The Impact of Dynamic Guardianship on Perception of Safety: A Gendered Study

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Abstract

Perception of safety refers to how safe an individual feels in a given environment, especially inside their home. To improve residents' perceptions of safety, the current study proposes a concept which could be known as dynamic guardianship. Dynamic guardians are Smart Home Devices (SHDs) which activate when someone approaches a property, ultimately giving them the impression that the home is occupied. Although not central in this study, dynamic guardians are thought to potentially deter burglars from invading a home. As research on dynamic guardians is scarce, little is known about whether they can make people feel safer. Moreover, as men and women differ in their levels of perceived safety, it is expected that gender may play a central role on the effectiveness of dynamic guardians. Therefore, the objective of this study was to investigate whether dynamic guardians (voice-enabled cameras, motion-activated lights and blinds) could increase residents' perceptions of safety, and whether the increase was lower for women. As well as, whether women noticed dynamic guardians more frequently than men. To test these hypotheses, 101 participants entered a VR residential neighborhood as potential home buyers and were randomly exposed to one of three dynamic guardians. The most noticed SHDs were voice-enabled cameras and motion-activated lights. Dynamic guardians did not improve residents' perceptions of safety, nor did men and women differ in their safety perceptions before and after being told about SHDs. Lastly, men and women noticed dynamic guardians with equal frequency.

The Impact of Dynamic Guardianship on Perception of Safety: A Gendered Study

Imagine returning home after a long day at work and discovering that someone has broken in your house and stolen your valuables. Burglary occurs when someone illegally enters a home with the aim to steal (Dutch Penal Code art. 311, 2024). Except for financial damages, victims of burglary may experience stress and trauma, which in extreme cases can develop into disorders (Hanson et al., 2010; Macmillan, 2000). Subsequently, these problems can lead to physical, financial and social challenges. To prevent these consequences, it is important to understand the factors that contribute to the occurrence of burglary.

Cohen and Felson (1980), founders of the *Routine Activity Theory (RAT),* suggested that for a crime to occur, three factors need to coincide: "a likely offender, a suitable target and the absence of a capable guardian". Many studies have been conducted on the motivation of offenders and the attractiveness of targets. But not enough research has focused on the effectiveness of guardians in crime deterrence. A guardian can be defined as one or more individuals that through their physical or symbolic presence can prevent a crime from occurring either intentionally by patrolling or unintentionally by mere presence (Hollis-Peel et al., 2011).

Some researchers have found that guardian presence has the most deterring effect on residential burglaries (Cohen & Felson, 1979; Coupe & Blake, 2006; MacDonald & Gifford, 1989; Van Sintemaartensdijk et al., 2020). To avoid being caught by residents, a lot of burglars use tactics to verify home occupancy (MacDonald & Gifford, 1989). For example, by knocking on the door of a target house and asking for a fictitious s person in case the resident is actually present (MacDonald & Gifford, 1989). Moreover, burglars are highly wary of neighbours, who might observe their activities, a concept known as physical guardianship (Reynald, 2008).

Physical guardianship is defined as the actual presence of a guardian in deterring crime and has been divided into three dimensions ranging in intensity (Reynald, 2008). In the first dimension the guardian is simply present. In the second dimension the guardian is able to surveil and monitor their surroundings. In the last dimension the guardian monitors their surrounding and is willing to intervene if suspicious activities are detected. Moreover, physical guardianship can be both formal (e.g. authorities and private security guards) and informal (e.g. residents, neighbours). Informal guardians are ordinary residents that by doing normal routine activities they create a feeling of security (Reynald, 2008). However, they should not be confused with formal guardians, as the latter are rarely present when a crime is committed (Felson & Boba, 2010 as cited in Hollis-Peel et al., 2011). Although physical guardianship is effective in deterring criminal activity, constant guardian presence is not realistic.

Over time, the concept of guardianship evolved, highlighting that physical presence is no longer necessary, provided that the potential offenders feel as if they are being observed. *Symbolic guardianship* relies on the use of symbols that create a perception of surveillance (Hollis et al., 2013). Examples include closed-circuit television (CCTV), where offenders are not certain whether the devices are active or not and whether someone is observing them in real time (Jones & Pridemore, 2018). This feeling of being watched can be explained by the *watching eyes effect,* which argues that the image of eyes or the idea that someone is watching can lower antisocial (Dear et al., 2019) and immoral (Nettle et al., 2012) behaviour. Moreover, the application of the watching eyes effect increases proactive behaviour including increase in blood donations (Sénémeaud et al., 2017), decline in littering (Bateson et al., 2013) and compliance with social norms such as recycling (Francey & Bergmüller, 2012). However, over time CCTV has lost its deterrent effect, as burglars have become used to their presence and doubt their constant surveillance (Reynald, 2009). To add to this, according to Piza et al (2019), passive surveillance is unable to detect crime, while active CCTV systems require human resources such as employees, funding etc.

Other symbolic guardians that have been utilised for deterring burglars are neighbourhood watch signs. These signs are placed in residential neighbourhoods, and they indicate the existence of group chats where residents can actively communicate with each other when something suspicious occurs. Although, watch signs are fairly common in the Netherlands and seem to have some effect on crime reduction, their effectiveness relies on residents' active participation (Bennett et al., 2008). Which means that residents who observe a suspicious activity taking place need to take immediate action by reporting the event in the chats. Yet, Sintemaartensdijk et al. (2022) concluded that symbolic tools have a lesser impact on burglars compared to physical guardians.

Dynamic Guardianship

Despite their advantages, both physical and symbolic guardians have certain limitations. Therefore, a third type of guardianship which combines both physical and symbolic elements would be worth investigating. This could be known as *dynamic guardianship.* Unlike symbolic guardians, which rely on passive monitoring systems and signs, dynamic guardians depend on technology, specifically smart home devices. Smart home devices (SHDs) are innovative technologies that interpret information from the environment and respond accordingly (Balta-Ozkan et al., 2014; Chan et al., 2008). By integrating smart home elements such as movement, light or sound, dynamic guardians can create the illusion that residents are home, thereby imitating physical presence. Moreover, as residents cannot be always present, the connectivity of SHDs to the internet enables users to control them remotely via their smartphones regardless of their location (Kotha & Gupta, 2018).

The newest revolution in dynamic technologies is Voice-Enabled Cameras (Tan et al., 2022). They are installed outside or inside a property and can be utilized for many purposes such as doorbell cameras, nanny cameras and baby monitors. Unlike passive surveillance systems, voice-enabled cameras can detect motion and warn residents via the phone or smartwatch about any activity wherever the residents are located. This allows residents to speak directly to the person of interest or program the cameras to use human-like voice to remind potential criminals that they are being monitored. As a result, this two-way communication may discourage potential burglars from intruding a property (Tan et al., 2022).

Another possible smart home solution is Motion-Activated lights. Motion activated lights refer to lighting systems that activate when someone approaches the residence and turn off after a certain amount of time. Welsh et al. (2022) found that simple outdoor lighting has an impact on crime. Specifically, they determined that the improvement of lighting in residential neighbourhoods led to a

14% decrease in total crime and more specifically a reduction in crimes associated with properties (burglaries, theft). Although currently there is little to no research regarding motion-activated lights, security experts believe that sudden light activation may potentially surprise or even scare burglars, by giving the impression that someone is home (Dorn, 2024).

Motion-Activated Blinds are another smart home guardian that might discourage burglars. These automated blinds can be set up to open and close automatically at different time intervals but can also be programmed to turn on and off when someone approached the property (Wolniak & Grebski, 2023). Furthermore, smart blinds can be paired with other smart home devices and can be activated through the phone regardless of the owner's location. Subsequently, these automatic activities may deceive burglars by giving the impression that residents are inside the house (Wolniak & Grebski, 2023).

The few researchers to ever explore dynamic technologies are McClanahan et al. (2024), who investigated their effect on fear of crime, in a virtual reality (VR) environment. In one of the experimental conditions, participants were exposed to a motion-activated led screen which illustrated the picture of two moving eyes, alongside a warning message "burglar we are watching you". Consequently, participants exposed to the watching eyes intervention felt that they were being watched. Further analyses revealed that the feeling of being watched, increased fear of crime in an emotional and cognitive level. Specifically, the image of eyes led participants to feel negative emotions such as fear and anxiety towards crime, while the introduction of the warning message intensified these feelings (McClanahan et al., 2024).

However, while dynamic technologies may potentially discourage criminal activity and increase fear of crime, it is unknown how they impact citizens' perceptions of safety. *Perceived safety* refers to the basic human need to feel safe and remain unharmed (Dickerson et al., 2007). Understanding the impact of dynamic guardians on feelings of safety is significant, as the adoption of dynamic technologies relies on how safe citizens feel around them (Malik et al., 2024). Moreover, as men and women differ on a biological and behavioural level (Szadvári et al., 2022), these differences may strongly influence how individuals respond to crime, perceive safety, and react to presence of dynamic technologies.

