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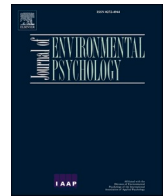
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The impact of nature-based solutions on perceptions of safety in public space

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ABSTRACT

Concerns around personal safety in public spaces constrain citizens' time-space access to opportunities of employment, schooling, socializing, and recreation. One widely promoted strategy for reducing fear of crime is through the transformation of the built environment. While policy efforts have focused on creating urban environments that target the conscious experience of fear of crime, Schachter-Singer's Two Factor Theory proposes that alterations of a person's emotional physiological expression could also reduce the emotional experience of fear. This study explores whether Nature-Based Solutions [NBSs] – a strategy that reduces the emotional expression of stress – can lead to reductions in fear of crime, and how this approach compares with two widely used criminology strategies tackling the emotional experience – Broken Windows Theory [BWT] and Eyes on the Street [EOS]. To test this, an image-based randomized control trial with 494 participants was conducted in 2021. Randomly assigned control and treatment images simulating each built environment strategy were viewed and ranked by participants according to perceived safety. The findings of this study suggest that all built environment strategies significantly increase the perception of safety in public spaces. NBSs are shown to be effective built environment strategies for increasing perceived safety, with an effect comparable to the experience-focused EOS and BWT strategies. Our results suggest that NBSs should be included as part of the safety-enhancing urban policy toolkit.

1. Introduction

Public spaces are integral in facilitating our access to urban opportunities for recreation, education and work. They are also essential elements for social life and individual wellbeing, and serve as hubs for socializing, celebrating, and expressing discontent. Though public spaces are in principle built for all, they are not equally open and accessible to everyone. Research shows that certain social groups, depending on their gender, age, ethnicity, abilities, or economic backgrounds, are more concerned about crime, and are more likely to take precautionary behavioral measures regarding their safety (Cattell et al., 2008; Garcia-Ramon & Prats, 2004; Jabareen et al., 2019; Williams & Hipp, 2020), including placing restrictions on their mobility in terms of hours of travel, route, mode of transport and destination (Ceccato, 2013; Hale, 1996; Pain, 2000; Riger & Gordon, 1981). Several studies have also found that a dilapidated physical environment can increase people's fear of crime (Brown et al., 2004; Nasar, & M Jones, 1997; Newman, 1972; Shu, 1999; Taylor, 2002), and that degraded public spaces tend to

be concentrated in low-income neighborhoods – areas that also see a concentration of vulnerable populations (Cavangah et al., 1998, p.172; see also Williams & Hipp, 2020). Further effects can be seen in people's physical and mental health, as withdrawal from public space in favor of a more housebound life can affect levels of physical activity and lead to chronic stress and anxiety (Jiang et al., 2017). Therefore, fear of crime in a society builds exclusionary mechanisms that hinder citizens in general, and vulnerable populations in particular, from accessing city opportunities; thus, addressing fear of crime in public spaces is a central challenge for the goal of creating more inclusive cities.

The transformation of the built environment has been one of the most widely used and advocated public policy strategies to prevent crime and reduce fear of crime in public spaces. This approach is grounded in environmental criminology theory (ECT) which, by modifying the configuration of built environments, aims to reduce an offender's advantage of environmental awareness of criminogenic urban locations (i.e., those that produce or lead to crime), and increase their perceived risk of identification and apprehension (Brantingham &

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Brantingham, 1981; Cohen & Felson, 1979). At the same time, certain sub-theories within ECT, such as Broken Windows Theory (BWT) and Eyes on the Street (EOS), propose that potential victims also receive criminogenic clues from their environment when navigating public spaces, enabling them to recognize safe and unsafe pathways. Although later generations of ECT went on to add further sophistication, taking into account variations in neighborhoods' social contexts and localized participatory and community-led approaches (Jeffery, 1977), and giving more attention to vulnerable groups such as children, women, and girls (Saville & Anderson, 2018), these theories remain focused on crime prevention, and thus primarily on the perpetrators of crime, with potential victims' experiences playing a lesser role. Although a large number of ECT strategies have been implemented, there is still little causal evidence demonstrating that this type of strategy is also effective for reducing fear of crime – even for widely used strategies such as street lighting or CCTV installation (Lorenc et al., 2013). According to Lorenc et al. (2013) this lack of causal evidence is due to possible confounders involved in complex social and environmental interventions such as these.

While most environmental crime prevention strategies focus on tackling the conscious experience of fear of crime either indirectly (by reducing crime) or directly (by eliminating criminogenic environmental clues), studies in psychology suggest that focusing on emotional [physiological] expression may also provide an effective strategy for reducing fear of crime in public spaces. The relationship between emotional expression – the sympathetic, motor, and sensory responses – and emotional experiences – the conscious emotional "awareness" in cortical areas – has been posited through several psychological theories. While Lazarus and Folkman (1984) theory holds that an emotional stimulus such as a threat would evoke first the emotional experience, before then triggering emotional expressions (such as pupil dilation or increased heart rate) (Fausto, 2019), the 'Two-Factor Theory' suggests that emotional experience and expression are interrelated and affect one another (Bear et al., 2006). Further empirical studies suggest that the activation and inhibition of emotional expression can feed back to regulate emotional experiences (Carney et al., 2010; Strack et al., 1988). Thus, in our context, the Two-Factor Theory suggests that, if we establish that a given built environment strategy is able to mitigate the emotional expression of fear, we should also observe a reduction in the emotional experience of fear of crime.

This research aims to evaluate whether NBSs – a built environment strategy based around emotional expression – are able to reduce fear of crime of public spaces, and furthermore, to see how this compares with traditional ECT interventions that tackle the emotional experience of fear. There is well-established evidence that the incorporation of nature into public space reduces the physiological expression of stress, i.e., the emotional expression of fear (Bratman et al., 2012; Hartig, 2008; Hartig et al., 2014; Ulrich et al., 1991; Yao et al., 2021). By drawing on this, we provide evidence of the causal impact of NBSs, EOS and BWT approaches on fear of crime, and understand how approaches based around both experience and expression could complement one another when addressing different urban spaces and across socioeconomic diversity, while also accounting for confounding factors. To this end, we run an image-based randomized controlled trial, collecting reported fear of crime in degraded public spaces in Milan. In total, 494 participants rated their fear of crime (through the proxy of perceived safety) when viewing control images (without interventions) and treatment images, with photo simulations of interventions drawing from each of the three approaches (BWT, EOS and NBSs). Ultimately, we are able to produce reliable estimates of the impact of NBSs in reducing fear of crime, and provide a comparison with two of the most widely used environmental crime-prevention strategies.

The next section provides an overview of the relevant literature on fear of crime in public spaces, the relationship between emotional experience and expression, and the details behind the fear-reducing interventions selected for this experiment. Following this, we present

the methodology of the study. We then present the findings of the study, with a particular focus on how the impact of NBSs compares with those of BWT and EOS. Finally, we conclude with a discussion of the study in relation to current theory, taking into account limitations and implications for urban policy.

2. Urban fear of crime: the problem, built environmental strategies and evidence

Fear of crime is an important public policy concern as it can degrade people's access to opportunities, quality of life, and physical and mental health (Anderson et al., 2017; Giddings et al., 2011; Grabosky, 1995). Research shows that fear of crime restricts people's ability to fully utilize public space, and influences mobility behaviors in terms of hours of travel, route, mode of transport and destination (Jeffery, 1977). These constraints on time-space mobility lead to more housebound lives, hindering access to cultural activities and opportunities for socializing and recreation. Studies also show that fear of crime might prevent people from starting businesses, and can limit their choices of location for housing, work, and schooling (Anderson et al., 2017; Blöbaum & Hunecke, 2005; Cattell et al., 2008; Giddings et al., 2011). Physical and mental health is also affected, as a withdrawal from public space leads to people spending more time at home, with consequent decreased levels of physical activity and higher probabilities of chronic stress (Jeffery, 1977). Fear of crime has also been associated with a decrease in community activities and in the natural surveillance of public spaces, which are in turn linked to increased chances of crime in an area (Gainey et al., 2011). Research further shows that fear of crime, along with its negative impacts, is more common in lower income areas and disproportionately affects vulnerable groups such as women, elderly people and migrant populations. This is true even in cities with low crime rates, and thus reinforces disparities in people's access to city opportunities and their quality of life (García-Ramón & Prats, 2004; Valera & Guàrdia, 2014).

Most fear-reduction policies are based on crime prevention theory, and hence focus on reducing criminals' motivations and opportunity to commit a crime, predicting that a reduction in crime rates will see a similar decrease in fear (Clarke, 1997; Cohen & Felson, 1979). One of the most popular approaches in urban policy to this end is the transformation of the built environment. The Crime Prevention Through Environmental Design (CPTED) method proposes that certain changes to the built environment – for example, enhancing natural surveillance, or increasing street lighting and CCTV – increase offenders' perceived risk of being caught, and thus lead to a reduction in opportunities for crime (Brantingham & Brantingham, 1981; Cornish & Clarke, 1986; Wikström & Robert, 2010). For instance, 'defensive space' techniques, operating within this CPTED framework, use built environment design to block opportunities for crime, and foster informal surveillance and guardianship (Atlas, 2013; Brown & Altman, 1983; Crowe, 1991; Reynald, 2011; Uittenbogaard, 2014). Two of the most prominent theories that informed this CPTED approach are Broken Windows Theory and Eyes on the Street. Broken Window Theory (Kornhauser, 1978; Sampson et al., 1997; Shaw & McKay, 1942), and the related Social Disorganization Theory, identify disorganized neighborhood characteristics, such as physical dilapidation, that provide criminals with clues of non-vigilant communities, and lead to an area increasingly becoming a magnet for crime and disorder. Eyes on the Street approaches propose that general activity occurring on city streets will bring a natural control over public spaces, and that by increasing risk of apprehension in this way, crime rates will in turn decrease. Although recent waves of CPTED approaches have addressed neighborhoods' socio-cultural specificities by promoting community-led approaches (Thorpe & Gamman, 2013), CPTED remains a technique centered on crime prevention by reducing an offender's advantage of environmental awareness. In this view, therefore, crime remains the primary cause of fear, and thus if crime rates can be reduced, a decrease in rates of fear would be expected to follow.

Research shows, however, that crime and fear of crime might in fact

be distinct urban phenomena that reflect unique social problems and, therefore, require unique policy solutions. Studies show, for instance, that fear of crime and actual crime rates are only weakly correlated in urban areas, and decreases in crime rates are often not followed by a decrease in people's fear of crime (Rader 876 N, 2017). Moreover, while men are more likely to be victims of crime, the evidence shows that women are more concerned about crime and are more likely to take precautionary safety measures (Riger & Gordon, 1981). The reasons for this discrepancy are uncertain and untested, however feminist theories propose a number of potential explanations: men's reluctance to admit feeling fear; men's dominance of public spaces; and women's greater risk of experiencing rape or sexual assault (Valentine, 1989). Regardless, these outcomes suggest that the measures that are effective for tackling crime itself might not be equally applicable for decreasing people's fear of crime, and so strategies that directly address fear are key if we wish for all citizens to be able to effectively reap the benefits and opportunities of living in cities.

