to cyclists. Cyclists however, are most attentive to changes in the middle-distance, as is hypothesized in this study, and would therefore be quicker at detecting changes in the middle-distance, compared to the foreground. Differences in the background are expected to be comparable in both conditions.

4.2 Participants

Participants are placed in one of two roles: pedestrian or cyclist. These roles were emphasized for the pedestrian by wearing backpack and for the cyclists by cycling on a home trainer. The role of the participant is assigned in a random order, balanced for gender. Since previous research is not conclusive over the influence of gender on risk perception, both male and female participants were invited to participate but spread evenly in a random order over the conditions.

In total 60 individuals participated (n=60) and completed the study. Of these 60 participants, 30 were male and 30 female and none of them currently live or originated from Best or Geldrop where the pictures were taken; this

ensured that all environments were new to all participants. Participants received a 5 Euro compensation (or 7 Euro for participants outside the TU/e or Fontys school) for participating. All participants who were randomly assigned to the cyclist condition owned a bicycle and used it on a regular basis. Of the participants, 47 were native Dutch speakers and received the verbal instructions in Dutch and 13 spoke English and received the verbal instructions in English. All instruction on the screen were in English but were repeated by the experimenter in either Dutch or English.

4.3 Setting & Apparatus

Tests were performed at the Game experience lab of the IPO building at Eindhoven University of Technology. In this nearly empty 4m by 5m room was a large projector screen (width 1,5m and height 2,5m) placed in the middle of the room in vertical position. By placing the projection screen in a vertical position, it gave the participant the option to look up and down. This screen is backlit by a NEC WT610 mirror projector. The participant stood in front of the screen such that the middle of the screen was at approximate eye-height. For the cyclist condition the hometrainer (Body Sculpture Smartbike BC 1510C) was placed on a 15cm high podium to make sure the horizon was at the same height. The horizon was in all images in the middle of the screen, at the approximate eye-height. As the projection is in a vertical position, it gives the participant the option to look up and down, as one would in a normal situation.

The experiment was conducted using E-prime software (version 2.0.10) and reaction times were recorded after a mousepress (left or right) by the participant and measured by the E-prime software. The images were night shots taken with a high-quality digital camera with tripod, in Best and Geldrop (Noord Brabant, the Netherlands). There are no people, animals, cars or other immediate threats on the images to limit distraction. Manipulations to the images are made using Adobe Photoshop CS5. Modifications include deletions, changes and additions such that the result was a realistic photograph, to prevent participants from easily detecting abnormalities.



Figure 4.1: Set-up of the lab room with additional light.

The modifications are not necessarily semantically relevant to pedestrians or cyclists, since this study investigates the focus of attention and the area which receives most attention as a consequence. The images were cropped such that the horizon was always in the centre of the image and fitter the vertical screen. The top half of the image was considered background, the bottom half was divided in two: the lower quart was considered foreground and the quart above middle-distance. See Figure 4.2 for a schematic drawing of this division. For detailed descriptions and examples see Appendix A.

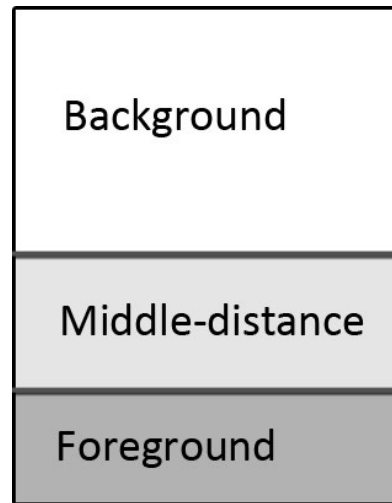


Figure 4.2: Division of an image into foreground, middle-distance and background. The horizon of the image is in the middle.

4.4 Procedure

Participants are welcomed and instructed and if there were no further question from the participant, they were asked to sign an informed-consent form. Using an example image, the procedure of the experiment was clarified to the participant. Similar to the original study by Gajadhar (2006), the image was shown for 500 ms, followed by a mask (grey screen) for 500 ms and the manipulated version of the image, again the mask and the process was repeated until the participant detected the change. Before each trial, participants were reminded of the condition they were in; they are alone and walking or cycling home late at night. See also Figure 4.4 for a schematic overview. As soon as the difference between the images was detected, the participant presses a mouse button to freeze the image and then identified the difference to the experimenter. Regardless of the correct or incorrect difference, the experiment continued, incorrect responses are ignored. If the participant had not detected the change within 2.5 minutes, the response was ignored, the experimenter informed the participant of the correct answer and the experiment continued.

