The Same Street, Different Safety Judgments: Evaluative Framing Effects in Daytime and Nighttime Street View Imagery

Tong Qin
Department of Geography, Ghent University, Belgium

Nico Van de Weghe
Department of Geography, Ghent University, Belgium

Wim Fias
Department of Experimental Psychology, Ghent University, Belgium

Haosheng Huang
Department of Geography, Ghent University, Belgium

Abstract

Street View Imagery (SVI) is widely used to study perceived street safety, yet most studies treat safety as a general impression of urban scenes and rely mainly on daytime imagery. It remains unclear whether safety judgments differ across evaluative framings, defined here as the safety question asked of participants, and whether this difference varies between daytime and nighttime scenes. We analyzed 7,320 safety ratings from 61 participants for 120 SVIs, including 60 daytime and 60 nighttime images. Participants judged scenes under two evaluative framings: crime-related safety and traffic-related safety. Using cumulative link mixed models with random intercepts for participants and stimuli, we found that the stimulus set received higher safety ratings in the crime-related framing than in the traffic-related framing. This evaluative-framing effect was stronger for daytime than for nighttime scenes. These findings indicate that perceived street safety in SVI is not a fixed property of image content, but also depends on the safety question asked during judgment.

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1 Introduction

Urban safety perception shapes how people experience and evaluate cities, including where they move, how they use public space, and how they assess urban quality [5, 6, 16, 9, 15]. From the perspective of spatial cognition, such judgments can be understood as interpretations of spatial information: people not only perceive physical environments of the street, but also assign meaning to them in relation to possible actions, risks, and movement decisions. In recent years, SVI and data-driven methods have made it possible to study perceived safety across large urban areas [13, 2, 3, 4, 7]. This work has shown that visible street features are related to safety judgments and has supported new ways to map, compare, and predict perceived safety across cities and neighborhoods. However, most SVI-based studies treat safety as a general evaluative impression of a street scene, often using daytime imagery as the main visual source [11]. This approach is useful for building comparable datasets and models, but it may hide important differences between specific safety concerns. A single general safety score cannot clearly show whether a street feature is related to fear of crime, traffic danger, or a mixture of both. This limits our ability to interpret the relationship between urban environments and perception, and also makes it harder to translate model results into targeted urban design strategies.

Urban safety perception is better understood as a multidimensional judgment rather than a single undifferentiated response [11]. In this paper, evaluative framing refers to the safety question asked of participants, namely crime-related safety or traffic-related safety. We do not assume that crime-related and traffic-related safety are the same type of judgment or rely on the same underlying process; rather, we use them as two distinct safety framings applied to a shared set of street-view images. The same street environment may be evaluated differently when people are asked to consider crime-related safety or traffic-related safety. These evaluative framings may change which visual cues people attend to and how they interpret a scene, and how the scene may support or discourage movement through urban space. This issue may be especially important when comparing daytime and nighttime scenes, because lighting conditions can change the meaning of specific environmental features. For example, greenery is often associated with more positive safety judgments in daytime settings [1], but after dark its effect may weaken or even reverse when vegetation is combined with poor lighting, reduced visibility, or a stronger sense of concealment [12]. It therefore remains unclear whether street-scene safety judgments differ under different evaluative framings, and whether this difference varies between daytime and nighttime scenes. Against this background, we ask two related questions:

- Does evaluative framing change perceived safety across a shared stimulus set?
- Does this evaluative-framing effect differ between daytime and nighttime scenes?

2 Methods

Overview

To examine whether perceived street safety changes with evaluative framing, and whether this effect differs between daytime and nighttime scenes, we conducted a controlled laboratory experiment using SVIs and analyzed the resulting ratings with cumulative link mixed models. The experiment was designed to estimate evaluative-framing effects while holding the stimulus set constant: a shared stimulus set of street scenes was evaluated under two evaluative framings, defined by crime-related and traffic-related safety questions, and both daytime and nighttime scenes were included (Figure 1). Because the outcome variable was an ordered 1-7 safety rating, and because observations were crossed by both participants and stimuli, cumulative link mixed modeling provided an appropriate analytic framework.