Creating cities that both *are* safe and *feel* safe has indeed increasingly become a focus of international organizations and local governments (Lim, et al., 2020), however public policy efforts to address fear of crime have thus far focused on CPTED-based measures, despite the aforementioned weak link between crime rates and fear of crime. Indeed, a vast number of these CPTED strategies have been implemented, yet their effect on fear of crime remains in debate: a systematic review by Lorence et al. (2013) revealed that, although a variety of built environment interventions have been theorized to reduce fear of crime, there are a limited number of causal empirical studies demonstrating their efficacy. The authors conclude that even widely used strategies such as improving street lighting or installing CCTV have been backed up with little causal evidence in this regard. Of the empirical studies that have considered the link between CPTED measures and fear, Navarrete-Hernandez et al. (2021) found in an image-based randomized controlled trial that removing blind walls in the built environment reduces fear of crime, however the effect is only significant for women, while removing graffiti tags has only a weak statistically significant result. Furthermore, Marzbali et al.'s (2012) structural equation study finds that CPTED has no direct effect on fear of crime. It is therefore not a given conclusion that those CPTED policies effective at decreasing crime rates are similarly effective for decreasing fear of crime rates, nor that these strategies will account for the intersectional dimension of perceptions of fear. Instead, the above evidence calls for further research efforts to address fear of crime in public spaces its own right, allowing us to find new strategies to effectively reduce this negative emotion, along with its associated detrimental individual behaviors and societal consequences.

2.1. The emotional experience and expression of fear

Fear is an emotion and a natural survival mechanism triggered by a real or imagined danger or perceived threat. The emotion of fear has two components: the emotional experience and the emotional expression. According to Horta Nogueira (2014), the "emotional experience" of fear is a highly personal feeling produced as a dialectic relationship between a subject's representation of the outside world and the way the world is experienced when a threat is perceived (LeDoux & Pine, 2016) – in our case a real or imagined threat of crime. The emotional expression of fear, instead, can be defined as the behavioral and biochemical changes that usually accompany this emotion – for instance, the behaviors (e.g. eyebrows raised and pulled together accompanied by a stretched mouth, being the facial expression of fear) and sympathetic biochemical changes (e.g. pupil dilation, increased heart rate, and increased adrenaline levels) that typify the "fight or flight" response triggered by fear (Gross et al., 2000; LeDoux & Pine, 2016).

Different psychological theories have conceptualized the relationship between emotional expression and experience and, by extension, the emotion of fear. In his theory of emotional expression, for instance, Darwin (1872) proposed that a threat stimulus elicits first an emotional

experience or "awareness", which subsequently triggers emotional expressions. Richard Lazarus and Folkman (1984) built on this, similarly suggesting that a stimulus would evoke a thought (the emotional experience of fear) which would then activate the physiological response (its emotional expression). In contrast, William James (1884) proposed a "somatic theory" in which an emotional stimulus, such as a threat, would trigger the activation of autonomic motor and sensory responses, which are then interpreted by the cortical areas through conscious emotional expression (Fausto, 2019). The James-Lange theory proposes that the experience of fear is triggered through the emotional expression (for example, rapid breathing, widened eyes, and increased blood adrenaline levels), and so the emotional expression is a required precondition (Coleman & Snarey, 2011). Under the Cannon-Bard theory, however, the emotional expression and experience of fear involve different neuronal structures that are triggered simultaneously, and therefore the activation of one is not required for the other. Finally, Schachter-Singer's Two-Factor Theory proposes that the experience and expression of emotions are interlinked; a threat would elicit a physiological response that is cognitively labeled as fear (Bear et al., 2006).

The emotional expression of fear is the physiological stress response. This expression of stress is defined in Lazarus' (2000) Cognitive Appraisal Theory as the psychological reactions produced when a person believes that the demands of a situation compromise their ability to respond to a threat. The body perceives fear via the amygdala (the brain's integrative center for the experience of fear, behavioral and physiological expression, and motivation), which sends a distress signal to the hypothalamus, activating the involuntary sympathetic response of the autonomic nervous system (ANS) and orchestrating the release of hormones from the pituitary gland. The sympathetic nervous system triggers physiological reactions, such as increased blood pressure and oxygenation, which prepares the body to fight or flee, allowing us to respond to a frightening situation more efficiently. Alongside this, the release of ACTH (adrenocorticotrophic hormone) via the pituitary gland into the blood stream activates the production of cortisol in the adrenal glands of the kidney. The release of cortisol into the blood stream mobilizes the body's energy reserves, suppresses the immune system, makes the person feel awake and conducive to irritable mood, and also increases alertness, sight, hearing, and sharpens other senses (Carreras-Sureda et al., 2018; Charmandari et al., 2005).

In spite of the range of theories that define the psychology of emotions, when considering their application to the built environment, CPTED-based efforts have exclusively tackled the emotional experience of fear of crime, and thus arguably follow Lazarus' Cognitive Appraisal Theory. However, the Two-Factor Theory provides alternative theoretical bases for tackling fear of crime through its emotional expression. Evidence from behavioral science suggests that altering emotional expression can indeed provide an effective strategy for triggering change in emotional experience. For instance, Strack et al. (1988) conducted an experiment in which participants watched comedy cartoons while holding a pen in their mouth that manipulated their facial muscles into either in smile-facilitating or smile-inhibiting positions, and found that the smiling-facilitated group reported significantly higher happiness responses. Carney et al. (2010) considered the influence of 'power poses' on emotional experiences, finding that participants using high-power bodily poses reported stronger emotional experiences of power and risk tolerance, along with higher testosterone and lower cortisol levels, while the reverse pattern was found for low-power poses. Further, Ekman et al. (1983) show that the activation of expressive facial muscles can on its own produce emotional experiences. In this experiment, participants were requested to perform universal emotion-prototypic facial expressions (such as those of fear, happiness, surprise, anger, and disgust), and measurements were taken of the biochemical changes triggered by the autonomic nervous system (ANS), such as heart rate and skin conductivity. The results confirmed that voluntary emotional facial actions activate the aligned ANS responses, i.e., a fearful facial expression triggers a sympathetic response, while a happy expression triggers a

parasympathetic response.

Emotional psychology theory and evidence therefore suggest that an alternative approach to built environment transformations, one that aims to trigger the activation of the parasympathetic nervous system, i.e. the 'rest and digest' responses (those that inhibit the sympathetic 'fight or flight' physiological response to fear), could decrease the conscious emotional experience of fear of crime. Analyzing whether this decrease does indeed occur, and comparing this new approach with the existing CPTED strategies currently in use, forms the core of this research.

2.2. Nature as an expression-based strategy to reduce fear of crime?

One of the most widely studied environmental factors causing stress reduction is our contact with nature. Two potential mechanisms are proposed behind this. First, nature can reduce exposure to everyday stressors in urban life, such as crowds, noise, and air and visual pollution, either reducing their perceptual salience or buffering people from their sources (Hartig et al., 2014). Second, nature can reduce stress through positive action, restoring people's adaptive resources. On this second point, Stress Reduction Theory posits that exposure to nature supports psychophysiological stress recovery, leading to a reduced experience of negative affect and arousal expression (Bratman et al., 2012; Ulrich et al., 1991). This psychoevolutionary theory proposes that nature is associated with access to resources and survival-evoking positive affects and thoughts, while inhibiting negative affect and reducing sympathetic physiological responses (Yao et al., 2021). Attention Recovery Theory (Kaplan, 1995) proposes that our attention, via intrinsic fascination, is effortlessly drawn to elements of nature – for example, beauty, scenery, and sound – which aids in restoration from neuro-cognitive fatigue from willful engagement requiring direct attention (see also Konijnendick, 2012). Cognitive fatigue tends to emerge in everyday life when an individual's effective performance of a task requires direct focus, while simultaneously inhibiting other irrelevant mental, social or environmental stimuli (Hartig et al., 2014). As fatigue from direct attention reduces the effectiveness of action, it increases our susceptibility to stress (Kaplan, 1995).

Over the last decades an increasing number of studies have shown through measurements of related indicators that exposure to natural environments leads to psychological and physiological stress reduction. Kim et al. (2010), for example, examined differences in brain activation when looking at pictures of rural and urban environments, observing that the activation of brain areas associated with positive emotions – e.g. the putamen – prevailed when viewing rural scenery, whereas activation of brain areas associated with negative emotions – e.g. the amygdala – was dominant when looking at urban scenery. Furthermore, Hartig (2008) found that walking in a natural environment was more restorative than walking in urban surroundings, confirming psychophysiological stress recovery by measuring ambulatory blood pressure, positive affect, attentiveness, fear arousal, sadness, and anger/aggression before and after walking in such environments. Elsadek et al. (2019) drew the same conclusion when studying the psychological indicators of states of attention, fatigue and anxiety for groups walking along urban roads with and without trees. Ewert and Chang (2018) measured participants' biophysical markers (cortisol and amylase) in three different 'degrees of nature': a wilderness-like setting; a municipal-type urban park; and an indoor exercise facility, with results showing that visitors to natural environments report significantly lower levels of stress than those in urban environments. A number of systematic reviews further confirm that spending time in outdoor green environments is associated with lower heart rate, blood pressure and self-reported measures of stress (Kondo et al., 2018). In a recent systematic review and meta-analysis (PRISMA), Yao et al. (2021) analyzed 31 studies totaling 1842 participants, concluding that exposition to nature results in a statistically significant reduction of psychological stress measures through PANAS, SDM, POMS and STAI, and of physiological stress reduction measured through salivary α -amylase, salivary

cortisol, systolic blood pressure, heart rate variability, diastolic blood pressure, and pulse rate.

It is thus well established in the literature that our contact with nature and green spaces reduces the physiological stress cause by fear through the deactivation of the sympathetic fight-or-flight response and the activation of the parasympathetic rest-and-digest response. However, the question remains whether nature, by mitigating the emotional expression of fear, can also reduce the emotional experience of fear, and specifically fear of crime. The study presented here thus explores the possibility of this causal link in depth, allowing us to compare NBSs with the established CPTED approaches.

2.3. Fear-reduction interventions in the built environment

We hypothesize therefore that the strategy of incorporating vegetation into a space (NBSs) – henceforth referred to as an 'expression-driven' strategy – by inhibiting the emotional expression of fear, can reduce conscious fear of crime in public space through the mechanism proposed by the Two-Factor Theory. While a number of approaches to CPTED built environment transformations have been advanced, we contrast NBSs with two of the most prominent ECT linking the built environment, crime rates and fear of crime: Broken Windows Theory and Eyes on the Street. Henceforth, we refer to these approaches as 'experience-driven' strategies.

2.3.1. Broken windows

Kelling and Wilson (1982) propose that crime, civil disorder and antisocial behavior generate visible environmental signs that then attract further disorder and crime. Under BWT, the sight of even minor public incivilities such as street drinking, spray-painted graffiti, and broken windows gives clues to prospective offenders of a lack of community control and vigilance, and to passers-by of ongoing criminal activity in public spaces, reinforcing a vicious circle of community withdrawal and escalation of crime (Samuels, 2001). On the other hand, the theory suggests that by modifying the design of urban spaces, we expect to reduce an offender's advantage of environmental awareness of criminogenic urban locations (i.e., those that produce or lead to crime), and increase their perceived risk of identification and apprehension (Cohen & Felson, 1979).