Gender, Safety Perception and Dynamic Guardians

Gender affects how individuals respond to crime, for instance in bystander situations where others are in danger. *Bystanders* are individuals who, may or may not intervene during an emergency (Banyard et al., 2007; Banyard et al., 2003). Women are more likely to intervene in cases of sexual harassment or stop a theft from occurring than men are (Austin, 1979; McMahon, 2010; McMahon & Banyard, 2011). This is due to men experiencing more bystander barriers than women (Burn, 2009). Barriers that affect bystander action include, overlooking signs of violence, failing to comprehend the seriousness of the situation, and failing to assume responsibility (Amar et al., 2012; Banyard & Moynihan, 2011). Gender disparities extend beyond bystander behaviour, to the way individuals perceive their surroundings.

Gender differences are especially visible in perceptions of safety. When both genders are exposed to the same environments, women tend to feel less safe than men (Baran et al., 2018). In line with this, Cui et al. (2023), discovered that after showing men and women the same street view images, women identified 63% of them as less safe, while men perceived only 23% as unsafe, highlighting a 40% difference. This is due to the fact that perception of safety depends greatly on whether an individual feels confident in their ability to protect themselves (Syropoulos et al., 2024). This does not necessarily mean that men feel less fear, rather it suggests that women may have less confidence in their self-protective abilities (Syropoulos et al., 2024). Additionally, gender is associated with fear of victimization from different types of crimes. For instance, Brands et al. (2024), determined that physical and social disorder was associated with fear of physical aggression for both men and women, while social disorder was specifically linked to fear of sexual harassment for women (Brands et al., 2024). This is understandable as women are two times more likely to experience sexual assault than men (Kearl, 2018). As perception of safety varies depending on gender, it is important to investigate whether dynamic guardians could impact men and women differently.

Since research on the impact of dynamic guardians on perceptions of safety is scarce, studies on related symbolic guardians such as CCTV cameras can be used to gain valuable preliminary insight on how men and women feel around security technologies. Spriggs et al. (2005) found that a large portion of UK citizens were very satisfied with the installation of cameras, especially those who had been victims of crime. Additionally, CCTV supporters, believed that the installation of such security devices around one's property would significantly lower levels of crime. Yet, no significant attitude differences were found between men and women towards CCTV cameras (Spriggs et al., 2005). On the contrary, Yavuz and Welch (2010), found that women remain skeptical as to whether CCTV cameras keep them safe. One explanation for this vulnerability could be due to women's heightened fear of crime (Ferraro, 1996). Even if men are more likely to be victimized, women experience more fear than men towards victimization (Ferraro, 1996). Therefore, although the majority of individuals think that CCTV cameras can reduce the chance of criminal activity, women are not convinced. In the context of dynamic guardianship, this could suggest that women might exhibit a lower perception of safety than men before and after exposure to dynamic guardians.

However, this concern with safety may lead women to adopt vigilance. This heightened alertness increases the likelihood of women noticing more environmentally threatening cues. For instance, Ding et al. (2020), found that women are more likely to notice details in their environment, such as potential dangers, other people and escape exits etc. Women seem to avoid empty streets, enclosed spaces, unattended areas (with graffiti or garbage), streets with inadequate lighting and limited visibility. On the contrary, they prefer walking on streets that are populated, well lit, clean, with good visibility and CCTV cameras (Ding et al., 2020). This increased awareness could extend to a higher sensitivity towards dynamic guardians such as voice-enabled cameras, motion-activated lights and blinds.

The Present Study

The current study aims to investigate the effect of dynamic guardianship on safety perception. Prior research on dynamic guardianship has been very limited, thus reaching a deeper understanding of dynamic guardians would be crucial for helping reduce burglaries in residential neighbourhoods.

Initially, it is important to determine whether dynamic guardians have any effect on perception of safety. Moreover, as men and women differ in their perceptions of safety, it would be interesting to investigate whether dynamic guardians influence safety perception differently depending on gender. As well as whether the frequency of noticing these dynamic technologies depends on gender. Therefore, in order to measure perception of safety, the latter will be measured twice. Once before participants have been informed about their exposure to dynamic guardians (voice-activated cameras, motion-activated lights and blinds) and once after.

This study will make use of Virtual Reality (VR) technology to expose citizens to dynamic guardians. The VR environment will imitate real-world environment, specifically a Dutch residential neighbourhood. While using this technology, participants will be able to walk around the neighborhood and will be exposed to presence of either one of three dynamic guardians. This is done to understand how participants feel about dynamic guardians, and whether these technologies will influence their perceptions of safety. While investigating this relationship, gender will be used as a second independent variable.

Hypotheses

H1: For participants exposed to dynamic guardians, perception of safety will be higher compared to those exposed to the control condition.

H2: Women exposed to dynamic guardians will have a lower perception of safety than men, both before being aware of dynamic guardians and after being informed about them.

H3: Women will identify the presence of dynamic guardians more than men will.

Methods

Participants

Initially, the study had a total of 105 participants, but four of them had to be excluded, as they were either unable to finish the study or did not prefer to state their gender. Hence their data was unusable for answering the hypothesis. Most participants were students from the University of

Twente, with their ages ranging between 18 and 28, *Mage* = 21.7*, SDage* = 1.92. The sample comprised of 45 males and 56 females, with 33.6% of participants originating from Germany, 22.7% from the Netherlands and 43.5% from other countries. Prior to data collection, ethical approval was granted by the Behavioural, Management Social Sciences (BMS) ethical committee of the University of Twente. To create an incentive for participation 1.5 Sona Credits were offered to participants in exchange for their time and effort. To increase participation, posters and social media were utilised to inform potential participants that were not aware of the study. Therefore, participants were gathered through convenience and snowball sampling. To participate, in this study participants had to fulfil three criteria, namely, to be over the age of 18, communicate well in English and to attend the study on campus.

Research Design

This study was of a quantitative nature, with safety perception serving as dependent variable and experimental conditions (cameras, lights, blinds) and gender as independent variables. Therefore, to investigate this relationship, a between-subjects design was applied. To achieve this, participants were distributed randomly to four experimental conditions: (1) control *(N* = 23*)*, (2) motion-activated blinds *(N* = 25*)*, (3) voice-enabled cameras *(N* = 27*)*, and (4) motion-activated lights *(N* = 26*)*. Prior to participation, participants were not informed of these dynamic guardians and the condition in which they would be allocated.

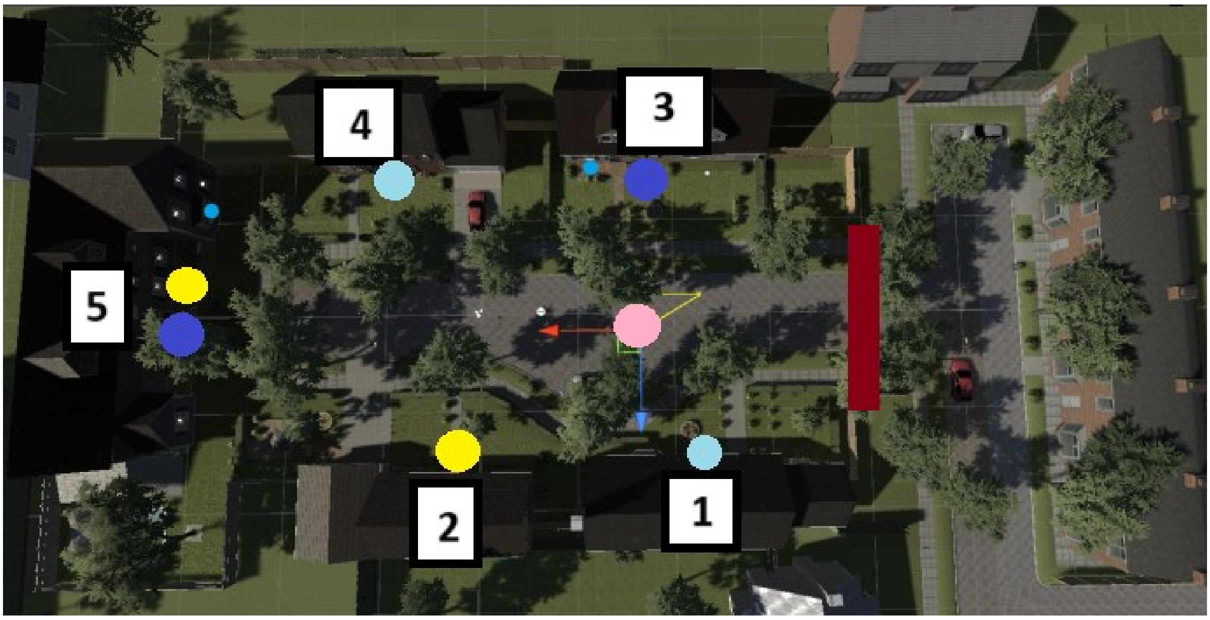
Materials

Questionnaires

The Virtual Neighbourhood. The virtual environment (VE) was designed using Unity Pro programming tools (version 2021.3.4f1) and participants could explore it by wearing a Meta Quest 2 headset, which offered a 360° high quality experience. Participants were given two game controllers, one to walk and the other to change their direction. To ensure that participants felt comfortable, they were offered the opportunity to choose whether their preferred to stand or sit during the VR experiment. Before entering the environment, participants were asked to pretend to be potential home buyers. This enabled them to visit all the homes, and to unknowingly activate the dynamic guardians. To guarantee an authentic experience, the VE imitated an average looking Dutch neighborhood with both acoustic sound effects and visual cues. Upon entering the VE, participants were exposed to a neighborhood which consisted of five unique looking houses (see figure 1).