Experiment

Sixty-one participants took part in the experiment. The stimuli consisted of 120 SVIs, including 60 daytime scenes and 60 nighttime scenes. Participants were instructed to adopt a pedestrian perspective and rate how safe they would feel in the depicted environment. Safety was evaluated under two evaluative framings: a crime-related safety question and a traffic-related safety question. In the crime-related safety framing, participants rated how safe they would feel with respect to possible criminal events, such as theft, assault, vandalism, robbery, and burglary, while walking as pedestrians. In the traffic-related safety framing, participants rated how safe they would feel with respect to possible traffic accidents while

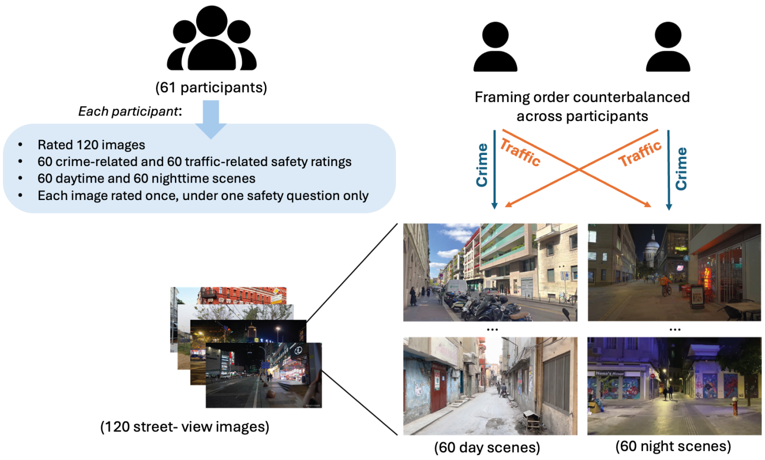

Figure 1 Overview of the experimental design and stimulus assignment. Participants completed both crime-related and traffic-related safety framings, while each image was shown only once to a given participant and under one framing only.

walking as pedestrians. For each trial, participants viewed one street scene and provided a safety judgment on an ordered 1-7 scale, where higher values indicated higher perceived safety. The final dataset contained 7,320 rating observations. Each participant completed both evaluative framings, but each image was shown only once to a given participant and under only one framing. Framing order and image presentation order were counterbalanced across four participant subgroups, reducing repetition and order effects while preserving comparison across the shared stimulus set.

Statistical analysis

The main analyses used cumulative link mixed models (CLMMs), reflecting both the ordinal outcome and the crossed data structure. The dependent variable was an ordered 1-7 safety rating, which has a clear rank order but cannot be assumed to have equal intervals between categories. Simple t-tests or ANOVA would require aggregation or would not adequately account for repeated ratings across both participants and stimuli. Linear mixed models can include random effects, but they treat the rating scale as continuous. CLMMs were therefore more appropriate because they model ordered responses directly while accounting for participant- and stimulus-level variability. We estimated two CLMMs with a logit link and random intercepts for participants and stimuli. Model 1 tested the main effects of evaluative framing and day-night condition while controlling for presentation order. Evaluative framing was coded with crime-related safety as the reference level, and daytime scenes served as the reference level for the day-night factor. Presentation order was mean-centered before analysis.

$$\begin{aligned}\text{Model 1: } & \texttt{rating} \sim \texttt{framing} + \texttt{day\_night} + \texttt{order} \\ & + (1 \mid \texttt{participant}) + (1 \mid \texttt{stimulus}). \end{aligned} \tag{1}$$

Model 2 extended Model 1 by adding the interaction between evaluative framing and day-night condition. This model tested whether the evaluative-framing effect differed between daytime and nighttime scenes.

$$\text{Model 2: } \texttt{rating} \sim \texttt{framing} + \texttt{day\_night} + \texttt{framing} : \texttt{day\_night} + \texttt{order} + (1 \mid \texttt{participant}) + (1 \mid \texttt{stimulus}). \quad (2)$$

Model interpretation focused on fixed-effect estimates and likelihood-ratio comparisons between nested models. Model 1 assessed whether safety ratings differed by evaluative framing and day-night condition. Model 2 assessed whether the effect of evaluative framing changed between daytime and nighttime scenes. Model fit was evaluated through likelihood-ratio comparisons between nested models. We first compared Model 1 with a reduced model excluding evaluative framing to test the overall contribution of evaluative framing, and then compared Model 2 with Model 1 to test whether adding the evaluative framing $\times$ day-night interaction improved model fit. All models were fitted in R using ordinal::clmm with Laplace approximation.

