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EXPLORING THERMAL ALLIESTHESIA AND PSYCHOGEOGRAPHY THROUGH MINIMAL VIRTUAL EXPOSURE

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ABSTRACT

Individual perceptions of urban space are shaped by physical adaptations associated with their region of origin. These psychogeographic factors influence how the body adjusts to environmental changes, including the mechanism of homeostasis (the body's ability to maintain internal balance), which results in different standards of thermal comfort among individuals. In the thermal context, homeostasis serves as a strong trigger for thermal alliesthesia, a condition in which sensations of comfort or discomfort arise in response to temperature changes relative to the body's prior state. This study adopts an exploratory approach aimed at assessing the potential detection of such processes in a virtual setting with minimal exposure, using video-based observations of urban environments. Structural Equation Modeling (SEM) was employed to examine multivariate relationships between mood states, regional background, and perceptions of physical elements (brightness, shading), as well as their impact on route comfort. The findings indicate that homeostatic processes can still be detected in virtual settings and are positively influenced by psychogeographic background, thereby opening opportunities for applications in spatial design, further research, and place branding, even without direct on-site involvement.

KEYWORDS: psychogeography, remote observation, structural equation modelling, thermal alliesthesia

Persepsi individu terhadap ruang kota dibentuk oleh adaptasi fisik yang berkaitan dengan daerah asal mereka. Faktor psikogeografis ini mempengaruhi bagaimana tubuh menyesuaikan diri terhadap perubahan lingkungan, termasuk terhadap mekanisme homeostasis (kemampuan tubuh menjaga keseimbangan internal), sehingga standar kenyamanan termal tiap orang dapat berbeda. Dalam konteks termal, mekanisme homeostasis ini menjadi pemicu kuat thermal alliesthesia, yaitu kondisi ketika sensasi nyaman atau tidak nyaman dipicu oleh perubahan suhu relatif terhadap kondisi tubuh sebelumnya. Penelitian ini mengambil pendekatan eksploratif yang bertujuan untuk menilai potensi deteksi proses tersebut dalam konteks virtual dengan paparan minimal, menggunakan video observasi lingkungan perkotaan. Structural Equation Modeling (SEM) digunakan untuk menguji hubungan multivariat antara kondisi suasana hati, latar belakang daerah asal, serta persepsi terhadap elemen fisik (kecerahan, keteduhan), beserta dampaknya terhadap kenyamanan rute. Hasil penelitian menunjukkan bahwa proses homeostatis terindikasi tetap dapat terjadi dalam setting virtual dan dipengaruhi secara positif oleh latar belakang psikogeografis, sehingga membuka peluang penerapan dalam perancangan spasial, penelitian lanjutan, dan place branding, bahkan tanpa keterlibatan langsung di lapangan.

KATA KUNCI: *psikogeografi, observasi jarak jauh, model persamaan struktural, alleythesia temporal*

INTRODUCTION

Psychogeography is an approach that emphasizes the emotional and affective experiences of users in relation to space. First introduced by Debord (1955) as a critique of urban design that prioritizes functionality and efficiency at the expense of emotional engagement, the concept was later expanded by Lomas and Case (2023), who framed psychogeography as a dynamic construct shaping human spatial orientation through social, political, and ecological contexts. Within this framework, Debord (1955) argued for urban spaces that encourage free exploration, while Gehl (2010) highlighted the importance of spatial variation and respect for users' agency.

Applying psychogeography in walking uncovered that walking was not only a mode of movement, but also embodying emotional, social, and political dimensions of urban life. This can be seen in Singleton's (2024) study in Newport, Wales, where elderly residents retraced the city through walks inspired by Debord's (1955) dérive, revealing mismatches between urban policy and community needs. Wilson (2024) similarly used walking as a critical lens along the Iquitos–Nauta highway in the Amazon, showing how global urbanization produces contradictions and exclusions that become tangible in pedestrian experience. Kunchuliya and Eckardt (2024) highlighted the role of walking in Weimar, Germany, where young refugees from the Russia–Ukraine war rebuilt belonging and agency by engaging with the city's everyday spaces.