Figure 1

Neighbourhood Overview



Note. Pink dot represents the starting point of each participant; Two yellow spots represent the houses for the voice-enabled camera condition; Two dark blue spots represent the light condition; Two light blue spots represent the blinds condition. The red line represents the finish point for each participant.

Once the participant entered the environment, they were immersed in different sounds such as singing birds and car engines. Moreover, participants could see a car passing by the neighborhood and two cars parked outside of two out of five homes (see figure 2). Visually the houses had different designs with each being unique inside and outside (see figure 3). All homes had front gardens, with flowers, bushes sand sprinklers. One of the houses had a big back garden, with a pool and a sitting area that was accessible for participants to explore. Participants did not have a time limit but once they were certain about their house choice, they could walk towards the construction barriers and exit the neighborhood.

Figure 2

Example of Parked car

Figure 3

Example House 3

Dynamic Guardianship Manipulations. The participants were exposed to one of three dynamic conditions: either voice-enabled cameras, or motion-activated lights or blinds. All dynamic guardians were activated once the participants approached the property. For the first condition, only house two and five were equipped with voice-enabled cameras, and as soon as the participants went near the property the camera asked the following question: ‘Hey, I see you are looking for something, can I help you?”, (see figure 4). For the second condition of the automated lights, once the participants approached houses number three and five, the lights turned on (see figure 5). Lastly, the motion-activated blinds were applied to houses one and four, and they were activated by closing when the participant approached the garden (see figure 6).

Figure 4

Camera Condition House 2

Figure 5

Lights condition House 5

Figure 6

Blinds Condition House 1

Manipulation Checks. Participants were asked an open-ended question regarding what they had seen in the VE in order to assess whether they had been aware of their exposure to Smart Home Devices (SHDs). Participants that detected either the voice-activated cameras, motion-activated lights or blinds were coded as “Noticed”. On the other hand, participants that did not detect any dynamic guardians were coded as “Not Noticed”. Lastly participants that noticed multiple of them, were coded as “Noticed Multiple”.

Effect of Dynamic Guardianship on Perceived Safety. Perception of safety was measured twice to determine the effectiveness of dynamic guardians on perceived safety. In the beginning, participants were introduced to the first set of questions where they could share their initial impressions and thoughts about the safety of the neighbourhood. These responses were coded as perceived safety 1 ($\alpha = 0.77$; $M = 3.63$ $SD = 0.66$). After being provided with the definition of Smart Home Devices (SHDs), participants were instructed to mention any SHDs they might have detected. Soon after, to assess whether perception of safety was re-evaluated after the introduction of SHDs, participants had to answer the same set of questions as before. The responses were coded as perceived safety 2 *(*$\alpha = 0.73$; $M = 3.6$, $SD = 0.56$).

The scale used to measure participants perceptions of the neighbourhood contained 6 items and allowed participants to mention their level of agreement from 1 to 5 *(1 = strongly disagree; 5 = strongly agree)*. Examples of these items include “Neighborhood residents look out for each other”, and “Neighborhood residents will call the police when they see crime taking place”, within the few. The 4 first items were preexisting and had been applied in the study of Van Sintemaartensdijk et al. (2021). The last 2 items were created for the purpose of the current study, and they were used to assess subjective perception of safety, with 1 of the 2 items being “I feel safe walking alone in the neighborhood”. This addition was used to enrich the data regarding participants’ safety experience in the VE ($r(101) = .497$, $p < .001$).

Game Experience. Participants were asked to share their gaming proficiency, to assess whether it had an impact on their answers and their navigation in the VE. Specifically, participants had to report the number of hours spent each week playing with a controller ($M = 1.05$, $SD = 2.15$), a keyboard ($M = 3.44$, $SD = 6.66$), and VR games with a head-mounted display ($M = 0.07$, $SD = 0.43$). Additionally, participants had to report on a scale of 1 to 5 their VR experience and confidence when dealing with a VR headset *(1 = beginner; 5 = expert)* ($\alpha = 0.77$; $M = 2.7$, $SD = 1.1$).

Presence. The assess the quality of the VE and how immersed participants felt in the neighbourhood, they were instructed to fill in a revised version of the Spatial Presence Experience Scale (Hartmann et al., 2016). They had to report their level of agreement on seven items from a scale of 1 to 5 *(1 = strongly disagree; 5 = strongly agree)* ($\alpha = 0.81$; $M = 3.3$, $SD = 0.78$) about their experience in the virtual neighbourhood, with statements such as “I felt like I was actually in the virtual neighbourhood” and “I felt like I was part of the virtual environment”, among others.

Cybersickness. The Simulator Sickness Questionnaire was used to measure the potential level of cybersickness participants might have experienced in the VE (Van Sintemaartensdijk, et al., 2021). Participants were instructed to indicate their level of discomfort on a 5-point Likert scale *(1 = strongly disagree; 5 = strongly agree)* ($\alpha = 0.82$; $M = 2.3$, $SD = 1$). Potential symptoms included nausea, stomack ache, dizziness, lack of focus and blurry vision.

Demographics. The last scale measured participants' demographic information. Except for age, country of origin and current level of education, gender was especially important for answering the hypotheses.

Procedure

The experiment lasted around forty-five minutes, and it was conducted in Flex room 2, property of the Behavioural, Management and Social Sciences in the Langezijds building of the University of Twente. Upon arrival, participants were given time to read the informed consent and decide whether they would continue with the experiment (Appendix 1). The informed consent clearly stated the context of the experiment, the procedure, potential discomforts, benefits, a confidentiality statement and the contact information of the researchers. Once the participant had consented to take part in the research, they read a study scenario (Appendix 2). The scenario encouraged participants to envision that they are potential home buyers and that by entering the VE they would be offered the opportunity to see different houses and then decide to hypothetically purchase one.

Prior to entering the VE, participants were introduced to the controllers and VR glasses, and they were informed about their usage. As well as, about the importance of exiting the environment via the construction barriers as soon as had finished navigating the neighbourhood. Participants were then given a brief amount of time to ask questions and adjust the glasses to their preferred size. Upon starting, participants were unknowingly assigned to one of the four conditions (control, voice-activated cameras, motion-activated lights or blinds). Once the glasses were on, the computer screen would display the actions of the participant in the VE, while the Open Broadcast Software (OBS) would record participants' activity. As soon as, the participant was satisfied with observing all houses, they would then exit the environment and return the equipment to the researcher.

After the experiment was over, the participant was given 5 minutes of rest time in case they felt discomfort and then continued with filling in the web-based questionnaire via Qualtrics. Lastly, immediately after finishing the questionnaire, participants were given a debriefing form which explained the true purpose of the study and then were given the chance to revoke their consent for participation (Appendix 3).

Data Analysis

Initially, the data was downloaded from Qualtrics and then imported into R (version 4.4.2) and Jamovi (version 2.3.28.0) to be analysed. In the preliminary phase, the data was cleaned, transformed, and summary statistics were calculated. Additionally, spearman's correlational analysis was conducted to assess whether the items 5 and 6 of the perceived safety scale were correlated with the rest of the items. Moreover, the all the questionnaire variables were investigated to assess whether they met parametric assumptions. Specifically, the results showed that linearity, homoscedasticity, and independence were satisfactory for all questionnaire variables, but the dependent variable Perception of Safety 1, did not follow a normal distribution. As both Perception of Safety 1 and Perception of Safety 2 had to be combined in subsequent analyses, a Box-Cox transformation was applied for both variables. Both transformations led to normal distributions.

In the next phase, a General linear model (GLM) was utilized to assess whether the VR components (Presence, VR experience and Cybersickness) differed between the experimental conditions. This GLM was performed to determine whether these three variables could be accounted as confounders in the subsequent analyses. Later on, manipulation checks were carried out, with Condition (control, blinds, camera, lights) as an independent variable (IV) and noticing Smart Home Devices (SHDs) as the dependent variable (DV). For this analysis, a Chi-square test of independence was conducted. After determining that noticing smart home devices varied greatly across conditions, fisher's exact test with Bonferroni correction was performed to see which specific pairs of conditions differed from each other.

To test the first hypothesis: '*For participants exposed to dynamic guardians, perception of safety will be higher compared to those exposed to the control condition*', two separate GLMs were performed. For the first GLM, the IV was Condition, while the DV was Perception of Safety 1. For the second GLM, Condition remained the IV and Perception of Safety 2 was the DV. The purpose of the two separate GLMs was to determine whether participants in the dynamic guardianship conditions had a higher perception of safety compared to the control group, both before and after being told about the presence of dynamic guardians.