3 Results

Descriptive patterns in observed safety ratings

Figure 2 shows the observed mean safety ratings across evaluative framings and day-night conditions. For daytime scenes, the mean rating was lower in the traffic-related safety framing than in the crime-related safety framing (4.51 vs. 4.79). For nighttime scenes, the same direction was observed, but the difference was smaller (4.46 vs. 4.53). This descriptive pattern suggests that evaluative framing changed perceived safety, with a larger framing-related difference for daytime scenes than for nighttime scenes.

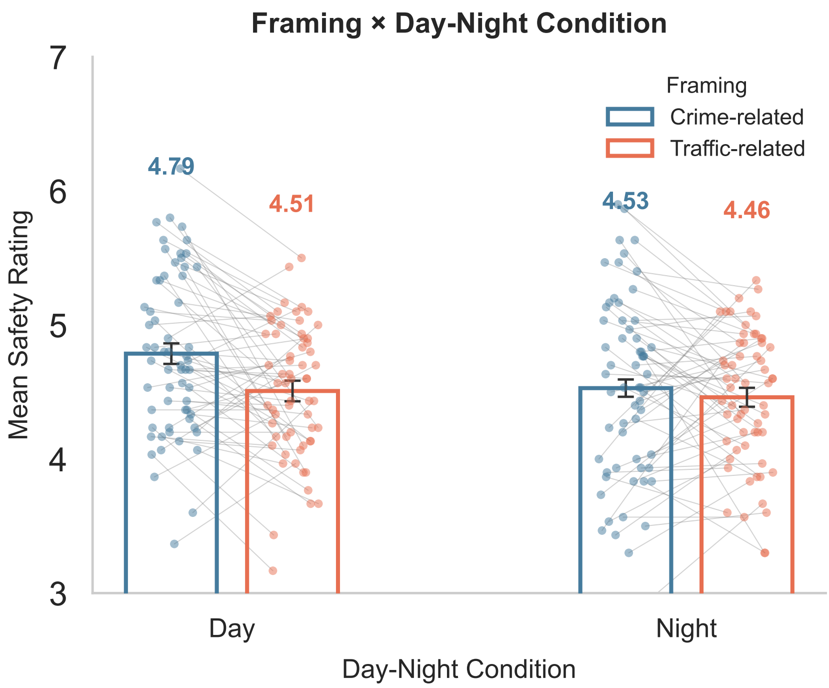

Figure 2 Mean safety ratings by evaluative framing (Crime vs. Traffic) and day-night condition (Day vs. Night).

Evaluative framing changes perceived safety

The CLMM results supported an effect of evaluative framing. In Model 1, ratings were significantly lower in the traffic-related safety framing than in the crime-related safety framing ($b = -0.324$, $SE = 0.043$, $z = -7.576$, $p < .001$). Adding evaluative framing significantly improved model fit compared with a reduced model without evaluative framing, $\chi^2(1) = 57.57$, $p < .001$. In contrast, neither day-night condition nor presentation order showed a significant main effect in this model (night: $b = -0.310$, $p = .344$; presentation order: $b = 0.001$, $p = .750$). These results indicate that, across the shared stimulus set, ratings were lower under traffic-related framing than under crime-related framing.

The evaluative-framing effect differs between daytime and nighttime scenes

Model 2 tested whether the effect of evaluative framing differed between daytime and nighttime scenes. The interaction between evaluative framing and day-night condition was significant (traffic framing $\times$ night: $b = 0.439$, $SE = 0.085$, $z = 5.136$, $p < .001$), and the interaction model fit the data better than the main-effects model, $\chi^2(1) = 26.42$, $p < .001$. The main effect of traffic-related framing remained negative in this model ($b = -0.546$, $SE = 0.061$, $z = -8.973$, $p < .001$), while the positive interaction term showed that this negative effect was weaker at night. Neither the main effect of day–night condition nor presentation order was significant (night: $b = -0.529$, $p = .110$; presentation order: $b = 0.001$, $p = .770$). This pattern supports the descriptive result shown in Figure 2: evaluative framing had a stronger effect on daytime scenes than on nighttime scenes.