BWT is one of the most rigorously tested criminological approaches for reducing crime and fear of crime. Regarding its impact on crime, Keizer et al. (2008) empirically tested BWT through six field experiments, finding that when people observed others violating a certain social norm or rule, they were more likely to go on to violate other norms or rules, and concluded from this that disorder tends to spread. Ramos and Torgler (2012) tested the applicability of BWT to minor violations of rules in shared workspaces, observing the behavior of academics and postgraduate students in both an ordered and a disordered setting (a messy environment). The results showed that signs of a disorderly environment triggered a threefold increase in littering behavior. In a correlational study, Baharom et al. (2008) explored whether property crime (as a proxy for minor crime) leads to violent crime (a proxy for major crime) in US states over the period 1960–2007, concluding that violent crime and minor crime are correlated in forty-eight out of fifty states.

The evidence linking BWT and fear of crime, however, is less robust. Gau et al. (2014) revisited BWT to examine the relationship between disorder and fear, exploring census data in Peoria, Illinois. They concluded that disorder may inspire fear, which can spill over into neighborhood cohesion and enhance the perception that social control is waning. Navarrete-Hernandez et al. (2021) explored BWT as applied to public spaces in London, using images with and without graffiti as a sign of deterioration, finding a weak statistical significance decrease of fear of crime in the graffitied spaces, and only for women. Taken as a whole, the existing evidence robustly shows that disorder leads to further criminal behavior, while less robust evidence demonstrates its

relationship with fear of crime.

3.2.2. Eyes on the street

Jane Jacobs (1961) proposes that the presence of people in public spaces serves as a form of informal surveillance that increases the likelihood of passers-by to witness, report, and intervene in crime, thereby increasing the risk of apprehension and reducing crime rates (Chiodi, 2016; Jacobs, 1961; Sweet & Escalante, 2010). These actions are also observed by bystanders, taken as a sign of security in an area, and reducing their fear of being a victim of crime. In what became known as the 'Eyes on the Street' theory, Jacobs proposed that the activity occurring on city streets brings a natural control over public spaces, not only making the streets secure, but also making them *feel* secure. Jacobs further revealed a link between urban design and acts of incivility in daily life (Wekerle, 2000), suggesting that minimizing the presence of solid walls or similarly large obstructions to public space visibility, and instead promoting the construction of windows and street-facing entrances, could again increase natural surveillance and reduce crime and fear (Chiodi, 2016; Cozens et al., 2015). Alongside these assertions, the Routine Activity theory proposes that three elements are required in order for a crime to take place: (1) an offender; (2) a target; and, (3) the lack of a capable guardian (Cohen & Felson, 1979). This theory supports the idea that 'eyes on the street' will lead to reductions in crime, as the desired 'capable guardians' would emerge as a result of street-facing windows and walkable neighborhoods. In the 1970s,

A number of correlational studies have considered the effectiveness of EOS strategies to tackle crime and fear of crime. Cozens and Davies (2013) examine the effect of using security shutters on residential windows in Western Australia, showing that although shutters do reduce burglary in individual properties, they also reduce natural surveillance, social interaction, and fear of crime measured through perceived personal safety at the street level, and overall increase the crime rate. Sereerat and Sirijintana (2020) examine incidents of crime in the Chatuchak District of Bangkok, observing that the presence of motorcycle taxis (a form of natural surveillance) was associated with lower crime rates within a 100-m radius. In a recent study, Navarrete-Hernandez et al. (2021) examine fear of crime through the perceived safety of participants observing streets with overlooking windows versus those with a blind wall, showing that window-based interventions produce a significant reduction in fear of crime. This emerging evidence suggests that EOS-based approaches may not only reduce crime itself, but could also have an impact on fear of crime.

3. Empirical strategy

We run a randomized control trial (RCT) to evaluate participants' fear of crime in various photo-simulated built environment scenarios. Data was collected from 494 individuals in December 2021 using the online platform Urban Experiment (www.urban-experiment.com). In this study, we use the variable 'perception of safety' as a proxy to measure the concept of fear of crime. Fear of crime is defined as an abstract affective construct, and as such it is difficult to directly measure and compare across studies, instead normally being measured through related proxies (Yang & Hinkle, 2012). 'Perception of safety' is the most common proxy used in large public sector surveys (such as the US National Crime Victimization Survey and Crime Survey for England and Wales) and academic literature (Cozens & Davies, 2013; Loewen et al., 1993; Navarrete-Hernandez et al., 2021, 2023). We thus measure 'perception of safety' to ensure a cohesive dialogue with the existing literature (Farrall & Gadd, 2004; Hinkle, 2014). To further clarify to participants that we are measuring perception of safety as related to crime, a fixed panel at the top of the screen displayed the phrase "Think about your perceptions of safety in relation to being a victim of crime. You are walking alone." on each occasion that participants rated an image.

3.1. Study design

Participants were briefly exposed to images of a public space either without (control image) or with (treatment images) one of three fear-reduction interventions. They then rated a series of randomly selected images according to how safe from crime they would feel walking alone in the presented public space, from 'not at all' to 'very safe'. For control images, we used pictures of urban spaces representing fifteen typologies of public spaces that convey high levels of fear of crime, as suggested by previous studies (see Table A for typologies and references in the Appendices). All images were taken in urban areas in Milan, Italy. On top of these control images, photo-simulated treatments were created to represent three fear-reduction intervention approaches: 1) Broken Window Theory; 2) Eyes on the Street, and 3) Nature-Based Solutions. To ensure comparability of control and treatment images, we further modified images to ensure consistency of all relevant features (e.g. cars, weather, light) aside from the intervention tested. From this, we produced a set of 60 photo simulations (Fig. 1). We further categorized images into seven typologies of public spaces: streets; abandoned areas; tunnels and underpasses; train and bus stations; parking spaces; rail and highways; and bridges. Finally, the NBSs used were also categorized against one another to create three scales of greenery intervention: small, medium and high. For this, we counted the number of pixels of vegetation added to create our NBS intervention, and divided this by the total number of pixels in the image, classifying simulations by the relative increase in greenery (1–10%, 11–20%, and >21%).

3.2. Sampling method

Participants were recruited through social media from 7–28 February 2022 and in four street locations in Milan. No monetary rewards or other compensation were offered for participation. Respondents were asked to sign an online participation consent form and to complete a short survey containing questions around socioeconomic factors and attitudes to crime. Following this, participants were instructed to imagine that they were walking alone in the location shown in each image and to rate their perception of safety on a scale from 1 (not at all safe) to 10 (very safe). Each participant rated fifteen randomly assigned images from the total pool of 60 photo simulations and continued until the experiment was completed. Finally, participants were given the option to share the experiment on social media. On average, respondents took 5:23 min to complete all steps. In total, 500 participants took part in the survey, of whom 6 did not rate all images, and the remaining 494 rated all 15 images, totaling 7410 image ratings. We also found that 2 participants gave the same response to all images, and so these were removed from the final data set. Our final valid rate of response is therefore 98.4%.

We used a computer-generated double randomization method (a random image-order assignment and a random control-or-treatment assignment) to guarantee that the covariates were balanced between participants in control and treatment groups. First, the algorithm randomly assigned the order of the fifteen sets of public space typologies presented to each participant. This allowed us to account for any spill-over or wear-out effect that could potentially alter participants' responses from one picture to the next. Second, as in any RCT, the algorithm randomly allocated the participant to see either a control image or treatment image, for each typology of public space.

3.3. Data set

For the analysis, we used three data sets: 1) participants' background characteristics and attitudes towards crime; 2) participants' perceptions of safety regarding crime; and, 3) experimental conditions. The first data set was collected via the registration questionnaire, and provides information on each participant's gender identity, year of birth, ethnicity, educational level, and residency, as well as reporting any recent

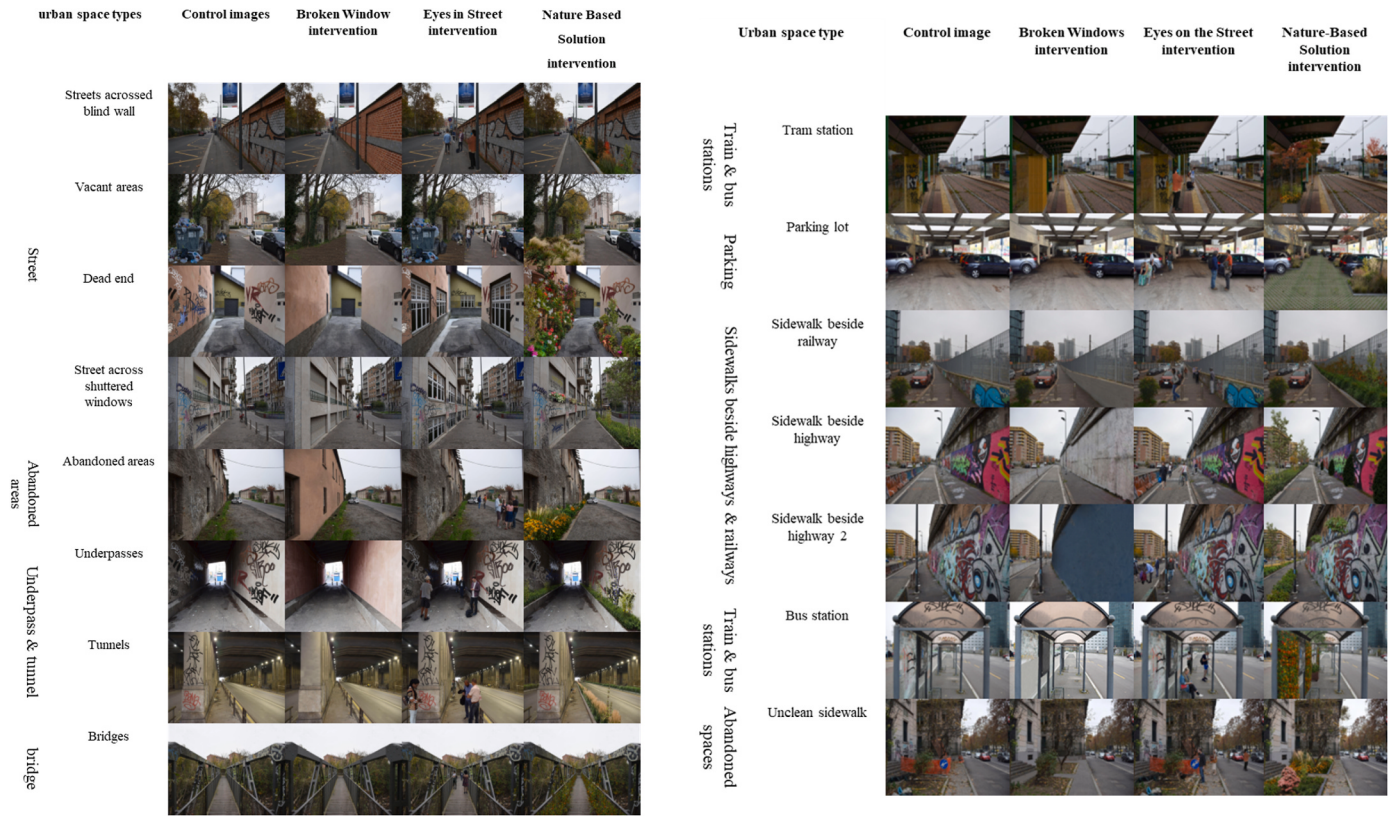


Fig. 1. Photographic simulations.

incidents of victimhood of crime, details of any type of crime suffered and their fear of various crime types. The second data set corresponds to participants' perceived safety from 1 to 10 for each of the presented images. The final data set contains the experimental conditions for each of the presented images, including the image treatment status, order of appearance, date and time of the test, and whether the participant rated all presented images or not. Descriptive statistics for the data set are presented in Table 1, while how we measured variables is presented in Table B in the Appendices.