After detecting the difference between the two images, the participant had to evaluate the original picture on perceived safety. The environment was evaluated on a scale from 1 (unsafe) to 7 (safe). The reason for this step is twofold: it stimulates the participant to stay focussed on the safety setting of the experiment and secondly, it could provide inside into a relation between perceived safety and focus of attention. After evaluating the original environment, the

experimenter continued the experiment until all images passed. There were 27 pictures in total, shown to each participant in completely random order.

4.5 Measures

The participant held a standard mouse in their primary hand. Once the difference was spotted, the participant had to press a mouse button (left or right) to halt the procedure and has to inform the experimenter directly what the difference was. Regardless whether it was a correct answer, the procedure continues. Incorrect answers were later removed from the dataset. The response time between onset of the first image until the difference has been spotted was recorded and served as the main dependent variable in this experiment.

After detecting the difference, the original image was shown again to the participants and they were asked to evaluate this environment. The participant had to tell the experimenter, sitting out of sight, the score on a Likert scale from one (unsafe) to seven (safe) how they would feel, being there alone at night, imagining they were travelling home. These scores were recorded by the experimenter and added to the dataset afterwards.



Figure 4.3: Hometrainer in front of the projection screen.

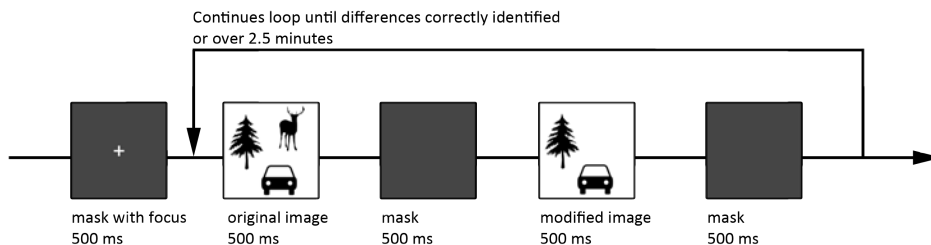


Figure 4.4: Schematic drawing of the experimental procedure for one trial.

Chapter 5

Results

This chapter describes the analysis and results from the experiment conducted to answer the hypotheses posed in Chapter 3. This is an objective overview of the findings, the interpretation and consequences will be discussed in the discussion hereafter.

5.1 Preprocessing

The data was first analysed for possible outliers, which could be due to errors in data-entry, images that were too difficult, participants that were significantly outside the average range, et cetera. The analysis was first performed without these outliers and later repeated to test the impact of these outliers on the results.

Outlier analysis

There was no significant difference in the number of *incorrect answers* between condition or gender. For this reason, the incorrect answers were recoded into missing values and ignored in further analysis. One image had significantly more incorrect answers (60% incorrect), compared to average (5% incorrect). The incorrect answers for this image were equally distributed over both conditions, therefore this image could be ignored for further analysis.

Outliers in *reaction time* were removed if per image the individual absolute reaction time was above 3,5 standard errors from the mean, this corresponded with a reaction time of 2.4 minutes and longer. This process was repeated per condition to test for abnormalities on a subject level. No items were removed based on these criteria.

Safety-scores were normally distributed, overall as well as factored by role. These scores were analysed for outliers, over three standard errors, on condition level, gender, environment (location of change) and per image. After

factoring per participant, one safety score (score of 1) was removed from the dataset as it was categorized as an outlier, since it was over three standard errors from the mean. This did not effect the normality assumption. The analysis was later repeated including this data item, which did not effect the results.

All of the assumptions required for the analysis were met, unless otherwise specified. Most notably the sphericity assumption, required for a repeated measures Analysis of Variance, tested by Mauchly's Test of Sphericity, was not significant.