4 Discussion

This study adds an evaluative-framing perspective to SVI-based research on perceived street safety. Our findings do not contradict content-based approaches, which have shown that visible environmental features are meaningfully related to safety judgments. Rather, they suggest that such approaches remain incomplete if perceived safety is treated as a fixed property of image content alone. The shared set of street scenes received different safety ratings depending on the evaluative framing, that is, the safety question participants were asked to answer. In this sense, perceived safety in SVI is not only content-sensitive but also framing-dependent. The main contribution of this study is to show that the difference between crime-related and traffic-related safety judgments depends on whether street-view images are shown in daytime or nighttime conditions.

A notable finding is that, for the same street scenes, ratings were generally lower under traffic-related framing than under crime-related framing. One possible explanation is that traffic safety judgments rely on more immediate and concrete visual criteria, such as the presence of sidewalks, the clarity of road markings or traffic signs, potential conflicts between vehicles and pedestrians, or the perceived danger of crossings and intersections [8]. Crime-related safety, by contrast, may be evaluated in a more general and diffuse way, because cues related to crime are often less direct and may depend more on broader environmental meaning than on clearly identifiable single-image features [14]. As a result, participants may have applied a stricter evaluative standard under traffic-related framing, leading to systematically lower ratings. However, crime-related and traffic-related safety may involve partly different perceptual and cognitive mechanisms, so the difference between them should not be interpreted as a simple shift along one general safety scale.

At the same time, the evaluative-framing effect was stronger in daytime scenes than in nighttime scenes. The model does not show a uniform day-night shift in safety ratings. Instead, it shows that day-night condition moderated how evaluative framing influenced safety judgments. As shown in Figure 2, ratings were lower in the traffic-related framing than in the crime-related framing for both daytime and nighttime scenes, but the gap between the two framings was larger for daytime scenes. This result suggests that the effect of evaluative framing was not the same across visual conditions.

One possible interpretation is that nighttime scenes provide less clear spatial information for differentiating between types of safety concerns. Reduced visibility, weaker prospect, lower social presence, and a greater possibility of concealment may make crime-related safety judgments more uncertain or more negative [10, 12]. Under such conditions, crime-related safety may move closer to traffic-related safety, reducing the contrast between the two evaluative framings. However, since perceived visibility, uncertainty, and concealment were not directly measured, further work is needed to test this mechanism more directly. Nevertheless, the finding is important for SVI-based research because it shows that day-night condition can change how evaluative framing shapes the interpretation of street-scene information. This matters especially for daytime-dominant SVI research, because the evaluative-framing effect appears to be strongest in the type of imagery on which the field has relied most heavily [11]. The result supports the view that SVI-based safety ratings are not direct readings of image content, but framing-dependent interpretations of spatial information. The meaning of a street feature may depend jointly on the evaluative question being asked and the visual condition under which the scene is represented.

These findings have broader implications for how results from SVI-based safety studies are interpreted and compared. If perceived safety depends partly on evaluative framing, then studies that use different safety questions, or leave the meaning of “safety” underspecified, may not be directly comparable even when they use similar images or modeling pipelines. The results also suggest that future datasets and empirical studies should make the evaluative meaning of safety more explicit. Taken together, these findings challenge the common assumption that perceived safety can be treated as a stable property of street imagery and instead suggest that it emerges from the interaction between visual content and evaluative framing.

5 Conclusion

This study investigated whether perceived street safety varies with evaluative framing and across day-night conditions. The results show that street-scene safety judgments can differ under crime-related and traffic-related safety framings, and that this difference is larger for daytime than for nighttime scenes. These findings suggest that perceived safety in street imagery is not determined by visual content alone but is partly shaped by the safety question asked about the scene. Recognizing this framing dependence is important for interpreting, comparing, and designing SVI-based studies of urban safety perception, especially when safety is otherwise treated as a single general rating.

References

1 Nandita Basu, Oscar Oviedo-Trespalacios, Mark King, Md. Kamruzzaman, and Md. Mazharul Haque. The influence of the built environment on pedestrians’ perceptions of attractiveness, safety and security. *Transportation Research Part F: Traffic Psychology and Behaviour*, 87:203–218, 2022. `doi:10.1016/j.trf.2022.03.006`.