To assess the second hypothesis: '*Women exposed to dynamic guardians will have a lower perception of safety than men, both before being aware of dynamic guardians and after being informed about them',* three GLMs were conducted. For the first GLM, the IVs were Condition and Gender, and the DV was Perceived Safety 1. For the second GLM, the IVs were Condition and Gender, and the DV was Perceived Safety 2. These GLMs examined whether women perceived lower safety than men, both before and after being told about dynamic guardians. For the last GLM, the IVs were Condition and Gender, and the DV was the difference between the two previous DVs (Perceived Safety1 - Perceived Safety 2). This GLM assessed whether the difference between Perception of safety 1 and 2 was lower for women than men.

To evaluate the third hypothesis: '*Women will identify the presence of dynamic guardians more than men will',* a Chi-Square of Independence was carried out. The IV was Gender and the DV was the Frequency of noticing SHDs. This analysis was conducted to determine whether gender had an impact on the frequency of noticing SHDs, and subsequently whether women noticed dynamic guardians more often than men.

Results

A summary of the descriptive statistics for Presence, cybersickness, VR experience, safety 1 and safety 2 across all condition can be found in Table 1. Moreover, to assess the differences of VR experience, presence and cybersickness across all conditions (control, blinds, camera and lights) a GLM was used. In the model, the VR components served as DVs while Condition as the IV. For VR experience there were no differences between conditions, $F(3, 97) = 1.48$, $p = .23$, $R^2 = .01$. Similarly, no significant effects were found for presence, $F(3, 97) = 1.82$, $p = .18$, $R^2 = .02$ and for cybersickness respectively, $F(3, 97) = 2.09$, $p = .15$, $R^2 = .02$. As VR components did not differ significantly across conditions, the variables were not controlled as confounders in the main analyses.

Table 1

Summary Statistics for Presence, Cybersickness, VR Experience, Safety Perception 1 and Safety Perception 2 Questionnaires Across all Conditions

Variables	Condition	*M*	*SD*
Presence	Control	3.5	0.7
	Blinds	3.4	0.6
	Camera	3.1	0.8
	Lights	3.2	0.9
Cybersickness	Control	2.0	0.9
	Blinds	2.3	1.1
	Camera	2.2	1.2
	Lights	2.5	0.9
VR experience	Control	2.6	1.2
	Blinds	2.3	1.1
	Camera	2.7	1.3
	Lights	2.0	1.2
Safety Perception 1	Control	3.8	0.6
	Blinds	3.6	0.7
	Camera	3.6	0.7
	Lights	3.5	0.5
Safety Perception 2	Control	3.7	0.5
	Blinds	3.6	0.6

Camera	3.7	0.5
Lights	3.4	0.5

Afterwards, a Chi-square test of independence was performed to determine whether participants noticed the manipulations in the Virtual Environment, and in which condition they noticed them more frequently. For the control condition (*M* = 0.5*, SD* = 0.5*)*, for the blinds condition (*M* = 0.7, *SD* = 0.4), for the camera condition (*M* = 0.9*, SD* = 0.3*)* and for the lights condition (*M* = 0.9*, SD* = 0.3*)*. The chi-square test showed a significant value, indicating that the conditions varied greatly from each other (χ^2 (3, 101) = 13.6, *p* = .003).

To investigate which pairs of conditions differed the most, pair-wise comparisons (Post-Hoc) were performed. For this purpose, Fisher's Exact test was employed, while the Bonferroni adjustment was applied to control the possibility of type 1 error. The findings showed that the control and camera conditions differed significantly, *p* Bonferroni = 0.02, *OR* = 0.109, 95% *CI* [0.01, 0.62]. Likewise, significant variations were detected between the control and lights condition too, *p* Bonferroni = 0.02, *OR* = 0.113, 95% *CI* [0.01, 0.65]. On the opposite side, the control and blinds conditions showed non-significant differences, *p* Bonferroni = 1.0, *OR* = 0.51, 95% *CI* [0.13, 1.96].

Main Analyses

For the first hypothesis, *'For participants exposed to dynamic guardians, perception of safety is higher compared to those not exposed'*, two General linear models (GLMs) were performed. In the first GLM regarding the effect of Condition on Perception of Safety 1, the analyses showed no statistical significance, $F(3, 97) = 0.64$, $p = .591$, $R^2 = .019$. Along the same lines, the second model revealed no significant findings between the IV and Perception of Safety 2, $F(3, 97) = 2.60$, $p = .056$, $R^2 = .076$.

To test the second hypothesis, *'Women exposed to dynamic guardians have a lower perception of safety than men, both before being aware of dynamic guardians and after being informed about them',* three GLMs were conducted. In the first GLM, neither Condition, $F(3, 97) = 0.63$, $p = .599$, $R^2 = .02$, nor Gender, $F(1, 99) = 0.26$, $p = .610$, $R^2 = .002$, nor the interaction of Condition and Gender, $F(3, 97) = 0.61$, $p = .611$, $R^2 = .04$, significantly predicted Perception of Safety 1. Similarly, for the second GLM, neither Condition, $F(3, 97) = 2.60$, $p = .056$, $R^2 = .08$, nor Gender, $F(1, 99) = 2.03$, $p = .157$, $R^2 = .02$, nor the interaction of Condition and Gender, $F(3, 97) = 0.69$, $p = .557$, $R^2 = .11$, significantly impacted Perception of Safety 2. Lastly, for the third GLM, neither Condition, F(3, 97) = 0.33, $p = .805$, $R^2 = .01$, nor Gender, F(1, 99) = 0.01, $p = .936$, $R^2 = .0001$, nor the interaction of Condition and Gender, $F(3, 97) = 0.63$, $p = .599$, $R^2 = .03$, significantly predicted the difference between perception of Safety 1 and Perception of Safety 2.

For the last hypothesis, '*Women will identify the presence of dynamic guardians more than men will'*, although women noticed all SHDs slightly more often than men did, the proportion of women in the study was higher. Men reported noticing SHDs in 35 out of 45 instances ($M = 0.78$, $SD = 0.42$), while women reported noticing SHDs in 45 out of 56 instances ($M = 0.8$, $SD = 0.40$). The Chi-square of Independence revealed no significant findings between Gender and the frequency of noticing SHDs (χ^2 (4, 101) = 1.52, $p = .824$. For this reason, no further analyses were conducted.

Discussion

The aim of the study was to evaluate whether dynamic guardians have an impact on perception of safety, and whether gender could affect this relationship. Additionally, this study aimed to determine whether the frequency of noticing SHDs depended on gender. Preliminary analysis revealed that participants were more likely to notice SHDs in the voice-enabled cameras and motion-activated lights condition compared to the motion-activated blinds condition. Regarding the main findings, none of the dynamic guardians (cameras, lights, and blinds) significantly influenced perceived safety, and no difference in perceptions of safety was found between the control group and the group exposed to SHDs. Contrary to expectations, men and women did not differ in their perceptions of safety both before and after being informed about the existence of SHDs. Lastly, gender had no effect on the frequency of noticing SHDs.

The Effect of Dynamic Guardians on Perceptions of Safety

In this research paper, it was hypothesized that dynamic guardians, specifically voice-enabled cameras, motion-activated lights, and blinds would increase participants' perceptions of safety. No such relationship was observed. To begin with, voice-enabled cameras are devices programmed to use human-like voice to imitate human presence (Tan et al., 2022). These cameras can be paired with one's smartphone and offer them access to real-time surveillance. Although they offer these benefits, people are sometimes scared of them. Abdi et al. (2021) found that residents who have adopted these devices, fear that they might be spied on through the smartphone app, leading them to turn off their phones during the night or when they discuss personal matters with others. Moreover, these devices create the feeling of constant surveillance, essentially making people feel that they are being watched and that their privacy has been breached (Makwana, 2019). The impression of constant surveillance can increase distress and even lead to paranoia, with individuals experiencing immense amounts of stress and even panic attacks (Makwana, 2019). Therefore, concerns of surveillance and privacy breaches can limit self-expression and personal freedom (Jain et al., 2021) and might essentially overshadow the positive effects of cameras on feelings of safety and overall well-being (Li & Liu, 2021).

Regardless of their impact on perceptions of safety, voice-enabled cameras were noticed frequently, and this was possibly due to two factors. The first one is the projection of red light on the top corner of the cameras. The red light suggests that the camera is working, and is essentially easy to detect (Abaya et al., 2014). The second factor is the presence of the human-like voice which accompanied the camera and was used to warn participants about the ongoing surveillance. Generally, the use of human-like voice relies on the natural instincts of humans to listen closely to speech (Kühne et al., 2020). Therefore, it would make sense that the combination of both visual and verbal cues would make cameras more noticeable to participants and possibly to potential burglars.