5.2 Data transformation

The data needs to be transformed and aggregated so it can be used in the statistical analysis. As described above, incorrect answers and outliers were removed from the dataset. Thereafter, reaction time was transformed using decadic logarithm (\log_{10}) into a 10-base logarithmic scale to compensate for the skewness often found in reaction time studies. This normalises the reaction time data, suitable for further analysis. After transforming, all reaction time datapoints were below three standard errors from the mean. Although the Kolmogorov-Smirnov test indicated the resulting transformed reaction time distribution was significantly non-normal, $D(1620)=.059$ $p < .001$, it was the closest to normal possible, within acceptable skewness and kurtosis values. Different data transformations, such the natural logarithm and reciprocal transformation, could not lead to better results.

Data was aggregated into subject level format, suitable for analysis of variance. Logarithmic reaction times and safety scores over the nine images per environment (foreground, middle-ground and background) were averaged per participant. This resulted in three datapoints in average reaction time and three datapoints in average safety scores; these were the averages over the foreground environment, middle-ground environment and background environment.

5.3 Hypothesis testing

The three hypotheses formulated to test the research question are analysed in the original order. To ensure no gender effects confounded with the outcome, the effect of gender was tested on reaction in a repeated measures ANOVA. No differences were found, $F(1,57)=0.885$; $p = .35$, therefore the effect of gender could safely be ignored in further analysis.

Hypothesis 1: Changes in the foreground and middle-ground detected faster than in the background Expected was that pedestrians focus most of their attention on the foreground and cyclists most of their attention on the middle-ground. To test their focus of attention, average reaction time to changes in the background is compared to the other images. As both pedestrians and cyclists focus their attention on either foreground or middle-ground, hypothesized is that the reaction time in the background is longer than in all other conditions. A repeated measures Analysis of Variance (ANOVA) with custom hypothesis testing $(-\frac{1}{2}, -\frac{1}{2}, 1)$ was performed to test this hypothesis. This result was significant, $F(1, 57)=7,94; p < .01$. However, the reaction time was shorter in the background condition for both roles as shown in Table 5.1 and Figure 5.1.

Table 5.1: Mean reaction time per role and environment in \log_{10} format.

	Foreground	Middle-ground	Background
Pedestrian	4.16	4.19	4.13
Cyclist	4.17	4.17	4.09

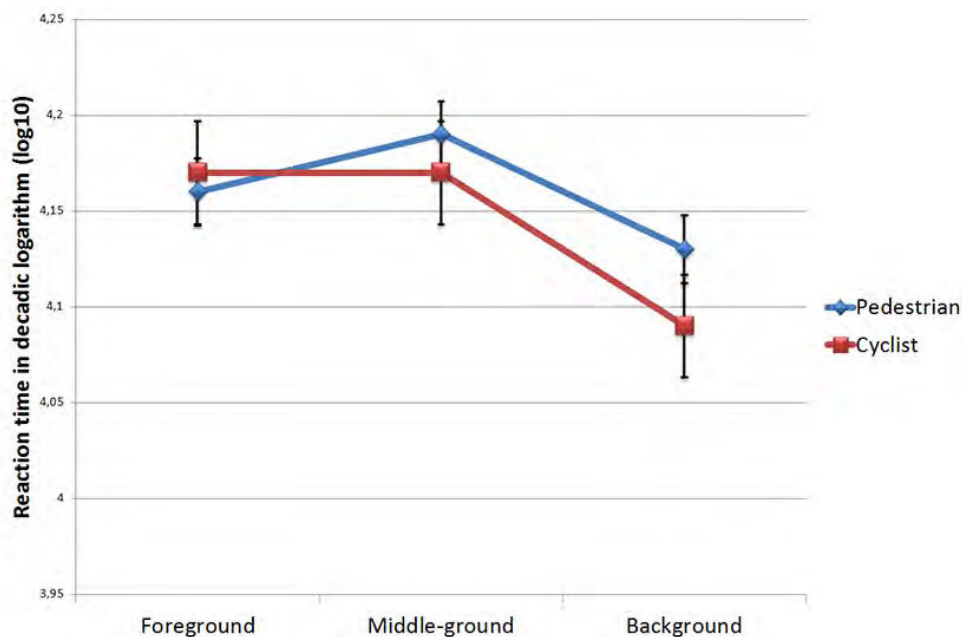


Figure 5.1: Graph showing the average reaction time \log_{10} for both roles

Hypothesis 2: Cyclists detect changes faster in the middle-ground, in comparison to pedestrians The second expected difference, based on the posed hypotheses, is that cyclists focus their attention on the middle ground and as a result are quicker in comparison to pedestrians in this area. Another repeated measures ANOVA with custom hypothesis (1, 0, 0) tested this outcome. This result was not significant, $F(1,57)=0.72$; $p = .40$.