3.4. Empirical strategy

The aim of this experiment is to test the efficacy of NBSs in reducing people's fear of crime, as measure through the variable of perception of safety, and comparing this with experience-driven interventions. In the analysis, we use random intercept models with fixed effects at the image level to explore this question. Random intercepts are used at the individual level to account for the fact that each participant might have a unique predisposition to feeling safe in public spaces. We include an image's fixed effects to control for each image's average safety rating. The models take the following form:

$$Safety_{ij} = \beta_1 Treatment_i + \beta_2 Image_i + U_j + E_{ij} \quad (1)$$

where $Safety_{ij}$ is the declared perception of safety related to crime of participant j for image i , rated on a scale of 1–10. Treatment is a categorical variable equal to zero if the i th image does not contain a public space intervention (control), and a consecutive number if it contains a BWT (treatment 1), EOS (treatment 2) or NBS (treatment 3) intervention. β_1 , the Average Treatment Effect, is the central coefficient of interest, which captures the impact of the fear-reducing interventions on participants' perceived safety related to crime. $Image_i$ is an image fixed effect for the i th image included to control for the fact that each image has a different average safety rating, reflected by β_2 . U_j is the random

intercept associated with the j th individual. E_{ij} is the error term.

We analyze the impact of fear-reduction interventions in the following ways. First, we run Eq. (1) at an aggregate level to estimate the overall impact of fear-reducing environmental interventions on participants' perceived safety. Following that, we run Eq. (1) on the NBS interventions to test the impact of nature on perception of safety in public spaces, and to compare this with the experience-driven built environment strategies proposed by environmental criminological theory. Then, we examine the effectiveness of fear-reduction interventions across different typologies of public space. Finally, we analyze how the impact of NBSs on perceived safety in public space varies with the amount of greenery incorporated.

3.5. Robustness checks

We conduct robustness checks of results, analyzing estimates from Eq. (1) with and without control variables (Eq. (2)). Control variables include the fifteen socio-demographic characteristics, respondents' attitudes to crime, and the experimental conditions. The model takes the following form:

$$Perception_{ij} = \beta_1 Treatment_i + \beta_2 Image_i + \beta_3 X_{ij} + U_j + E_{ij} \quad (2)$$

This follows the same form as Eq. (1) with the exception of X_{ij} , which contains the socio-demographic and crime attitude variables for participant j , and experimental condition measures for image i . β_3 reflects the associated regression coefficients. To test the robustness of the results produced by the analysis using Eq. (1), we re-run all versions of the models using Eq. (2). We conduct an ANOVA F-test to determine whether there is a significant difference in means between interventions groups. We then conduct pairwise comparisons using Bonferroni corrections to detect statistical differences among the effect size of BWT, EOS and NBS intervention types. Below, we report the results of Eq. (2) with controls, and report results with at least a 5% significance level.

Table A1
Descriptive statistics.

Variables		Mean	N	Percentage
Gender	Female	–	4329	59.3
	Male		2930	39.5
	Other		88	1.2
Age	≤30	27.02	5743	77.5
	31–40		1191	16.1
	≥41		476	6.4
Ethnicity	Asian	–	1995	26.9
	White		4294	57.0
	Other		1121	15.1
Educational level	Secondary education or lower	–	1995	26.9
	Tertiary education		5415	73.1
Residency	Milan	–	3856	52.0
	Lombardy (excluding Milan)		1281	17.3
	Elsewhere in Italy		898	12.1
	Another European country (including the UK)		493	6.7
	Non-European country		882	11.9
Victim of crime in the last twelve months?	Yes	–	1161	15.6
	No		6248	84.3
Type of crime suffered	I did not suffer from crime in the past 12 months	–	5980	80.7
	Theft (non-violent)		642	8.6
	Robbery (violent)		163	2.2
	Personal injury or violence (in public space)		85	1.1
	Sexual assault		148	2.2
	Burglary (e.g. house break-in)		86	1.2
	Other		246	3.3
	Prefer not to say		60	0.7
	Very worried	–	1387	18.7
	A little worried		2958	39.9
	Neither worried nor not worried		1040	14.0
	Not very worried		1454	19.6
	Not at all worried		571	7.8
Worry about being robbed or mugged in public spaces	Very worried	–	1337	18.0
	A little worried		2541	34.3
	Neither worried nor not worried		953	12.9
	Not very worried		1709	23.0
	Not at all worried		870	11.7
Worry about being victim of physical violence or aggression	Very worried	–	1702	22.0
	A little worried		2021	27.3
	Neither worried nor not worried		1421	19.1
	Not very worried		531	7.1
	Not at all worried		1744	23.5
Worry about sexual assault and rape	Desktop	–	120	1.6
	Laptop		505	6.7
	Tablet		72	0.1
	Smartphone		6713	90.6

4. Results

Since the wording used in the photo-simulation questionnaire referred to perceptions of safety in relation to being a victim of crime, this is the term that will be used here to report results. However, it is important to note that, as discussed earlier, this is being used as a proxy to measure fear of crime, and so all results will be used to support our hypothesis accordingly.

4.1. The impact of built environment interventions on perceptions of safety

First, we run Eq. (1) on the whole sample to explore whether built environment interventions impact people's perceptions of safety. Graph 1(a) displays the differences between people's perceptions of urban sites before and after the introduction of interventions. The results show that participants perceive public spaces with these three interventions as safer places, with significant increases to people's perceptions of safety (estimate = 0.652, S.E. = 0.0601, $p < 0.001$). As comparing column 1 and 2 in Table C in the Appendices indicates, these results are robust to the addition of 11 controls. These results indicate that, when taken together, the various built environment transformation types have a positive overall impact on people's perceptions of safety.

4.2. The impact of nature-based solution interventions on perceptions of safety

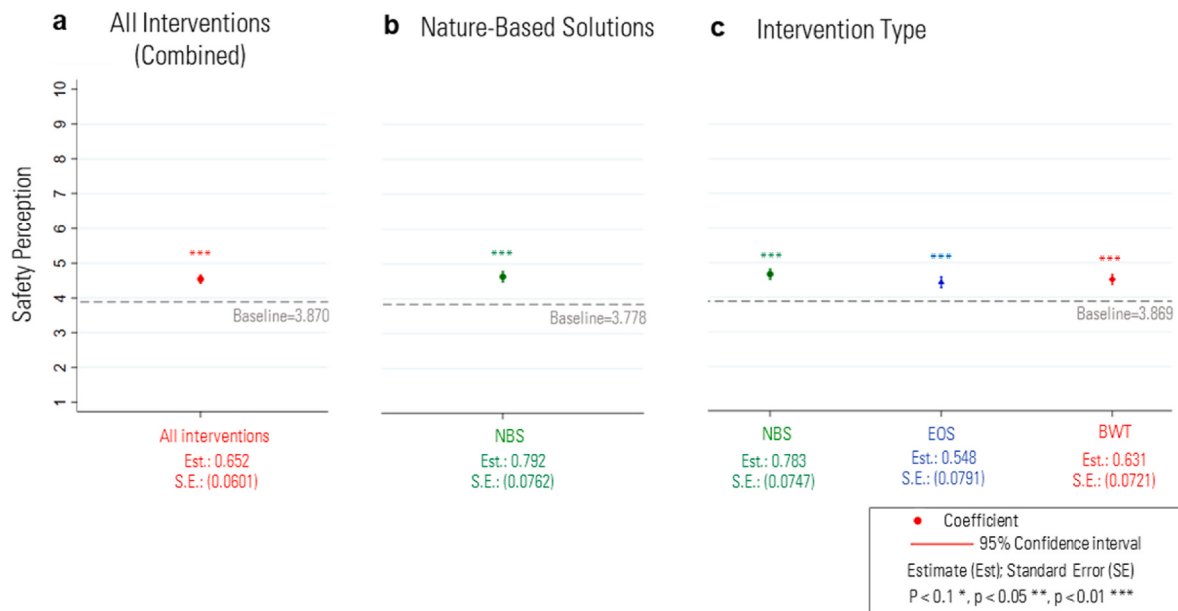
We now explore the impact specifically of NBSs on people's perceptions of safety. For this, we run Eq. (1) on samples without interventions (control images) and with nature interventions. As Graph 1 (b) shows, NBSs significantly increase perceived safety levels (estimate = 0.792, S.E. = 0.0762, $p < 0.001$). As columns 1 and 2 in Table D indicate, these results are robust to the addition of controls. This suggests that the expression-driven effect of nature is also able to change the conscious experience of perceived safety.

4.3. The impact of different types of environmental strategies on perceptions of safety

We further analyze the impact of NBSs when compared with the established expression-driven strategies to increase perceived safety. To do so, we run Eq. (1) on three sub-samples representing the different types of interventions of BWT, EOS, and NBSs. Graph 1(c) illustrates the differences between people's reported perceptions of urban spaces before and after the incorporation of the three types of interventions. As column 2 in Table E (see the Appendices) indicates, while all the interventions produce a significant improvement in perceived safety, when compared with BWT- and EOS-based interventions (BWT-estimate = -0.631, S.E. = 0.072, $p < 0.001$; EOS-estimate = -0.548, S.E. = 0.079, $p < 0.001$), NBSs produce a significantly larger increase in the perceived level of safety (estimate = 0.783, S.E. = 0.0747, $p < 0.001$). Overall, this suggests that NBSs are more effective than traditional CPTED strategies in increasing perceived safety.

4.4. In each urban space type, which intervention works best?

Here, we analyze the impact of the interventions for a selection of public spaces cited in the literature as typically being perceived as dangerous. To do this, we run Eq. (1) for the three interventions in the seven defined types of urban spaces (streets [St], abandoned areas [Ab], tunnels and underpasses [T&U], train and bus stations [TBS], parking spaces [PS], rail and highways [R&H], and bridges [Br]). Graph 2 summarizes these impacts. The results show that, excluding covered areas (tunnels and underpasses) and bridges, NBSs significantly enhance perceptions of safety ([St]: estimate = 0.810, S.E. = 0.151, $p < 0.001$; [Ab]: estimate = 0.911, S.E. = 0.155, $p < 0.001$; [TBS]: estimate = 0.764, S.E. = 0.279, $p < 0.001$; [PS]: estimate = 1.232, S.E. = 0.304, $p < 0.001$; [R&H]: estimate = 1.009, S.E. = 0.131, $p < 0.001$). As seen in columns 2 and 12 in Table F, when compared with EOS and BWT interventions, NBSs have a statistically significant larger impact on perceptions of safety for the street, railway, and highway public spaces typologies, and a larger impact than EOS for the abandoned area and bridge typologies. No statistically significant differences were found between the three intervention types in the parking, train and bus station space typologies. The evidence suggests that nature-based strategies



Graph 1. The impact of different types of safety-enhancing environmental strategies.

are widely effective tools to increase perceived safety across a variety of public spaces, although this also suggests that there is a space-specificity regarding which interventions work best in each urban space.