Secondly, motion-activated lights are programmed to automatically activate when someone or something is in close proximity of a property. While it was hypothesized that smart lights would increase participants' perception of safety, such link was not found. Although the presence of lights has been found to foster feelings of safety for humans, the colour of lights plays a large role (Boomsma & Steg, 2014). For instance, warmer (yellow tone) lights enhance perceived safety (Portnov et al., 2020), while cooler (blue tone) lights just improve visibility (Knight, 2010). Additionally, the intensity of lights can also impact emotions (Schlangen, 2019). For example, dim lights have been found to calm people, while exposure to cool and high illuminance lighting can foster negative emotions as well as make individuals feel nervous (Masullo et al., 2022). Therefore, it is possible that the motion-activated lights of this study were not designed with the correct colour and intensity to achieve a noticeable effect on feelings of safety.

Generally, participants detected the motion-activated lights more frequently than the blinds. This could be due to the attention-grabbing nature of visual dynamics (Yantis & Jonides, 1984). The sudden onset of a visual stimulus in an environment can be particularly attention-grabbing, as humans cannot easily overlook the sudden appearance of an object in their visual field. An everyday example of a visual stimulus that is difficult to ignore, are flashing lights or flickers, which are normally used by police officers and ambulances. Although, these flickers turn on and off multiple times to grab the recipient's attention (Cass et al., 2011), the motion activated lights, while different, operate with a similar mechanism by creating an abrupt and unexpected visual disruption. As the motion-activated lights in this study appeared suddenly after participants approached the houses, it very likely that the lights captured their attention.

Thirdly, motion-activated blinds automatically close when someone is approaching a property. It is possible that the blinds had no impact on perception of safety either because participants did not understand their importance or because they failed to notice them. When filling out the questionnaires, participants were asked to mention whether they noticed any SHDs. Normally, smart blinds would be considered as useful home-appliances rather than security measures (Valencia-Arias et al., 2023). Therefore, participants might have noticed the blinds but not mentioned their presence because they did not consider them as security devices. Yet, as the preliminary findings revealed that blinds were rarely detected, it is possible that participants missed them completely. This could be due to inattentional blindness, which occurs when individuals are performing a task and unintentionally fail to detect stimuli in an environment (Hyman et al., 2010). Moreover, when one does not expect to see an object, they might fail to notice it even if they directly glazed at it (Simons & Chabris, 1999). Especially in complex and confusing virtual environments, where cues are very subtle (Hyman et al., 2010; Gajjar et al., 2017). As virtual reality, compared to the use of a normal computer, can lead to higher cognitive overload (Juliano et al., 2022). *Cognitive Overload* occurs when the amount of information surpasses a person's cognitive capacity (Cao & Sun, 2017). Therefore, the prominence of visual and acoustic elements in the virtual environment could have overshadowed the presence of the blinds and potentially diminishing their impact on residents' perceptions of safety.

Although the findings did not support the hypothesis, it is important to mention that none of the dynamic guardians decreased residents' perceptions of safety. Which means that the SHDs did not induce any fear on residents and were rather neutral. These findings may be explained by the notion of technology neutrality. Technology neutrality refers to the idea that technology is neither bad nor good (Heyndels, 2023). As Noam Chomsky said, "Technology is usually fairly neutral. It's like a hammer, which can be used to build a house or to destroy someone's home. The hammer doesn't care. It is almost always up to us to determine whether the technology is good or bad", (as cited in Valetsianos, 2014). This means that the impact of a technology lies mostly on the way it is handled and the context in which it is used. For instance, although surveillance by voice-enabled cameras may pose a risk on consumer privacy, it does not mean that cameras cannot be used to deter burglars from invading a house. It is all a matter of prioritizing safety, but also thinking about the deterring benefits dynamic guardians may offer.

The strongest advantage of dynamic guardians is their element of surprise. Normally, victims of burglary are not aware about an ongoing burglary. But with voice-enabled cameras, residents can be warned in real time about any ongoing activity on their property (De Oliveira, 2016). Residents can inform the police and essentially stay ahead of burglars without having to physically confront them.

Shifting residents from passive victims to active but safe participants (De Oliveira, 2016). Moreover, although motion-activated lights and blinds may not directly inform residents of an ongoing activity, they function by activating once someone gets close enough and potentially surprising them when they least expect it (Dorn, 2024; Wolniak & Grebski, 2024). Therefore, despite their effect on residents' feelings of safety, dynamic guardians deserve to be investigated in regard to their effectiveness in deterring criminals.

Gender, Perceived Safety and Noticing Dynamic Guardians

For the second hypothesis, it was expected that women exposed to dynamic guardians would feel less safe than men, both before and after being informed about the guardians. This hypothesis was not confirmed. An explanation for this could be the absence of any simulated threats within the Virtual Environment (VE), which made the differences in perception of safety between men and women impossible to measure. For instance, Cui et al. (2023), revealed that even though women perceive dangerous scenes as less safe than men, there are no gender disparities when environments are safer. They added that as safety in an environment decreases, the disparities in feelings of safety between men and women become more noticeable. Therefore, it is possible that women have a lower perception of safety than men, but the VE may have been too neutral to highlight any gender differences.

Another reason for failing to capture gender differences in regard to feelings of safety is the absence of social cues in the VE. Social cues such as facial expressions, body language and speech are important in channeling, expressing and interpreting emotions, as well as shaping impressions of situations or other individuals (Ekman et al., 1980). Brands et al. (2024), for instance found that the presence of male loiterers in the underpass of a train station increased fear of sexual aggression for women compared to men. This means that the presence of avatars demonstrating realistic social cues such as eye contact and body language could have influenced feelings of safety differently depending on gender. Therefore, measuring differences in perceptions of safety between men and women was not successful, as the VR environment was generally perceived as safe and it lacked essential social cues.

For the third hypothesis, women were expected to notice smart home devices more frequently than men. This was anticipated due to women exhibiting increased vigilance when in public and subsequently noticing cues, such as the presence of dynamic guardians (Ding et al., 2020). However, this was not the case, as women and men observed SHDs equally. Research has been scarce and the studies that exist have generally shown mixed results about awareness of security measures such as CCTV and gender. Honess and Charman (1992), reported that men were significantly more likely to notice CCTV cameras in public places than women. The difference was most noticeable in street locations, with 42% of men reporting seeing CCTV, compared to 25% of women. On the other hand, a more recent study by Ding et al. (2020) found that women are especially aware of their surroundings and actively seek out security exits, CCTV cameras, and lighting to reduce the likelihood of victimization. Given these inconsistent findings, it is possible that men and women notice SHDs at similar frequencies, but for different underlying reasons. For instance, it is suggested that men notice CCTV cameras due to their concerns for privacy and freedom (Honess & Charman, 2012), while women actively seek out CCTV cameras in order to ensure that they will stay safe (Ding et al., 2020). Thus, men and women may both be aware of SHDs, but their attention is drawn for different reasons.

Strengths and Limitations

The current study had a variety of strengths. Firstly, 105 participants were recruited in a brief period of time. Which ensured statistical significance and subsequently led to precision of analyses and detection of significant effects (Andrade, 2020). Secondly, this study utilized a Virtual Reality Environment, which was accessed through an HMD (Head-Mounted-Display). It offered a controlled environment, which was highly realistic, and safe for participants to explore. Compared to traditional laboratories that limit natural and spontaneous behaviour (Holmes, 2020). Lastly, two items for the Perceived Safety Scale were created to measure subjective safety, only for the purpose of this paper. The items were created to ensure that the data collected would be precise and highly relevant to the study (Stewart et al., 2012).

Yet, this research paper has a few limitations. Firstly, participants were recruited through convenience sampling. Although, convenience samples are easy to collect, they are normally derived from a concentrated population such as students (Hedt & Pagano, 2011). Thus, the data points are not representative of the whole population, but rather individuals that are close, available and are easy to access (Hedt & Pagano, 2011). Convenience sampling can sometimes be biased and this lack of representation, can essentially skew the data (Galloway, 2005). Secondly, the questionnaires relied mainly on close-ended questions, which take less time for participants to answer and are easier to code and later analyze. However, they are not very informative, as they provide little insights on participants' attitudes (Hyman & Sierra, 2016). Lastly, the only confounding variables that were controlled for in the study, were cybersickness, presence and VR experience. Yet, other factors such as an individual's culture and past experiences can influence the variables and subsequently the relationship (Malik et al., 2024). Confounder variables should be investigated as they can lead to misrepresented relationships and distorted findings (Jager et al., 2007).

Future Directions

Firstly, an important future suggestion is the inclusion of physiological measures during the VR session, to measure the effect of dynamic guardians on residents' physiological states. Physiological measures are used to measure heartrate, skin conductance or cortisol levels (Yetton et al., 2019) and can objectively record participants' physiological responses to different experimental conditions. The inclusion of physiological measures can be greatly beneficial, as questionnaires alone may not fully capture participants' emotional responses (Yetton et al., 2019). While in other cases participants may not be truthful in their responses (Yetton et al., 2019). In practice, to measure situational fear of crime Brands et al. (2024), combined VR with psychophysiological measures, and afterwards administered participants a survey. They found that physiological data have the potential to offer a more complete understanding of fear of crime. Similarly, incorporating these measures would offer the change to explore how participants' bodies change in response to dynamic guardians.