Hypothesis 3: Pedestrians detect changes faster in foreground, in comparison to cyclists Pedestrians are expected to be quicker in the foreground condition, since they focus most attention to this area as is hypothesized. A change in the contrasts created a different custom hypothesis (0, 1, 0) which showed that also this result is not significant, $F(1,57)=0.07$; $p = .79$.

5.4 Explorative results

Safety scores per environment were recorded as well. These scores were given by participants about their sense of safety in the original (unmodified) environment, shown to them after detecting the difference. These scores are on a Likert scale from 1 (unsafe) to 7 (safe). There are significant differences between participants in different roles as shown by a repeated measures ANOVA, $F(1,58)=4.50$; $p = .04$, on average the cyclists gave score of 4.40 (SD=1.42) and pedestrians a score of 3.96 (SD=1.38). As shown in Table 5.2, cyclists feel safer in all environments indicated by the higher safety scores for the same environments. Gender did not differ in safety scores, as was tested with a repeated measures ANOVA, $F(1,58)=0.247$; $p = .62$.

Table 5.2: Average safety scores (Likert scale 1 to 7) for the environment per role and environment.

	Foreground	Middle-ground	Background
Pedestrian	4.13	3.89	3.87
Cyclist	4.59	4.30	4.33

All analysis described in this chapter were repeated including outliers; however, this did not lead to different test results.

Chapter 6

Discussion

This study tested the focus of attention when making safety judgements of different road users, comparing cyclists and pedestrians, in night time environments. By means of a change-blindness paradigm, the reaction time to a change in focus of attention is tested. This provides an indication for the immediate environment in which threats appraisals are formed. We predicted that the size of the immediate environment road users are attentive to would depend on mode of transportation. Results could not confirm these expectation.

Based on the theory of spatial navigation and appraisal we expected a difference in focus of attention between road users. We anticipated that the area in which safety judgements are formed is related to the road user's action radius and velocity. Therefore, we expected pedestrians to focus more on the relative foreground in comparison to cyclists, as this offers more imminent threats to them. Cyclists, on the other hand, are expected to focus on an area further in the distance, as this area is more important to them in this process. If these expectations are true, both road users will be able to detect changes in their respective immediate environment quicker, as it is in their focus of attention. Results showed that cyclists were not quicker in detecting changes in the middle-ground in comparison to pedestrians. Also vice versa, pedestrians were not quicker in finding the differences if they occurred in the foreground.

After detecting the difference, participants were asked to evaluate the urban scene. There was a significant difference between cyclists and pedestrians. Cyclists generally experience the same scene as safer in comparison to pedestrians. We also found no effect of gender on the safety evaluation of the scenes. As this was a measure of subjective safety in the environment, comparisons to previous works (Fisher and May, 2009; Haans and de Kort, 2012) are difficult. We did not inquire participants about their perceived personal safety in environment in the same manner as previous works. In the current study,

participants were asked to evaluate the environment on subjective safety, the interpretation of this was open to the participant. The significant difference in the resulting scores could be an indication that pedestrians and cyclists have a different view on the same environment, or approach the same environment differently. On a bike, one can quickly escape the scene, possibly giving a higher perceived personal safety regardless of the environment. The current study could not confirm a different focus on the environment to form these safety scores. However, participants were asked to evaluate the environment after detecting the change in the scene, the shown environment was a still image. Possibly, the cyclists used a different evaluation approach in comparison with pedestrians, but did not employ this until after detecting the change.

Eye-tracking can supplement these findings to gain a better understanding of the environmental elements important in safety judgements. Not only the area used in these safety evaluations is of importance, but also the relation to the objects in this environment. As an example: Possibly, cars are a bigger threat to cyclists than they are to pedestrians, therefore an environment with a crossing in the distance may be perceived differently between roles. The same crossing may be less relevant directly to the pedestrian. Because we wanted to simulate a night-time environment, testing the focus of attention of these road users, the room was too dark for eye-tracking and therefore not possible.