4.5. Impact of nature-based solutions for different socio-demographics

In this sub-section, we show the impact of NBSs on perceived safety changes according to different socio-demographic characteristics. For this, we run Eq. (1) as in the previous section, restricting the sample to different socio-demographic categories. Graph 3(a-b) shows that NBSs significantly increase safety perceptions for men and women, with the estimates being similar for both genders (female: estimate = 0.832, S.E. = 0.096, $p < 0.001$; male: estimate = 0.739, S.E. = 0.120, $p < 0.001$, see columns 2 and 4 in Table G in the Appendices for results with controls) This impact is comparable the outcomes for both BWT and EOS interventions for women, and significantly larger than only EOS interventions for men.

Graph 3 (c-d) shows the results by age group – as most participants are either <30 or 30 years old, we show the results for these groups – and indicates that NBSs have a significant and similar effect on perceived safety for those under 30 (<30: estimate = 0.815, S.E. = 0.082, $p < 0.001$) and 31–40 years old (estimate = 0.740, S.E. = 0.193, $p < 0.001$; see columns 2, 4 and 6 in Table H for results with controls). For the group under 30 years, this is a similar effect to BWT interventions, and is larger than EOS interventions. For the 31–40 years old group all the three interventions have a similar effect.

Graph 3 (e-f) shows impact by ethnicity – as most of participants are White or Asian, only the results for these categories are reported. NBSs produce a significant increase in participants' perceptions of safety of comparable magnitude for both ethnicities (Asian: estimate = 0.869, S.E. = 0.158, $p < 0.001$; White: estimate = 0.870, S.E. = 0.088, $p < 0.001$, see columns 2, 4 and 6 in Table I in the Appendices for results with controls). For Asian participants, the effect of NBSs is comparable to that of BWT and EOS interventions, and for White participants the effect is larger than that of EOS approaches.

Finally, Graph 3 (g-h) shows that NBSs significantly increase safety perception to a similar degree for people from varied educational backgrounds (estimate = 0.938, S.E. = 0.137, $p < 0.001$; tertiary education: estimate = 0.729, S.E. = 0.088, $p < 0.001$, see columns 2 and 4 in Table J for results with controls). For participants with a tertiary

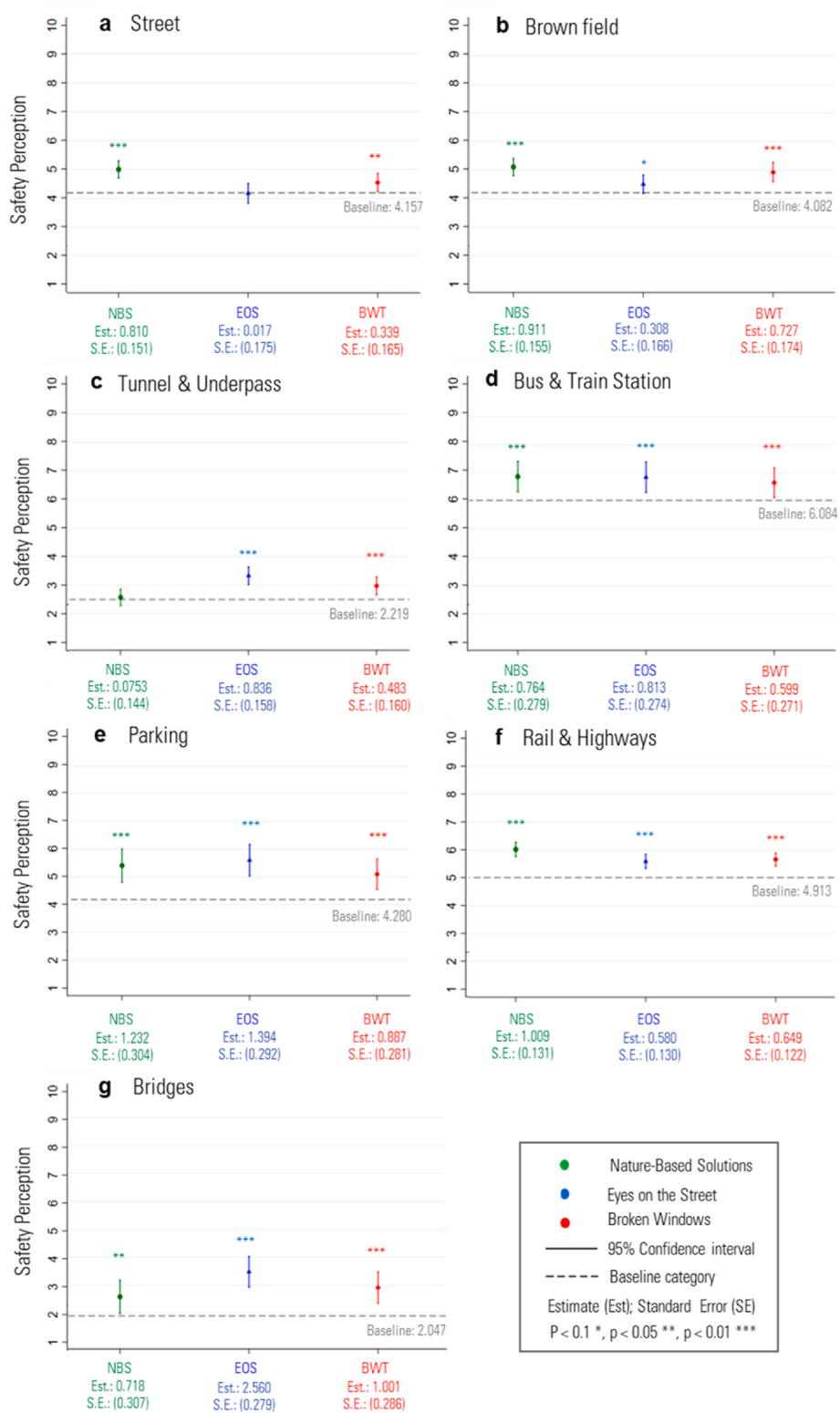
education, this effect is comparable to EOS and BWT interventions, and for those with a secondary education of lower, the effect is greater than that of EOS interventions.

4.6. How does the proportion of greenery impact the effectiveness of nature-based solutions?

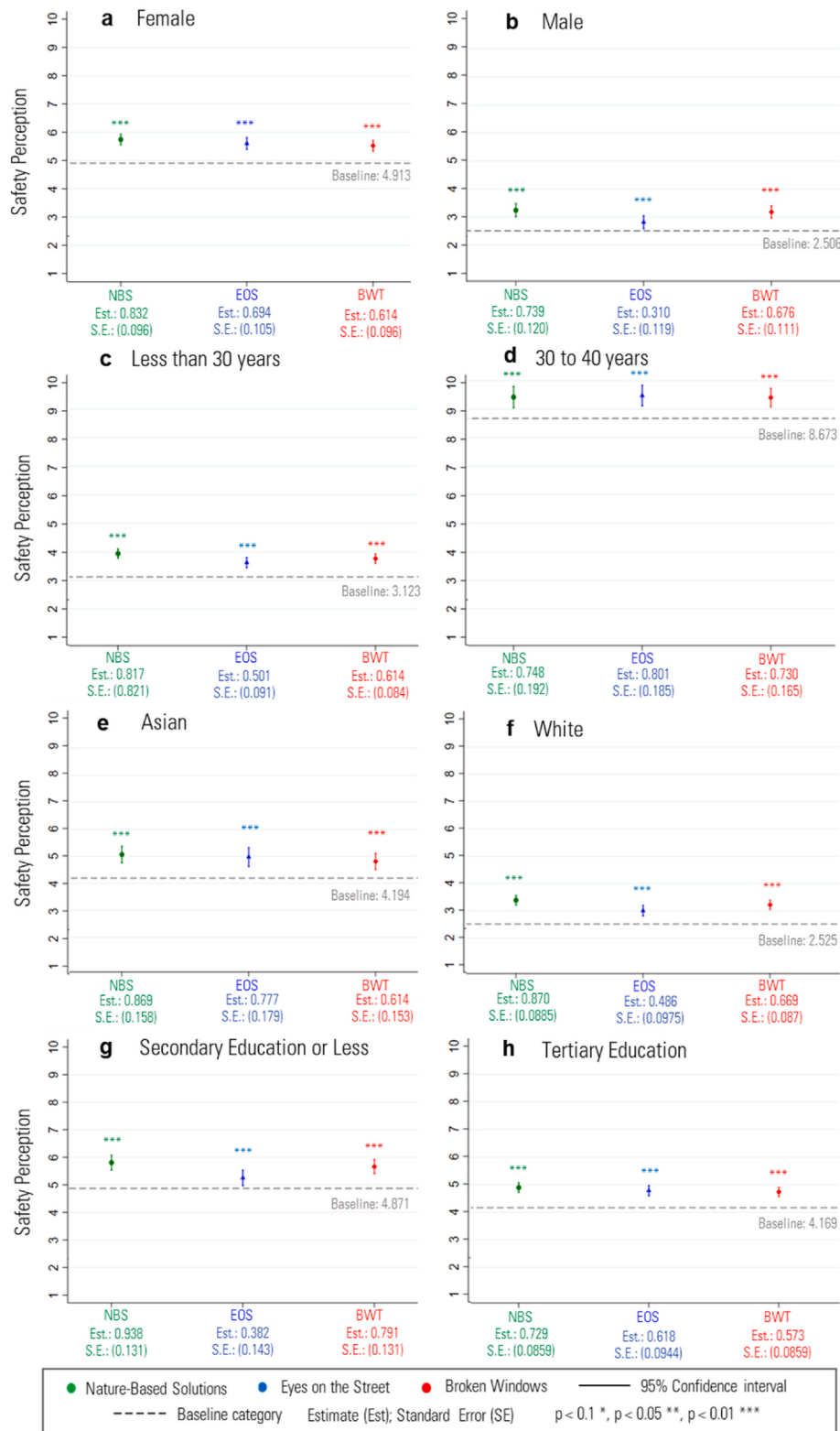
We finally run an exploratory analysis to examine the effect of the amount of greenery on perceptions of safety. As mentioned in the Methods section, we calculated the percentage of greenery added to each photo when creating NBS interventions, and categorized them into three levels, as shown in Graph 4. This graph indicates that there is a strong positive association between the amount of greenery incorporated to public space and people's safety perceptions, with Table K (in the Appendices) showing a significant effect as levels of greenery are increased (1-10%-estimate = 0.585, S.E. = 0.112, $p < 0.001$; 11-20%-estimate = 1.252, S.E. = 0.110, $p < 0.001$; 21-45%-estimate = 1.930, S.E. = 0.201, $p < 0.001$). As the ANOVA test in Table K column 2 shows, all results are statistically different from each other, providing strong evidence that higher levels of greenery leads to higher perceived safety in public spaces.