Lastly, it is important to investigate the different variables that may influence the relationship between dynamic guardians and citizens perceptions of safety. The first factors are cultural and societal influences. Culture and society impact how individuals perceive situations and ideas, as well as how they perceive security devices (Malik et al., 2024). For example, some cultures and societies may have more positive attitudes towards technology, than others. Which could subsequently influence perceptions of safety as well as adoption of SHDs. Another factor, which may influence attitude towards SHDs are past experiences (Malik et al., 2024). Participants that have had positive experiences with SHDs (e.g., successful prevention of security breaches), are more likely to exhibit trust and positive attitude towards security devices. On the contrary, negative experiences (e.g., failure to prevent an invasion), can lead to distrust and fear (Malik et al., 2024). Thus, factors such as culture, society and past experiences need to be investigated as they may affect the interaction between dynamic guardians and residents' perceptions of safety.

Conclusion

Perception of safety refers to how safe individuals feel in an environment, especially within their homes. Dynamic guardians are Smart Home Devices that can be programmed to activate when motion is detected. Their aim is to give outsiders the impression that residents are present, and essentially discouraging potential burglars from entering the property. In the current study, the presence of dynamic guardians did not increase residents' perceptions of safety, nor did men and women differ in these perceptions. Although voice-enabled cameras and motion-activated lights were noticed very frequently, no differences in frequency were found between men and women. While these hypotheses were rejected, it is important to remember that SHDs did not make participants feel less safe. Although dynamic guardians may not directly affect residents' feeling safe, they may still have a powerful deterrent effect on burglars.

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References

Abaya, W. F., Basa, J., Sy, M., Abad, A. C., & Dadios, E. P. (2014). *Low-cost smart security camera with night vision capability using Raspberry Pi and OpenCV*. IEEE. https://doi.org/10.1109/HNICEM.2014.7016253

Abdi, N., Zhan, X., Ramokapane, K. M., & Such, J. (2021). Privacy norms for Smart Home Personal assistants. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/3411764.3445122

Amar, A. F., Sutherland, M., & Kesler, E. (2012). Evaluation of a Bystander Education Program. *Issues in Mental Health Nursing*, *33*(12), 851–857. https://doi.org/10.3109/01612840.2012.709915

Andrade, C. (2020). Sample Size and its Importance in Research. *Indian Journal of Psychological Medicine*, *42*(1), 102–103. https://doi.org/10.4103/ijpsym.ijpsym_504_19

Austin, W. (1979). Sex differences in bystander intervention in a theft. *Journal Of Personality And Social Psychology*, *37*(11), 2110–2120. https://doi.org/10.1037/0022-3514.37.11.2110

Balta-Ozkan, N., Davidson, R., Bicket, M., & Whitmarsh, L. (2013). Social barriers to the adoption of smart homes. *Energy Policy*, *63*, 363–374. https://doi.org/10.1016/j.enpol.2013.08.043

Banyard, V. L., & Moynihan, M. M. (2011). Variation in bystander behavior related to sexual and intimate partner violence prevention: Correlates in a sample of college students. *Psychology Of Violence*, *1*(4), 287–301. https://doi.org/10.1037/a0023544

Banyard, V. L., Moynihan, M. M., & Plante, E. G. (2007). Sexual violence prevention through bystander education: An experimental evaluation. *Journal Of Community Psychology*, *35*(4), 463–481. https://doi.org/10.1002/jcop.20159

Banyard, V. L., Plante, E. G., & Moynihan, M. M. (2003). Bystander education: Bringing a broader community perspective to sexual violence prevention. *Journal Of Community Psychology*, *32*(1), 61–79. https://doi.org/10.1002/jcop.10078

Baran, P. K., Tabrizian, P., Zhai, Y., Smith, J. W., & Floyd, M. F. (2018). An exploratory study of perceived safety in a neighborhood park using immersive virtual environments. *Urban Forestry & Urban Greening*, *35*, 72–81. https://doi.org/10.1016/j.ufug.2018.08.009

Bateson, M., Callow, L., Holmes, J. R., Roche, M. L. R., & Nettle, D. (2013). Do Images of 'Watching Eyes' Induce Behaviour That Is More Pro-Social or More Normative? A Field Experiment on Littering. *PLoS ONE*, *8*(12), e82055. https://doi.org/10.1371/journal.pone.0082055

Bennett, T., Holloway, K., & Farrington, D. (2008). The Effectiveness of Neighborhood Watch. *Campbell Systematic Reviews*, *4*(1), 1–46. https://doi.org/10.4073/csr.2008.18

Bhandari, A. (2022). *Feminist Perspectives on Space, Safety and Surveillance: improving a Woman's Right to the City*. Transitions Research. https://transitionsresearch.org/feminist-perspectives-on-space-safety-and-surveillance-improving-a-womans-right-to-the-city/

Boomsma, C., & Steg, L. (2014). Feeling safe in the dark. *Environment and Behavior*, *46*(2), 193–212. https://doi.org/10.1177/0013916512453838

Brands, J., Jansen, J. M., Van Doorn, J., & Spithoven, R. (2024). Measuring and Explaining Situational Fear of Crime: an experimental study into the effects of disorder, using virtual reality and multimodal measurement. *The British Journal of Criminology*. https://doi.org/10.1093/bjc/azae072

Burn, S. M. (2009). A Situational Model of Sexual Assault Prevention through Bystander Intervention. *Sex Roles*, *60*(11–12), 779–792. https://doi.org/10.1007/s11199-008-9581-5

Cao, X., & Sun, J. (2017). Exploring the effect of overload on the discontinuous intention of social media users: An S-O-R perspective. *Computers in Human Behavior*, *81*, 10–18. https://doi.org/10.1016/j.chb.2017.11.035

Cass, J., Van Der Burg, E., & Alais, D. (2011). Finding Flicker: Critical differences in temporal frequency capture attention. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00320

Chan, M., Estève, D., Escriba, C., & Campo, E. (2008). A review of smart homes—Present state and future challenges. *Computer Methods and Programs in Biomedicine*, *91*(1), 55–81. https://doi.org/10.1016/j.cmpb.2008.02.001

Cohen, L. E., & Felson, M. (1979). Social Change and Crime Rate Trends: A Routine Activity Approach. *American Sociological Review*, 44(4), 588. https://doi.org/10.2307/2094589

Coupe, T., & Blake, L. (2006). Daylight and darkness targeting strategies and the risks of being seen at residential burglaries. *Criminology: An Interdisciplinary Journal, 44*(2), 431–464. https://doi.org/10.1111/j.1745-9125.2006.00054.x

Cui, Q., Zhang, Y., Yang, G., Huang, Y., & Chen, Y. (2023). Analysing gender differences in the perceived safety from street view imagery. *International Journal Of Applied Earth Observation And Geoinformation*, *124*, 103537. https://doi.org/10.1016/j.jag.2023.103537

De Oliveira, C. A. (2016). The impact of private precautions on home burglary and robbery in Brazil. *Journal of Quantitative Criminology*, *34*(1), 111–137. https://doi.org/10.1007/s10940-016-9325-6

Dear, K., Dutton, K., & Fox, E. (2019). Do 'watching eyes' influence antisocial behavior? A systematic review & meta-analysis. *Evolution And Human Behavior*, *40*(3), 269–280. https://doi.org/10.1016/j.evolhumbehav.2019.01.006

Dickerson, A. E., Molnar, L. J., Eby, D. W., Adler, G., Bédard, M., Berg-Weger, M., Classen, S., Foley, D., Horowitz, A., Kerschner, H., Page, O., Silverstein, N. M., Staplin, L., & Trujillo, L. (2007). Transportation and Aging: A Research Agenda for Advancing Safe Mobility. *The Gerontologist*, *47*(5), 578–590. https://doi.org/10.1093/geront/47.5.578

Ding, H., Loukaitou-Sideris, A., & Agrawal, A. W. (2020). Sexual Harassment and Assault in transit Environments: A review of the English-language literature. *Journal of Planning Literature*, *35*(3), 267–280. https://doi.org/10.1177/0885412220911129

Dorn, M. (2024, September 11). *The Role of Visibility in Crime Prevention*. Tech Deployments Made Simple by Critical Tech Solutions. https://www.criticalts.com/articles/maximizing-visibility-a-key-factor-in-crime-prevention/

Dutch Penal Code, art. 311 (2024). *Wetboek van Strafrecht*. https://wetten.overheid.nl/BWBR0001854/

Ekman, P., Friesen, W. V., O'Sullivan, M., & Scherer, K. (1980). Relative importance of face, body, and speech in judgments of personality and affect. *Journal of Personality and Social Psychology*, *38*(2), 270–277. https://doi.org/10.1037/0022-3514.38.2.270