One of the hypotheses posed in the beginning of this study was that changes in the background would be detected slower by both pedestrians and cyclists, since it is outside the expected focus of attention for both. However, changes in the background were generally detected faster than changes in foreground or middle-ground. This unexpected outcome could be due to the screen surface covered by the background area. The screen surface which was considered as background was the same size as the foreground and middle-ground combined. The top half of the screen was background, compared to the bottom half which was split up into either foreground or middle ground. If one was to employ a simple search strategy, systematically scanning the images for changes, the background receives more focus in comparison to the other areas. In addition, changes that occur in the background of an image are interpreted differently from changes in the foreground. As the photo appears to have depth, our brain corrects for object size in the distance, which could emphasize changes in the background. Both explanations would not result in a difference between pedestrians and cyclists, since they would be of influence in both roles in the same manner. As shown in this study, there was no difference between roles in detecting changes in the background; this had no influence on the manipulation or the results.

6.1 Future improvements

A follow-up study is needed to test the theory outside the lab, on a real street. Such a setup would be more realistic than a simulated lab setting. In the current study, static images were used to induce the feeling of being present in the displayed environment. However, in reality pedestrians or cyclists move and the area around them therefore also changes due to their own actions. The theory of spatial navigation and appraisal states that the area used in safety judgements is dependent on action radius and velocity. Possibly, these could not be effectively induced using still images. This is an important element of the theory of spatial navigation and appraisal, but could not be tested in the (current) lab setting.

A possible confounding factor to the lab setup was the priming of all participants. Participants were primed to the centre of the screen at the beginning of each trial using a black screen and a “+”-symbol, in accordance with the study from Gajadhar (2006). The purpose of this screen is to “reset” the participant’s view between images and limit transfer between images. However, as a result the induced difference between condition is diminished. Participants were forced to focus on the centre of the screen, counteracting our expected difference between roles. Where pedestrians are expected to focus more attention to the relative foreground, priming participants to the centre of the screen before each trial removes these effects. A follow-up study should reset the view without attracting the participant’s focus to the centre of the screen. Showing a black screen or neutral image for a few seconds could effectively do this.

The current results showed no significant differences between gender in safety scores or reaction time. The study by Haans and de Kort (2012) found a significant difference between gender, where female participants felt less safe in comparison to male participants. A different study into perceived personal safety by Fisher and May (2009) found the difference between female and male participants to be very minimal. Possibly, the fear of being at the scene alone at night was not induced strongly enough in this lab study, showing a difference between road users, but not between gender. A lab study might therefore not be the ideal setup to test small gender effect on subjective safety. Extending research is needed to gain a better understanding of the possible gender differences in safety appraisals.

6.2 Concluding remarks

The research question as posed in the beginning of this study: *“Do cyclists and pedestrians have different immediate surroundings (to which one is at-*

tentive) and does this influence their perceived personal safety of the environment?" cannot be denied or confirmed by these outcomes. There is no evidence to support the idea that cyclists have a different focus of attention. Participants in the cyclists condition, however, evaluated the scenes significantly safer, which could indicate a different safety appraisal process. Possibly, the lab setup, the distinction between foreground, middle-ground and background or trials were insufficient to identify a significant difference.

This study was an attempt to better understand what influences our perceived personal safety at night. By understanding how safety appraisals are formed at night, urban environments can be improved to facilitate a higher perceived personal safety. Innovations such as (intelligent) dynamic road lighting installations should not influence road users' perceived personal safety. The environmental and ecological benefits are evident, however, the underlying mechanisms behind safety perceptions are still fairly unknown.

The current study was oriented at the focus of attention of two types of road users: cyclist and pedestrians. We hypothesized that these two types of road users have a different immediate environment in which safety appraisals are formed. The current lab study could not confirm this difference between roles. We found a difference in subjective safety between the pedestrian and cyclist condition. It seems that cyclists have a higher sense of safety, an important factor to take into account when designing urban environments and for future research into (perceived) safety. Replication of this study, including the future improvements, is suggested.

These findings are a step towards better understanding the mechanisms that influence perceived personal safety. Fear of crime is a substantial problem, limiting individuals in going out, thus having a more extensive social impact that is often ignored. By gaining a better understanding of perceived personal safety and how this is influenced by the environment, urban environments can be improved.

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Appendices

Appendix A

Example of Images Adjustments

This appendix shows examples of adjustments to the images. Figure A.1 shows an example with an alteration in the foreground, Figure A.2 in the middle-ground and Figure A.3 in the background. Figure A.4 shows an overview of all 27 changes.