5. Discussion and conclusion

According to Schachter-Singer's Two Factor Theory, changes in a person's emotional physiological expression lead to differences in emotional experience. We hypothesize that this relationship should also be true of changes influenced by a person's environment. While the emotional expression-experience link has been supported by evidence in emotional psychological studies (Carney et al., 2010; Ekman et al., 1983; Strack et al., 1988), to the best of our knowledge, there is no evidence demonstrating that a place that reduces physiological stress might lead to reductions of the emotional experience of fear – and particularly fear of crime. In this study, we examined the influence of nature-based solutions (NBSs), a public infrastructure that reduce the emotional expression of stress (Bratman et al., 2012; Hartig et al., 2014; Kaplan, 1995; Konijnendick, 2012; Ulrich et al., 1991; Yao et al., 2021), on people's fear of crime in public spaces, and compared these results with traditional experience-focused strategies from environmental criminology. The randomized controlled trial revealed that NBSs



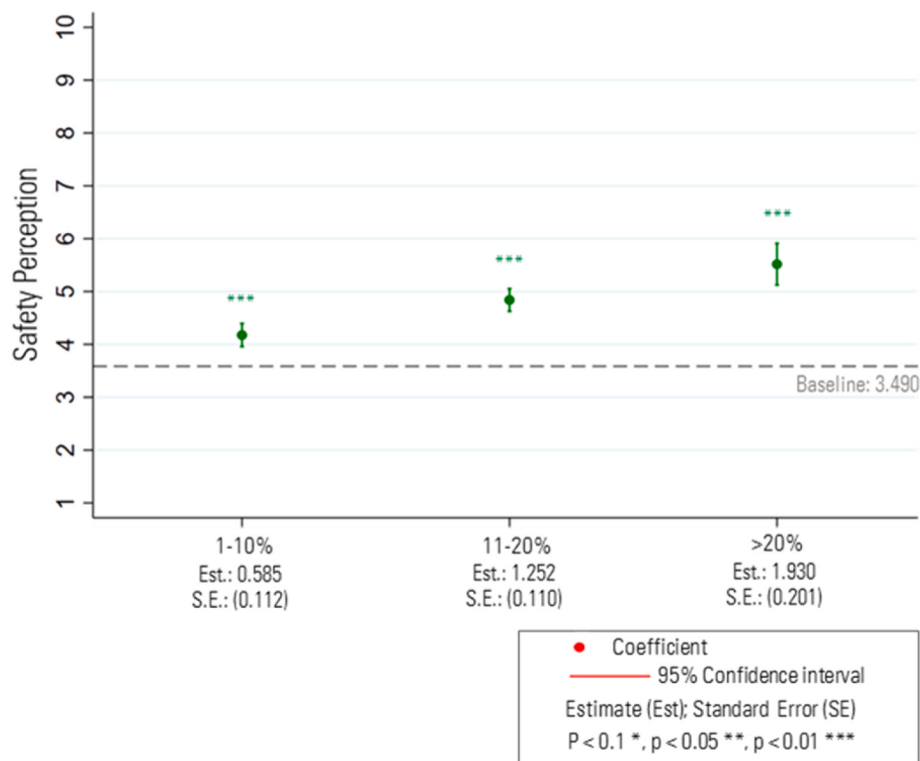
Graph 2. The impact of different interventions on perceptions of safety for each type of urban spaces.



Graph 3. The impact of nature-based solutions on perceptions of safety for different socio-demographic characteristics.

effectively decrease fear of crime, with effect sizes comparable to established Crime Prevention Through Environmental Design (CPTED) interventions. Specifically, NBSs mitigate fear of crime across a number of different types of deteriorated public spaces, and had a positive impact across a wider range of socio-demographic groups. This study underscores the importance of integrating expression-driven strategies,

like NBSs, into fear-prevention policies, and highlights the need for further research to explore diverse populations, different landscape strategies, and the optimal effects of NBSs.



Graph 4. The impact of percentage of greenery on perceptions of safety.

5.1. Main findings

5.1.1. Influence of NBSs on fear of crime

Our broadest findings – that NBSs have the ability to increase perceptions of safety – are aligned with the current theories around this issue. Research has shown that exposure to images or depictions of nature promotes physiological stress reduction (Bratman et al., 2012; Ulrich, 1984, Hartig, 2008; Van den Berg et al., 2003; Korpela & Hartig, 1996), eliciting positive feelings of calmness and relaxation. Schachter-Singer's Two-Factor Theory proposes that nature, by reducing physiological stress, mitigates the emotional expression of fear. Additionally, Attention Recovery Theory (Kaplan, 1995) proposes that vegetation attracts people's attention. By this mechanism, the redirection of attention toward more pleasant and calming stimuli might also serve as a distraction from fear-inducing stimuli associated with crime. This is aligned with previous empirical studies that show a negative correlation between fear of crime and green spaces (Mouratidis, 2019; Navarrete-Hernandez & Laffan, 2019; Navarrete et al., 2023).

5.1.2. NBSs and socio-demographic diversity

This study reveals that NBSs have a positive impact on fear of crime across a wider and more diverse socio-demographic range than current experience-based approaches. A potential linking mechanism can be drawn here with biophilia theory (Wilson, 1984), which proposes that physiological and psychological emotional responses to nature were developed throughout human evolution, and are therefore common to all humans. In contrast, fear-inducing factors proposed by BWT – such as associating graffiti with social disorder – and EOS – such as relating residential windows with surveillance – are arguably culturally constructed, and thus depend on an individual's knowledge and personal and social experience. Therefore, biophilic links between stress reduction and increased perceived safety are likely to be more widely spread across diverse population characteristics than other culturally

constructed factors. The diversity of people positively impacted by NBSs highlights a major strength of this approach, bringing with it the potential to overcome some of the inherent cultural barriers associated with fear of crime in urban environments.

5.1.3. Increased impact of NBSs with increased quantity

The effect of NBSs on fear of crime is larger than for those interventions based on BWT and EOS. This is reasonable and supported by the theoretical frameworks and empirical studies discussed earlier. First, empirical research supports the idea that increased exposure to nature results in greater reductions in physiological stress (Alvarsson et al., 2010; Jiang et al., 2014; Roe et al., 2013). Therefore, based on Schachter-Singer's Two-Factor Theory, more pronounced nature-based interventions ought to result in lower levels of physiological stress and more pronounced decrease of the emotional experience of fear of crime. Furthermore, Attention Recovery Theory suggests that, as an environment become more dominated by natural features, it has a stronger tendency to attract people's attention, and therefore will be more effective at diverting attention from fear-inducing factors – although studies do not yet confirm this hypothesis. Finally, the biophilia hypothesis suggests that, as environments see an increase in vegetation, their natural evolute appeal increases and their cultural influence decreases, seeing impacts on a more diverse population – potentially resulting in larger average mitigations of fear of crime.

5.1.4. Place-specific effects of NBSs

While this study demonstrates the efficacy of NBSs on mitigating fear of crime, it also highlights the importance of considering the context in which interventions take place. While the effect of NBSs remained in all but one case at least comparable to BWT and EOS approaches, we cannot claim that it is a silver bullet for addressing urban fear of crime. Instead, we found that effective environmental interventions are highly place-specific. When carefully considering our results, we can propose a

potential explanation in people's rational thought process regarding which interventions may be plausible and/or effective in a given area. For instance, NBSs were not effective in underpasses or tunnels – areas where vegetation is unlikely to grow – while they were most effective when applied to streets, empty fields and along highways, where their presence is more familiar and realistic. Regardless of the mechanism, our findings are coherent with recent evidence showing the context-specific effect of fear-reducing environmental interventions (Harvey et al., 2015; Hong & Chen, 2014; Navarrete-Hernandez et al., 2023a; 2023b). Further research should explore this interaction between interventions and contexts to better understand and optimize the effects of NBSs, and to contribute to the development of targeted interventions that address fear of crime in specific locations.

5.2. Theoretical and practical implications

The outcomes assessed through the current experiment – that NBSs mitigates fear of crime across diverse sociodemographic and spatial configuration, and their effect increases with intervention size – are important for both theory and practice. While evidence of the impact of emotional expression on experience largely comes from behavioral experiments in emotional psychology (Carney et al., 2010; Ekman et al., 1983; Strack et al., 1988), this paper shows that Schachter-Singer's Two-Factor Theory can be applied to the built environment and physical interventions, affecting emotional expression and mitigating people's negative emotional experiences in urban environments. A relevant avenue for future research is then to investigate whether other physiological stress-reducing built environment conditions may buffer fear of crime along with other negative emotions. For example, the potentially calming sounds of water or nature might be expected to reduce physiological stress and mitigate fear of crime, while physiological stress-inducing environmental factors might be expected to prompt an increase in fear.

Second, most of the existing literature on built environment strategies for reducing fear of crime focuses on conscious experiences, such as Broken Windows Theory (BWT) and Eyes on the Street (EOS) strategies. The demonstrated effectiveness of NBS interventions suggests that built environment strategies for reducing the fear of crime should extend beyond its current focus of targeting people's conscious experiences, to incorporate urban environment interventions that target the emotional physiological expression of fear. Traditional CPTED strategies have often relied on theories from criminology, encouraging a perception of territory through the (legitimate) surveillant and the (illegitimate) surveyed users of public space – an approach that can be highly racialized (Holman et al., 2022) and can have differentiated impacts for different populations (Navarrete-Hernandez et al., 2021, 2023). Since NBSs rely on physiological mechanisms that are potentially established through a deeper-rooted evolutionary history, they might not face these same issues.

From a policy perspective, this study highlights the relevance of integrating urban NBSs to reduce fear of crime for all citizens. Given the effectiveness of NBSs across a range of contexts and people, with outcomes at least comparable to experience-driven approaches – not to mention the wide array of additional benefits of urban nature only briefly touched upon here, such as mental and physical health, carbon capture, pollution retention, and urban heat mitigation – we suggest that NBSs should be fully integrated into the fear prevention policy toolkit.

5.3. Limitations

This study is however not without limitations. First, the current findings correspond to a sample of people who received the experiment

link through social media, which carries with it the limitations of self-reporting methods. Subsequently, this study incorporates a large proportion of White and Asian young adult participants. Although, as in any RCT, we are able to establish a causal link, this link applies to the sampled population only, and so further studies are necessary to extrapolate the results to other population groups. Second, our interventions were limited to well-maintained conventional green spaces, which might not be the case for all types of greening strategies. For instance, wilderness is commonly reported to evoke feelings of both fascination and fear (Konijnendijk, 2012; Wesely & Gaarder, 2004). Future research is needed to clarify the impact of different vegetation landscape strategies and optimize the effects of NBSs. Third, participants were exposed solely to photo-visual landscapes, however research has revealed that the interaction of visual and audial stimuli can enhance people's perceived emotions (Annerstedt, 2013). That being said, we consider that emotions triggered by images can reasonably be considered as a lower-bound estimate. As we can expect that the fear experienced when actually in an unsafe space would be stronger than when viewing an image of this same space, we expect that fear would increase as more immersive and coherent sensorial stimuli are incorporated.

Finally, many of our baseline images, and thus the photo simulations, incorporate elements that may be considered representative of urban dilapidation, particularly visible graffiti. While we felt that it was important for our choices of location to reflect a familiar and realistic local space within urban Milan – and it is common in urban contexts for high levels of graffiti to occur together with busy human activity (e.g. La Vucciria in Palermo, Italy or Hackney Wick in London, UK) and in well-maintained green spaces (e.g. Parque Forestal in Santiago de Chile) – we cannot rule out that some participants might have felt that some of the generated urban contexts were not sufficiently realistic, which may have therefore influenced their perceptions.