Felson, M., & Cohen, L. E. (1980). Human ecology and crime: A routine activity approach. *Human Ecology, 8*, 389-406. https://doi.org/10.1007/BF01561001

Ferraro, K. F. (1996). Women's fear of victimization: Shadow of sexual assault? *Social Forces*, *75*(2), 667. https://doi.org/10.2307/2580418

Francey, D., & Bergmüller, R. (2012). Images of Eyes Enhance Investments in a Real-Life Public Good. *PLoS ONE*, *7*(5), e37397. https://doi.org/10.1371/journal.pone.0037397

Gajjar, V., Gurnani, A., & Khandhediya, Y. (2017). Human Detection and Tracking for Video Surveillance: A Cognitive Science Approach. arXiv preprint arXiv:1709.00726. https://doi.org/10.48550/arXiv.1709.00726

Galloway, A. (2005). Non-probability sampling. In *Elsevier eBooks* (pp. 859–864). https://doi.org/10.1016/b0-12-369398-5/00382-0

Hanson, R. F., Sawyer, G. K., Begle, A. M., & Hubel, G. S. (2010). The impact of crime victimization on quality of life. *Journal Of Traumatic Stress*, *23*(2), 189
197. https://doi.org/10.1002/jts.20508

Hartmann, T., Wirth, W., Schramm, H., Klimmt, C., Verderer, P., Gysbers, A., Böcking, S., Ravaja, N., Laarni, J., Saari, T., Gouveia, F., & Sacau, A. M. (2016). The Spatial Presence Experience Scale (SPES). *Journal Of Media Psychology Theories Methods And Applications*, *28*(1), 1–15. https://doi.org/10.1027/1864-1105/a000137

Hedt, B. L., & Pagano, M. (2011). Health indicators: Eliminating bias from convenience sampling estimators. *Statistics in Medicine*, *30*(5), 560–568. https://doi.org/10.1002/sim.3920

Heyndels, S. (2023). Technology and neutrality. *Philosophy & Technology*, *36*(4). https://doi.org/10.1007/s13347-023-00672-1

Hollis, M. E., Felson, M., & Welsh, B. C. (2013). The capable guardian in routine activities theory: A theoretical and conceptual reappraisal. *Crime Prevention and Community Safety*, *15*(1), 65–79. https://doi.org/10.1057/cpcs.2012.14

Hollis-Peel, M. E., Reynald, D. M., Van Bavel, M., Elffers, H., & Welsh, B. C. (2011). Guardianship for crime prevention: a critical review of the literature. *Crime Law and Social Change*, *56*(1), 53–70. https://doi.org/10.1007/s10611-011-9309-2

Holmes, N. G. (2020). Why traditional labs fail. . .and what we can do about it. In *Springer eBooks* (pp. 271–290). https://doi.org/10.1007/978-3-030-33600-4_18

Honess, T., & Charman, E. (1992). *Closed circuit television in public places: Its acceptability and perceived effectiveness*. In The University of Edinburgh. London: Home Office Police Department. http://www.casa.ucl.ac.uk/cyberspace/fcpu35.pdf

Hyman, H. M. R., & Sierra, S. J. J. (2016). Open- versus closed-ended survey questions. *Business Outlook*, *14*(2), 1–5. https://www.researchgate.net/publication/282249876

Hyman, I. E., Jr., Boss, S. M., Wise, B. M., McKenzie, K. E., & Caggiano, J. M. (2010). Did you see the unicycling clown? Inattentional blindness while walking and talking on a cellphone. *Applied Cognitive Psychology, 24*(5), 597-607. https://doi.org/10.1002/acp.1638

Jager, K., Zoccali, C., MacLeod, A., & Dekker, F. (2007). Confounding: What it is and how to deal with it. *Kidney International*, *73*(3), 256–260. https://doi.org/10.1038/sj.ki.5002650

Jain, A. K., Sahoo, S. R., & Kaubiyal, J. (2021). Online social networks security and privacy: comprehensive review and analysis. *Complex & Intelligent Systems*, *7*(5), 2157–2177. https://doi.org/10.1007/s40747-021-00409-7

Jones, R. W., & Pridemore, W. A. (2018). Toward an integrated multilevel theory of crime at place: routine activities, social disorganization, and the law of crime concentration. *Journal of Quantitative Criminology*, *35*(3), 543–572. https://doi.org/10.1007/s10940-018-9397-6

Juliano, J. M., Schweighofer, N., & Liew, S. (2022). Increased cognitive load in immersive virtual reality during visuomotor adaptation is associated with decreased long-term retention and context transfer. *Journal of NeuroEngineering and Rehabilitation*, *19*(1). https://doi.org/10.1186/s12984-022-01084-6

Kearl, H. (2018). *The facts behind the #metoo movement: A national study on sexual harassment and assault*. Stop Street Harassment. https://www.nsvrc.org/sites/default/files/2021-04/full-report-2018-national-study-on-sexual-harassment-and-assault.pdf

Knight, C. (2010). Field surveys of the effect of lamp spectrum on the perception of safety and comfort at night. *Lighting Research & Technology*, *42*(3), 313–329. https://doi.org/10.1177/1477153510376794

Kotha, H. D., & Gupta, V. M. (2018). IoT application, a survey. *International Journal of Engineering & Technology*, *7*(2.7), 891. https://doi.org/10.14419/ijet.v7i2.7.11089

Kühne, K., Fischer, M. H., & Zhou, Y. (2020). The human takes it all: humanlike synthesized voices are perceived as less eerie and more likable. evidence from a subjective ratings study. *Frontiers in Neurorobotics*, *14*. https://doi.org/10.3389/fnbot.2020.593732

MacDonald, J. E., & Gifford, R. (1989). Territorial cues and defensible space theory: The burglar's point of view. *Journal Of Environmental Psychology*, *9*(3), 193–205. https://doi.org/10.1016/s0272-4944(89)80034-9

Macmillan, R. (2000). Adolescent victimization and income deficits in adulthood: Rethinking the costs of criminal violence from a life-course perspective*. *Criminology*, *38*(2), 553–588. https://doi.org/10.1111/j.1745-9125.2000.tb00899.x

Makwana, N. (2019). Disaster and its impact on mental health: A narrative review. *Journal of Family Medicine and Primary Care*, *8*(10), 3090. https://doi.org/10.4103/jfmpc.jfmpc_893_19

Malik, A. S., Acharya, S., & Humane, S. (2024). Exploring the Impact of security Technologies on Mental Health: A Comprehensive review. *Cureus*. https://doi.org/10.7759/cureus.53664

Masullo, M., Cioffi, F., Li, J., Maffei, L., Scorpio, M., Iachini, T., Ruggiero, G., Malferà, A., & Ruotolo, F. (2022). An investigation of the influence of the night lighting in an urban park on individuals' emotions. *Sustainability*, *14*(14), 8556. https://doi.org/10.3390/su14148556

McClanahan, W. P., Sergiou, C. S., Siezenga, A. M., Gerstner, D., Elffers, H., Van Der Schalk, J., & Van Gelder, J. (2024). Neighborhood crime reduction interventions and perceived livability: A virtual reality study on fear of crime. *Cities*, *147*, 104823. https://doi.org/10.1016/j.cities.2024.104823

McMahon, S. (2010). Rape Myth Beliefs and Bystander Attitudes Among Incoming College Students. *Journal Of American College Health*, *59*(1), 3–11. https://doi.org/10.1080/07448481.2010.483715

McMahon, S., & Banyard, V. L. (2011). When Can I help? A Conceptual Framework for the Prevention of Sexual Violence Through Bystander Intervention. *Trauma Violence & Abuse*, *13*(1), 3–14. https://doi.org/10.1177/1524838011426015

Nettle, D., Nott, K., & Bateson, M. (2012). 'Cycle Thieves, We Are Watching You': Impact of a Simple Signage Intervention against Bicycle Theft. *PLoS ONE*, *7*(12), e51738. https://doi.org/10.1371/journal.pone.0051738

Oken, B., Salinsky, M., & Elsas, S. (2006). Vigilance, alertness, or sustained attention: physiological basis and measurement. *Clinical Neurophysiology*, *117*(9), 1885–1901. https://doi.org/10.1016/j.clinph.2006.01.017

Piza, E.L., Welsh, B.C., Farrington, D.P., & Thomas, A.L. (2019). CCTV surveillance for crime prevention: A 40-year systematic review with meta-analysis. *Criminology & Public Policy*. 2019; 18: 135–159. https://doi.org/10.1111/1745-9133.12419

Portnov, B. A., Saad, R., Trop, T., Kliger, D., & Svechkina, A. (2020). Linking nighttime outdoor lighting attributes to pedestrians' feeling of safety: An interactive survey approach. *PLoS ONE*, *15*(11), e0242172. https://doi.org/10.1371/journal.pone.0242172