2 Filip Biljecki and Koichi Ito. Street view imagery in urban analytics and GIS: A review. *Landscape and Urban Planning*, 215:104217, 2021. doi:10.1016/j.landurbplan.2021.104217.

3 Zhuangyuan Fan, Fan Zhang, Becky P. Y. Loo, and Carlo Ratti. Urban visual intelligence: Uncovering hidden city profiles with street view images. *Proceedings of the National Academy of Sciences of the United States of America*, 120(27):e2220417120, 2023. doi:10.1073/pnas.2220417120.

4 Yuhao Kang, Jonatan Abraham, Vania Ceccato, Fábio Duarte, Song Gao, Lukas Ljungqvist, Fan Zhang, Per Näsman, and Carlo Ratti. Assessing differences in safety perceptions using GeoAI and survey across neighbourhoods in stockholm, sweden. *Landscape and Urban Planning*, 236:104768, 2023. doi:10.1016/j.landurbplan.2023.104768.

5 Eduardo E. Lozano. Visual needs in the urban environment. *Town Planning Review*, 45(4):351–374, 1974. doi:10.3828/tpr.45.4.h43m7270u0m3x968.

6 Jack L. Nasar. Perception, cognition, and evaluation of urban places. In Irwin Altman and Ervin H. Zube, editors, *Public Places and Spaces*, pages 31–56. Springer, Boston, MA, 1989. doi:10.1007/978-1-4684-5601-1_3.

7 Yoshiki Ogawa, Takuya Oki, Chenbo Zhao, Yoshihide Sekimoto, and Chihiro Shimizu. Evaluating the subjective perceptions of streetscapes using street-view images. *Landscape and Urban Planning*, 247:105073, 2024. doi:10.1016/j.landurbplan.2024.105073.

8 Callista A. Ottoni, Joanie Sims-Gould, and Meghan Winters. Safety perceptions of older adults on an urban greenway: Interplay of the social and built environment. *Health & Place*, 70:102605, 2021. doi:10.1016/j.healthplace.2021.102605.

9 Luca Pappalardo, Ed Manley, Vedran Sekara, and Laura Alessandretti. Future directions in human mobility science. *Nature Computational Science*, 3(7):588–600, 2023. doi:10.1038/s43588-023-00469-4.

10 Yunmi Park and Max Garcia. Pedestrian safety perception and urban street settings. *International Journal of Sustainable Transportation*, 14(11):860–871, 2020. doi:10.1080/15568318.2019.1641577.

11 Tong Qin, Nico Van de Weghe, and Haosheng Huang. The role of urban built environments in the perception of safety: A systematic review. *Environmental Impact Assessment Review*, 114:107915, 2025. doi:10.1016/j.eiar.2025.107915.

12 Johan Rahm, Catharina Sternudd, and Maria Johansson. “in the evening, i don’t walk in the park”: The interplay between street lighting and greenery in perceived safety. *Urban Design International*, 26(1):42–52, 2021. doi:10.1057/s41289-020-00134-6.

13 Philip Salesses, Katja Schechtner, and César A. Hidalgo. The collaborative image of the city: Mapping the inequality of urban perception. *PLOS ONE*, 8(7):e68400, 2013. doi:10.1371/journal.pone.0068400.

14 I. Senna, F. Iglesias, and L. H. Matsunaga. Measuring the effects of Crime Prevention Through Environmental Design (cpted) on fear of crime in public spaces. *Crime Prevention and Community Safety*, 27(1):1–17, 2025. doi:10.1057/s41300-025-00223-0.

15 Petrus te Braak and Theun Pieter van Tienoven. Navigating the city: A systematic literature review on women’s perceived safety in urban public space. *Cities*, 162:105907, 2025. doi:10.1016/j.cities.2025.105907.

16 Fan Zhang, Bolei Zhou, Liu Liu, Yu Liu, Helene H. Fung, Hui Lin, and Carlo Ratti. Measuring human perceptions of a large-scale urban region using machine learning. *Landscape and Urban Planning*, 180:148–160, 2018. doi:10.1016/j.landurbplan.2018.08.020.