Figure A.1: Example of the two alternating images with a change in the foreground. There is a third shadow in the right image.



Figure A.2: Example of the two alternating images with a change in the middle-ground. The road on the right side disappears.



Figure A.3: Example of the two alternating images with a change in the background. There is a window in the building on the right.

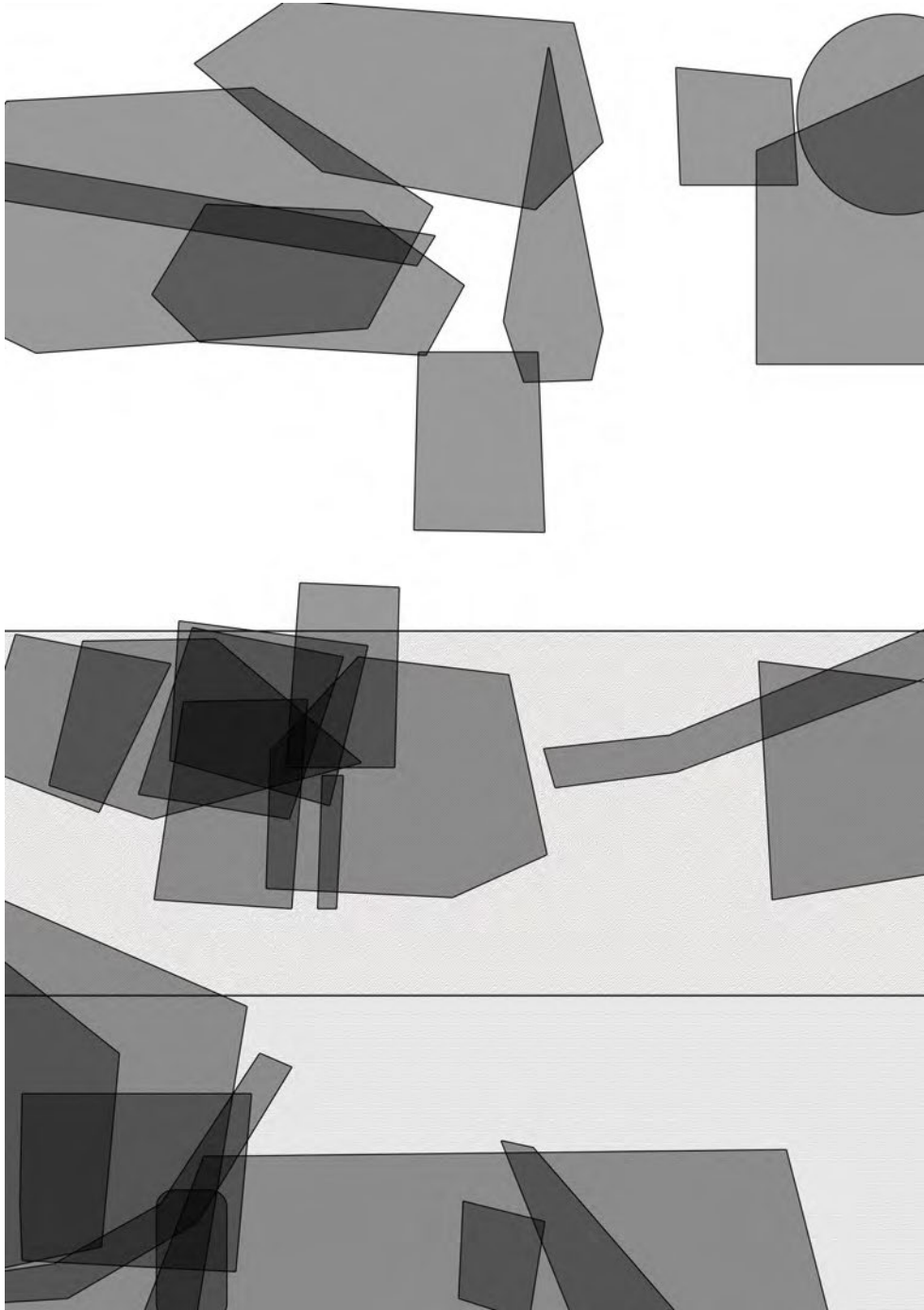


Figure A.4: Schematic overview of the location and size of the 27 alterations.

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