Reynald, D. M. (2009). Guardianship in action: Developing a new tool for measurement. *Crime Prevention and Community Safety*, *11*(1), 1–20. https://doi.org/10.1057/cpcs.2008.19

Reynald, D. M. (2010). Guardians on guardianship: Factors affecting the willingness to supervise, the ability to detect potential offenders, and the willingness to intervene. *Journal of Research in Crime and Delinquency*, *47*(3), 358-390. https://doi.org/10.1177/0022427810365904

Schlangen, L. J. (2019). *CIE position statement on non-visual effects of light: recommending proper light at the proper time*. Research Portal Eindhoven University of Technology. https://research.tue.nl/en/publications/cie-position-statement-on-non-visual-effects-of-light-recommendin

Sénémeaud, C., Sanrey, C., Callé, N., Plainfossé, C., Belhaire, A., & Georget, P. (2017). The watching-eyes phenomenon and blood donation: Does exposure to pictures of eyes increase blood donation by young adults? *Transfusion And Apheresis Science*, *56*(2), 168–170. https://doi.org/10.1016/j.transci.2016.11.001

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our Midst: Sustained inattentional blindness for dynamic events. *Perception*, *28*(9), 1059–1074. https://doi.org/10.1068/p281059

Spriggs, A. S., Argomaniz, J. A., Gill, M. G., & Bryan, J. B. (2005). *Public attitudes towards CCTV: Results from the Pre-intervention Public Attitude Survey carried out in areas implementing* CCTV. In College of Policing. University of Leicester. https://www.ojp.gov/ncjrs/virtual-library/abstracts/public-attitudes-towards-cctv-results-pre-intervention-public

Stewart, A. L., Thrasher, A. D., Goldberg, J., & Shea, J. A. (2012). A framework for understanding modifications to measures for diverse populations. *Journal of Aging and Health*, *24*(6), 992–1017. https://doi.org/10.1177/0898264312440321

Syropoulos, S., Leidner, B., Mercado, E., Li, M., Cros, S., Gómez, A., Baka, A., Chekroun, P., & Rottman, J. (2024). How safe are we? Introducing the multidimensional model of perceived personal safety. *Personality and Individual Differences*, *224*, 112640. https://doi.org/10.1016/j.paid.2024.112640

Szadvári, I., Ostatníková, D., & Durdiaková, J. B. (2022). Sex differences matter: Males and females are equal but not the same. *Physiology & Behavior*, *259*, 114038. https://doi.org/10.1016/j.physbeh.2022.114038

Tabrizi, L. R., & Madanipour, A. (2005). Crime and the city: Domestic burglary and the built environment in Tehran. *Habitat International*, *30*(4), 932–944. https://doi.org/10.1016/j.habitatint.2005.04.007

Tan, N. H., Wong, R. Y., Desjardins, A., Munson, S. A., & Pierce, J. (2022). Monitoring Pets, Deterring Intruders, and Casually Spying on Neighbors: Everyday Uses of Smart Home Cameras. *CHI Conference On Human Factors in Computing Systems*. https://doi.org/10.1145/3491102.3517617

Valencia-Arias, A., Cardona-Acevedo, S., Gómez-Molina, S., Gonzalez-Ruiz, J. D., & Valencia, J. (2023). Smart home adoption factors: A systematic literature review and research agenda. *PLOS ONE, 18*(10). https://doi.org/10.1371/journal.pone.0292558

Van Sintemaartensdijk, I., Van Gelder, J. L., Van Prooijen, J. W., Nee, C., Otte, M., & Van Lange, P. (2021). Mere presence of informal guardians deters burglars: A virtual reality study. Journal of Experimental Criminology, 17, 657-676.

Van Sintemaartensdijk, I., Van Gelder, J., Van Prooijen, J., Nee, C., Otte, M., & Van Lange, P. (2022). Assessing the deterrent effect of symbolic guardianship through neighbourhood watch signs and police signs: a virtual reality study. *Psychology Crime And Law*, *30*(1), 1–21. https://doi.org/10.1080/1068316x.2022.2059480

Veletsianos, G. (2014, January 23). *On Noam Chomsky and technology's neutrality*. George Veletsianos, PhD. https://www.veletsianos.com/2014/01/23/on-noam-chomsky-and-technologys-neutrality/

Welsh, B. C., Farrington, D. P., & Douglas, S. (2022). The impact and policy relevance of street lighting for crime prevention: A systematic review based on a half-century of evaluation research. *Criminology & Public Policy*, *21*(3), 739–765. https://doi.org/10.1111/1745-9133.12585

Wolniak, R., & Grebski, W. (2023). Smart mobility in smart city – Singapore and Tokyo comparison. *Scientific Papers Of Silesian University Of Technology Organization And Management Series*, *2023*(176). https://doi.org/10.29119/1641-3466.2023.176.44

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Journal of Experimental Psychology Human Perception & Performance*, *10*(5), 601–621. https://doi.org/10.1037/0096-1523.10.5.601

Yavuz, N., & Welch, E. W. (2010). Addressing fear of crime in public space: Gender differences in reaction to safety measures in train transit. *Urban Studies*, *47*(12), 2491–2515. https://doi.org/10.1177/0042098009359033

Yetton, B. D., Revord, J., Margolis, S., Lyubomirsky, S., & Seitz, A. R. (2019). Cognitive and Physiological Measures in Well-Being Science: Limitations and Lessons. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.01630

Appendices

AI Statement: “During the preparation of this work the author used GEMINI in order to find synonyms of words. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the work”.

Appendix 1

Informed Consent

Dear participant,

Thank you for choosing to participate in this study. The study aims at looking into how citizens perceive the safety of Dutch neighbourhoods, and what we can learn from these perceptions in order to create better deterrent measures to deter burglars.

Procedure

Participation in this study takes maximum 45 minutes. You will walk around a neighbourhood using a virtual reality headset and to tell us what you think of this neighbourhood. Afterward you will answer questions on the realism of the neighbourhood and how you perceived this neighbourhood.

Potential Risks and Discomforts

There are no obvious physical, legal, or economic risks associated with your participation in this study. If, however, you feel a little nauseous due to being in virtual reality you can always stop or pause the study. This research was reviewed and approved by the BMS Ethics Committee of the University of Twente. For questions or problems regarding ethics of the study, the Secretary of the Ethics Commission of the faculty Behavioural, Management and Social Sciences at University Twente may be contacted through ethicscommittee-bms@utwente.nl.

Potential Benefits

If you have signed up over SONA you will receive 1.5points for participation.

Confidentiality

Your privacy will be protected to the maximum extent allowable by law. Since your responses are completely anonymous, no data, such as names, is being collected that can be traced back to you.

Your response is only used for scientific research. In case of a withdrawal, your data will be deleted immediately.

Right to Withdraw and Questions

Your participation is voluntary. If you participate, you may decide to withdraw from the study at any time. You will not be penalized or lose any benefits to which you otherwise quality if you decide to not to participate or to stop participating. If you have questions or concerns regarding this research, please contact us.

Contact Information

Dr. Iris van Sintemaartensdijk (i.vansintemaartensdijk@utwente.nl)

Statement of Consent

By checking the box below, you confirm that you are at least 18 years of age, you have read and understood all the information, give your consent, and that you voluntarily agree to participate in this study.

- I have been sufficiently informed about the study and all my questions are answered to my satisfaction
- I have the right to withdraw from the study at any time
- I have understood that no personally identifiable information will be reported in the research report and confidentiality is ensured

→If you do not agree to this, end the study by leaving the website.

Appendix 2

Scenario

In a few moments, you will dive into a virtual reality environment of a typical Dutch neighbourhood. We want you to imagine you are in the market to buy a new house. You have been saving for a while and have finally decided to make this significant investment. Your task will be to walk around the neighbourhood and tell us what you see. After you have viewed the neighbourhood, we would like to know your impressions and preferences as well as which house you liked best.

Appendix 3

Debriefing Form

Thank you for participating in this study.

In this study, we looked at the perceptions of citizens on safety of neighbourhoods. For the purpose of this study, we did not tell you that you were in one of three conditions where dynamic guardians were placed in the neighbourhood. A dynamic guardian is the combination of a physical guardian, such as a person being present in front of the house, and a symbolic guardian, such as a sign indicating a neighbourhood has a Neighbourhood watch group. In the context of the study the dynamic guardian was a technical device that was supposed to leave the impression that a person was home when in reality nobody was in the house. This could either be automatic lighting in a house, curtains that were closed or a camera with sound. You could also have been allocated to the control condition where no such measures were present.

We want to see if people feel more safe in a neighbourhood when such measures are present, or if these measures make people feel as if a neighbourhood is less safe because there are many protection measures.

Please do not share the content of this study with other potential participants to allow them an unbiased view in case of participation.

Do you have any other question right now? Please let the researchers who are present now know. If more questions arise later, you can contact Dr. Iris van Sintemaartensdijk (i.vansintemaartensdijk@utwente.nl)

If you now feel like you would rather withdraw your consent of participation and usage of your data you can say so now.