5.4. Concluding statement

This experiment provides causal evidence that NBSs reduce fear of crime across diverse socio-demographic groups and urban spaces, with an impact comparable to established CPTED interventions. The reported effects are conceptualized as being linked to the physiological stress-reducing effects of nature, inhibiting the emotional experience of fear of crime. These findings reinforce the relevance of Schachter-Singer's Two-Factor Theory within city contexts, extending its applicability beyond emotional psychology to urban planning. Additionally, the observed effects of NBSs across a wide range of socio-demographic groups suggests that, as physiological emotional responses to nature are inherent to all humans, the effects of NBSs on fear of crime might transcend cultural constructs. Furthermore, understanding more about how Two-Factor Theory can inform urban interventions that mitigate negative and promote positive emotional experiences has the potential to inform novel strategies that further promote citizens' emotional wellbeing and mental health. In the meantime, the broader incorporation of NBSs into urban planning could contribute significantly to reducing the fear of crime, and fostering safer and more inclusive cities.

Statement of contribution

Pablo Navarrete-Hernandez: Conceptualization; Formal analysis; Investigation; Methodology; Software; Supervision; Validation; Visualization; Writing - review & editing. **Kousha Afarin:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Resources; Software; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing.

Appendix

Table A

Typologies of Public Spaces Associated with Perceived Fear of Crime

Selected Public Space Types	Safety Literature	Control	Theory-driven Interventions		
			Broken Windows	Eyes on the street	Nature-based solutions
1.Streets acrossed blind wall	(Keizer et al., 2008)	Blinds walls + tags	Remove graffiti	Windows	Vertical Greenery
2. Vacant areas	(Foster et al., 2010)	Vacant block adjacent to house + garbage	Remove garbage	People front of vacant block	Green fence for vacant block
3.Dead end	(Foster et al., 2010)	Alley + garbage/graffiti	Remove garbage	Put window	Vertical greenery
4.Street across shuttered windows	(Cozens & Davies, 2013)	Street with graffiti on walls and windows with shutter	Remove graffiti	Remove shutter	Vertical greenery
5.Abandoned areas	(Koskela & Pain, 2000)	Abandoned buildings (broken window, damaged facades, ...)	Paint the facades	People on street	Vertical greenery
6.Underpasses	(Koskela & Pain, 2000)	Unclean underpasses with tags	Painting	People	Vertical greenery
7.Tunnels	(Koskela & Pain, 2000)	Unclean Tunnels with tags	Painting	People	Vertical greenery
8.Bridges	(Koskela & Pain, 2000)	Bridges with tags	Painting	People	Vertical greenery
9.Tram stations	(Koskela & Pain, 2000)	Tram stations + graffiti	Clean graffiti	People	Greenery
10.Parkings	(Eck & Weisburd, 2015)	Parking areas + graffiti	Clean graffiti	people	Greenery
11.Sidewalks beside railways	(Koskela & Pain, 2000)	Sidewalks beside railways + graffiti	Clean graffiti	People	Greenery
12.Sidewalks beside highways	(Brantingham & Brantingham, 1995)	Sidewalks beside highways + graffiti	Clean graffiti	People	Greenery
13. Bus station	(Koskela & Pain, 2000)	Bus station out of residential areas + graffiti	Clean graffiti	People	Greenery
14.Unclean sidewalks	(Keizer et al., 2008)	Sidewalks of the street + litter on floor	Cleaning the side walks	People on side walks	Greenery

Table B

Measurements

Variable	Definition
Treatment Status	Equals to 1 if the participant was rating an after-intervention image and equal to 0 if they were presented with a before image.
Safety Level	Equals the safety participants report associating with the image of the site on a 1 to 10 scale where 1 equal "completely unsafe" and 10 equals "completely safe".
The date	Equals the date the participant undertook the experiment
Image order	Equals the order in which an image appears in the 15 images sequence.
Gender	Equals 1 if the participant reported being a man and equal to 0 if the participant reported being a woman and equal to 2 if the participant reported being other
Year of birth	Ranging from 1930 to 2010
ethnicity	Equals 0 if the participants are Asian, equals 1 if they are Black, equals 2 if they are Mixed, equals 3 if they are White, equals 4 if they are Other and equals 5 if they are Rather not say.
Educational level	Equals 1 if the participant had was studying or had obtained a tertiary education on the day the experiment was conducted and equals 0 e if they have secondary education level or less than it.
Where do you live?	Equals 0 if the participants are living in Milan, equals 1 if they are living in Lombardy (except Milan), equals 2 if they are living in another European country (including the UK), equals 3 if they are living in another European country (including the UK) and equals 4 if they are living non-European country.
Have you ever been a victim of crime in the last twelve months?	Equals to 0 if the participant was answering yes equal to 1 if they answered no.
What type of crime did you suffer in the last twelve months?	Equals 0 if the participants answered did not suffer from crime in the past 12 months, equals 1 if they answered Theft (occurs without violence), equals 2 if they answered Robbery (occurs with violence), 3 if they answered Personal injuries, equals 4 if they answered Sexual assault/Violence, equals 5 if they answered Burglary (e.g., housebreaking), equals 6 if they answered others and equals 7 if they answered I prefer not to say.
how worried are you about being robbed or mugged on the street	Equals 0 if the participants answered Very worried, equals 1 if they answered a little worried, equals 2 if they answered Neither worried nor not worried, 3 if they answered Not very worried and equals 4 if they answered Not at all worried.
how worried are you about being victim of physical violence or aggression	Equals 0 if the participants answered Very worried, equals 1 if they answered a little worried, equals 2 if they answered Neither worried nor not worried, 3 if they answered Not very worried and equals 4 if they answered Not at all worried.
how worried are you about sexual crime and rape	Equals 0 if the participants answered Very worried, equals 1 if they answered a little worried, equals 2 if they answered Neither worried nor not worried, 3 if they answered Not very worried and equals 4 if they answered Not at all worried.
What type of devices are you using to answer this questionnaire	Equals 0 if the participants answered Desktop, equals 1 if they answered Laptop, equals 2 if they answered Tablet and 3 if they answered Smart phone.

Table C

The impact of all types of Built Environment interventions on perceptions of safety.

VARIABLES	Safety Perception	
	1	2
All intervention	0.650*** (0.0602)	0.652*** (0.0601)
Constant	5.008*** (0.0843)	3.870*** (0.859)
Controls	No	Yes
Observations	7410	7410
Number of groups	504	504

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Table D

The impact of nature-based solutions on perceptions of safety

VARIABLES	Safety Perception	
	1	2
Nature-Based Solution	0.785*** (0.0763)	0.792*** (0.0762)
Constant	5.000*** (0.0853)	3.778*** (0.899)
Controls	No	Yes
Observations	3680	3680
Number of groups	503	503

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Table E

The impact of different type of interventions on perceptions of safety

VARIABLES	Safety Perception	
	1	2
Broken Window	0.630*** (0.0722)	0.631*** (0.0721)
Eyes On Street	0.543*** (0.0792)	0.548*** (0.0791)
Nature-Based Solution	0.781*** (0.0748)	0.783*** (0.0747)
Constant	5.008*** (0.0843)	3.869*** (0.861)
Controls	No	Yes
Observations	7410	7410
Number of groups	504	504
ANOVA F-test F(3,7406) = 41.08***		
Pairwise comparisons (Bonferroni's corrections)		
Control VS BWT	0.630 ⁺⁺⁺ (0.0721)	0.631 ⁺⁺⁺ (0.0721)
Control VS EOS	0.543 ⁺⁺⁺ (0.0792)	0.548 ⁺⁺⁺ (0.0791)
Control VS NBS	0.781 ⁺⁺⁺ (0.0748)	0.783 ⁺⁺⁺ (0.0747)
EOS VS BWT	-0.087 (0.0810)	-0.084 (0.0810)
NBS VS BWT	0.151 (0.0744)	0.152 (0.0745)
NBS VS EOS	0.238 ⁺⁺⁺ (0.0814)	0.236 ⁺⁺⁺ (0.0813)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, ⁺p < 0.1, ⁺⁺p < 0.05, ⁺⁺⁺p < 0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table F

The impact of different interventions for each type of urban spaces on perceptions of safety

VARIABLES	Streets		Abandoned areas		Tunnels and Underpasses		Train and Bus Stations		Parking		Rail and Highways		Bridges	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Broken Window	0.413**	0.339**	0.746***	0.727***	0.515***	0.483***	0.544*	0.599**	0.684**	0.887***	0.647***	0.649***	1.007***	1.001***
Eyes On Street	(0.169)	(0.165)	(0.173)	(0.174)	(0.163)	(0.160)	(0.281)	(0.271)	(0.287)	(0.281)	(0.122)	(0.122)	(0.310)	(0.286)
Nature-Based Solution	0.00242	-0.0170	0.324*	0.308*	0.868***	0.836***	0.689**	0.813***	1.203***	1.394***	0.563***	0.580***	1.523***	1.560***
Constant	(0.179)	(0.175)	(0.167)	(0.166)	(0.159)	(0.158)	(0.283)	(0.274)	(0.290)	(0.292)	(0.132)	(0.130)	(0.300)	(0.279)
Controls	0.850***	0.810***	0.898***	0.911***	0.0959	0.0753	0.768***	0.764***	0.969***	1.232***	1.012***	1.009***	0.687**	0.718**
Observations	(0.156)	(0.151)	(0.156)	(0.155)	(0.148)	(0.144)	(0.292)	(0.279)	(0.301)	(0.304)	(0.133)	(0.131)	(0.322)	(0.307)
Number of groups	5.757***	4.157***	5.307***	4.082***	3.544***	2.219**	5.828***	6.084***	4.640***	4.280***	4.998***	4.913***	4.396***	2.047
	(0.133)	(0.863)	(0.129)	(0.825)	(0.127)	(0.963)	(0.202)	(0.915)	(0.207)	(0.959)	(0.111)	(0.852)	(0.224)	(1.315)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1482	1482	1611	1611	991	991	494	494	492	492	1843	1843	497	497
Number of groups	504	504	503	503	504	504	488	488	488	488	504	504	492	492

ANOVA F-test $F(3, 1478) = 9.33***F(3, 1607) = 13.53***F(3, 987) = 8.31***F(3, 490) = 2.90***F(3, 488) = 7.61***F(3, 1839) = 9.68***F(3, 493) = 8.50***$

Pairwise comparisons (Bonferroni's corrections)

Control VS BWT	0.413 ⁺	0.339	0.746 ⁺⁺	0.727 ⁺⁺	0.483 ⁺⁺	0.483 ⁺⁺	0.544	0.599	0.887 ⁺⁺	0.887 ⁺⁺	0.647 ⁺⁺	0.649 ⁺⁺	1.007 ⁺⁺	1.001 ⁺⁺
	(-0.169)	(0.165)	(0.173)	(0.1739)	(0.160)	(0.160)	(0.281)	(0.270)	(0.281)	(0.281)	(0.122)	(0.1219)	(0.310)	(0.286)
Control VS EOS	0.002	-0.017	0.324	0.308	0.836 ⁺⁺	0.837 ⁺⁺	0.689 ⁺⁺	0.813 ⁺⁺	1.394 ⁺⁺	1.394 ⁺⁺	0.563 ⁺⁺	0.580 ⁺⁺	1.523 ⁺⁺	1.560 ⁺⁺
	(-0.179)	(0.175)	(0.167)	(0.1664)	(0.158)	(0.158)	(0.283)	(0.274)	(0.292)	(0.292)	(0.132)	(0.130)	(0.300)	(0.280)
Control VS NBS	0.850 ⁺⁺	0.810 ⁺⁺	0.898 ⁺⁺	0.911 ⁺⁺	0.075	0.075	0.768 ⁺⁺	0.764 ⁺⁺	1.232 ⁺⁺	1.232 ⁺⁺	1.012 ⁺⁺	1.009 ⁺⁺	0.687	0.718
	(0.156)	(0.151)	(0.156)	(0.1546)	(0.144)	(0.144)	(0.292)	(0.279)	(0.304)	(0.304)	(0.133)	(0.1313)	(0.322)	(0.307)
EOS VS BWT	-0.411	-0.356	-0.421 ⁺	-0.419*	0.353	0.353	0.146	0.214	0.507	0.507	-0.084	-0.068	0.516	0.559
	(0.173)	(0.171)	(0.170)	(0.1703)	(0.203)	(0.203)	(0.282)	(0.266)	(0.283)	(0.283)	(0.124)	(0.124)	(0.293)	(0.270)
NBS VS BWT	0.437 ⁺⁺	0.471 ⁺⁺	0.152	0.184	-0.408	-0.408	0.224	0.165	0.345	0.345	0.365 ⁺⁺	0.3607 ⁺	-0.320	-0.283
	(0.153)	(0.151)	(0.161)	(0.1625)	(0.171)	(0.171)	(0.290)	(0.275)	(0.287)	(0.287)	(0.136)	(0.135)	(0.321)	(0.308)
NBS VS EOS	0.848 ⁺⁺	0.827 ⁺⁺	0.573 ⁺⁺	0.604 ⁺⁺	-0.760 ⁺	-0.760 ⁺	0.079	-0.050	-0.161	-0.161	0.449 ⁺⁺	0.429 ⁺⁺	-0.836 ⁺	-0.842 ⁺
	(0.158)	(0.156)	(0.162)	(0.160)	(0.169)	(0.1686)	(0.293)	(0.271)	(0.298)	(0.298)	(0.136)	(0.136)	(0.309)	(0.298)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p < 0.1, ++p < 0.05, +++p < 0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table G

The impact of nature-based solutions on perceptions of safety for different gender

VARIABLES	. Female.		. Male.	
	1	2	3	4
Broken Window	0.621***	0.614***	0.673***	0.676***
	(0.0959)	(0.0959)	(0.111)	(0.111)
Eyes On Street	0.691***	0.694***	0.310***	0.310***
	(0.105)	(0.105)	(0.119)	(0.119)
Nature-Based Solution	0.836***	0.832***	0.733***	0.739***
	(0.0964)	(0.0963)	(0.120)	(0.120)
Controls	No	Yes	No	Yes
Constant	4.632***	4.913***	5.541***	2.506**
	-0.104	-1.123	-0.135	-1.175
Observations	4392	4392	2930	2930
Number of groups	297	297	201	201
ANOVA F-test $F(3, 4388) = 27.14***F(3, 2926) = 18.17***$				
Pairwise comparisons (Bonferroni's corrections)				
BWT vs Control	0.621 ⁺⁺⁺	0.614 ⁺⁺⁺	0.673 ⁺⁺⁺	0.676 ⁺⁺⁺
	(0.096)	(0.096)	(0.111)	(0.111)
EOS vs Control	0.691 ⁺⁺⁺	0.694 ⁺⁺⁺	0.310*	0.310*
	(0.105)	(0.105)	(0.119)	(0.119)
NBS vs Control	0.836 ⁺⁺⁺	0.832 ⁺⁺⁺	0.733 ⁺⁺⁺	0.739 ⁺⁺⁺
	(0.096)	(0.096)	(0.120)	(0.120)
EOS vs BWT	0.070	0.080	-0.363	-0.366
	(0.106)	(0.106)	(0.124)	(0.124)
NBS vs BWT	0.215	0.218	0.060	0.0636
	(0.099)	(0.010)	(0.114)	(0.114)
NBS vs EOS	0.145	0.138	0.423 ⁺⁺⁺	0.430 ⁺⁺⁺
	(0.110)	(0.109)	(0.120)	(0.120)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p<0.1, ++p<0.05, +++p<0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table H

The impact of nature-based solutions on perceptions of safety for different age groups

VARIABLES	<30		31–40	
	1	2	3	4
Broken Window	0.639*** (0.0835)	0.641*** (0.0836)	0.725*** (0.165)	0.729*** (0.165)
Eyes On Street	0.498*** (0.0911)	0.501*** (0.0909)	0.794*** (0.186)	0.801*** (0.185)
Nature-Based Solution	0.815*** (0.0823)	0.817*** (0.0822)	0.740*** (0.193)	0.748*** (0.192)
Controls	No	Yes	No	Yes
Constant	4.975*** (0.0933)	3.123*** (0.821)	5.275*** (0.212)	8.673*** (1.404)
Observations	5743	5743	1191	1191
Number of groups	394	394	78	78
ANOVA F(3, 5739) = 33.27***F(3, 1187) = 6.06***				
Pairwise comparisons (Bonferroni's corrections)				
BW vs Control	0.639+++ (0.084)	0.641+++ (0.084)	0.725+++ (0.165)	0.729+++ (0.165)
EOS vs Control	0.498+++ (0.091)	0.501+++ (0.091)	0.794+++ (0.186)	0.801+++ (0.185)
NBS vs Control	0.815+++ (0.082)	0.817+++ (0.082)	0.740+++ (0.193)	0.748+++ (0.191)
EOS vs BW	−0.141 (0.095)	−0.140 (0.095)	0.070 (0.189)	0.072 (0.189)
NBS vs BW	0.176 (0.084)	0.176 (0.084)	0.015 (0.183)	0.019 (0.185)
NBS vs EOS	0.317+++ (0.089)	0.316+++ (0.089)	−0.055 (0.239)	−0.053 (0.239)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p<0.1, ++p<0.05, +++p<0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table I

The impact of nature-based solutions on perceptions of safety for different ethnicities

VARIABLES	Asian		White	
	1	2	3	4
Broken Window	0.619*** (0.153)	0.614*** (0.154)	0.696*** (0.0873)	0.699*** (0.0868)
Eyes On Street	0.766*** (0.179)	0.777*** (0.179)	0.482*** (0.0974)	0.486*** (0.0976)
Nature-Based Solution	0.869*** (0.157)	0.869*** (0.158)	0.865*** (0.0888)	0.870*** (0.0884)
Controls	No	Yes	No	Yes
Constant	5.179*** (0.172)	4.194*** (1.075)	4.818*** (0.108)	2.525*** (0.637)
Observations	1995	1995	4294	4294
Number of groups	131	131	297	297
ANOVA F-test F(3, 1991) = 15.35***F(3, 4290) = 29.46***				
Pairwise comparisons (Bonferroni's corrections)				
BW vs Control	0.619+++ (0.153)	0.614+++ (0.154)	0.696+++ (0.087)	0.699+++ (0.087)
EOS vs Control	0.766+++ (0.179)	0.777+++ (0.179)	0.481+++ (0.097)	0.486+++ (0.097)
NBS vs Control	0.869+++ (0.157)	0.869+++ (0.158)	0.865+++ (0.089)	0.870+++ (0.088)
EOS vs BW	0.147 (0.161)	0.162 (0.162)	−0.214 (0.106)	−0.213 (0.106)
NBS vs BW	0.250 (0.153)	0.255 (0.153)	0.169 (0.090)	0.171 (0.090)
NBS vs EOS	0.103 (0.176)	0.092 (0.175)	0.383+++ (0.100)	0.384+++ (0.100)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p < 0.1, ++p < 0.05, +++p < 0.01 (Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table J

The impact of nature-based solutions on perceptions of safety for different education level

VARIABLES	Equal or less than secondary education		Tertiary education	
	1	2	3	4
Broken Window	0.796*** (0.132)	0.791*** (0.131)	0.572*** (0.0856)	0.573*** (0.0859)
Eyes On Street	0.372*** (0.144)	0.382*** (0.143)	0.612*** (0.0944)	0.618*** (0.0944)
Nature-Based Solution	0.936*** (0.139)	0.938*** (0.137)	0.727*** (0.0885)	0.729*** (0.0884)
Controls	No	Yes	No	Yes
Constant	4.795*** (0.157)	4.871*** (1.493)	5.089*** (0.0996)	4.169*** (0.747)
Observations	1995	1995	5415	5415
Number of groups	141	141	363	363
ANOVA F-test F(3, 1991) = 14.83***F(3, 5411) = 29.41***				
Pairwise comparisons (Bonferroni's corrections)				
BW vs Control	0.796*** (0.132)	0.791*** (0.131)	0.572*** (0.086)	0.573*** (0.086)
EOS vs Control	0.372*** (0.144)	0.382*** (0.143)	0.612*** (0.094)	0.618*** (0.094)
NBS vs Control	0.936*** (0.139)	0.938*** (0.137)	0.727*** (0.088)	0.729*** (0.088)
EOS vs BW	-0.424*** (0.151)	-0.409*** (0.150)	0.041 (0.095)	0.045 (0.095)
NBS vs BW	0.140 (0.140)	0.147 (0.140)	0.156 (0.088)	0.156 (0.088)
NBS vs EOS	0.564*** (0.144)	0.555*** (0.145)	0.115 (0.097)	0.111 (0.097)

Notes: Broken Window Theory (BWT), Eyes on the Streets (EOS), Nature-Based Solutions (NBS).

Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p < 0.1, ++p < 0.05, +++p < 0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

Table K

The impact of greenery percentage on perceptions of safety

VARIABLES	Safety Perception	
	1	2
1%–10% Added Greenery	0.578*** (0.112)	0.585*** (0.112)
11%–20% Added Greenery	1.238*** (0.110)	1.252*** (0.110)
>20% Added Greenery	1.917*** (0.201)	1.930*** (0.201)
Controls	No	Yes
Constant (0% Greenery)	4.786*** (0.0900)	3.490*** (0.708)
Observations	2674	2674
Number of groups	502	502
ANOVA F-test F(3, 2670) = 53.97***		
Pairwise comparisons (Bonferroni's corrections)		
1–10% vs 0%	0.578*** (0.112)	0.585*** (0.112)
11–20% vs 0%	1.238*** (0.110)	1.252*** (0.110)
20% < vs 0%	1.917*** (0.201)	1.930*** (0.208)
11–20% vs 0–10%	0.660*** (0.127)	0.667*** (0.127)
20% < vs 0–10%	1.338*** (0.212)	1.345*** (0.212)
20% < vs 11–20%	0.678*** (0.201)	0.678*** (0.200)

Notes: Robust standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Bonferroni-adjusted p-values, +p < 0.1, +⁺p < 0.05, +⁺⁺p < 0.01.

(Bonferroni-corrected alpha level for a 5% probability of Type 1 Error is 0.008).

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