Kaplan and Kaplan (1989) identified universal human needs for safety, pleasing visual structure, environmental compatibility with personal motives, and ease of spatial navigation. These principles underpin how urban design is sensitive to the compatibility between body, perception, and environment, including thermal and sensory comfort. Mohite et al. (2024) in Nagpur, India, found that the absence of shading elements and monotonous street façades not only triggered thermal discomfort and negative spatial perceptions but also reduced the willingness to walk, a condition further exacerbated by the dominance of highways. This finding emphasizes that walkability is not solely determined by physical specifications but is deeply linked to the degree of local adaptation to climate and environment. Similarly, Vasilikou and Nikolopoulou (2019) showed how spatial morphology shapes sensitivity to thermal comfort: London, with its homogeneous streets and small plazas, elicited relatively muted responses, while residents of Rome—accustomed to a more varied and sequential urban fabric—displayed sharper reactions to microclimatic changes. These cases suggest that comfort thresholds are not fixed but adaptively shaped by the urban structure and the lived experiences of its pedestrians.

This feeling and experiences of comfort are shaped by, amongst other, thermal alliesthesia, which slightly differs from thermal comfort. While thermal comfort refers to a psychological state of feeling at ease with surrounding temperatures, thermal alliesthesia describes the underlying homeostatic mechanism that produces such sensations. Alliesthesia occurs when thermal stimuli opposite to the body's internal condition generate pleasurable feelings, reflecting the body's effort to restore balance (Cabanac, 1971). In this sense, thermal alliesthesia can be understood as the process through which thermal comfort is dynamically achieved. Building on this, Peng et al. (2022) highlighted the close connection between psychogeography and alliesthesia, as both involve subjective responses to environmental stimuli shaped by individual backgrounds.

Further studies reinforce the distinction between thermal comfort and thermal alliesthesia by situating alliesthesia within dynamic contexts. Li et al. (2025) and Khovalyg et al. (2023) found that alliesthesia is more likely to emerge when individuals are moving—such as walking or transitioning between spaces—particularly after prolonged exposure to extreme temperatures. However, because most of these insights come from field-based observations, an open question remains as to whether such homeostatic responses can also be captured in mediated environments, such as using virtual reality.

Liao et al. (2022), for instance, showed that walkability perceptions can be affectively measured through virtual reality. Liao et al. (2022) classified perceptions of walkability into three affective groups: the Happy Group (33.9%), who linked walkable areas with improved mood; the Secure Group (44.3%), who prioritized safety; and the Comfortable Group (21.8%), who valued physical comfort above all. This distribution was shaped by socio-demographic factors, with women and apartment residents more often in the Comfortable group, indicating that micro-environmental factors such as temperature, lighting, and humidity strongly influence walking experiences. Their findings imply that virtual methods hold potential for capturing sensory perceptions traditionally observed through field surveys.

However, the corresponding study did not examine the homeostatic dimension of thermal perception. Addressing this gap, this study investigates whether thermal alliesthesia—normally experienced through direct bodily exposure can be psychologically triggered in participants observing only dynamic virtual representations of space, thereby extending the convergence between psychogeography and thermal alliesthesia into a novel virtual domain.

METHODS

Research Location

This study does not rely on direct physical immersion but instead employs a virtual representation of Pogung, Sleman, through video recordings of walking routes. The choice of Pogung is deliberate: as a student precinct adjacent to Universitas Gadjah Mada, it is predominantly composed of boarding houses that attract students from diverse cultural and regional backgrounds across Indonesia and abroad. This diversity makes Pogung a rich context for examining psychogeographical influences on walkability, as individual backgrounds shape how urban spaces are emotionally and affectively perceived. By situating the virtual walking experience within this setting, the study tests whether thermal alliesthesia can emerge even when sensory engagement is restricted to visual perception through video. In doing so, it highlights the minimal conditions under which subjective thermal responses can be triggered in walkable environments, extending psychogeography into the virtual domain.

The virtual representation of an urban walking space is defined by creating a video of a certain walking route in Pogung (Figure 1). The route selection considers the integration value, which was computed using Space Syntax following the work of Hiilier and Hanson (1984 as cited in Koohsari et al., 2019). The route covers 1,33 kilometer length and captured a wide variety of land uses, which enable different perception of thermal alliesthesia.

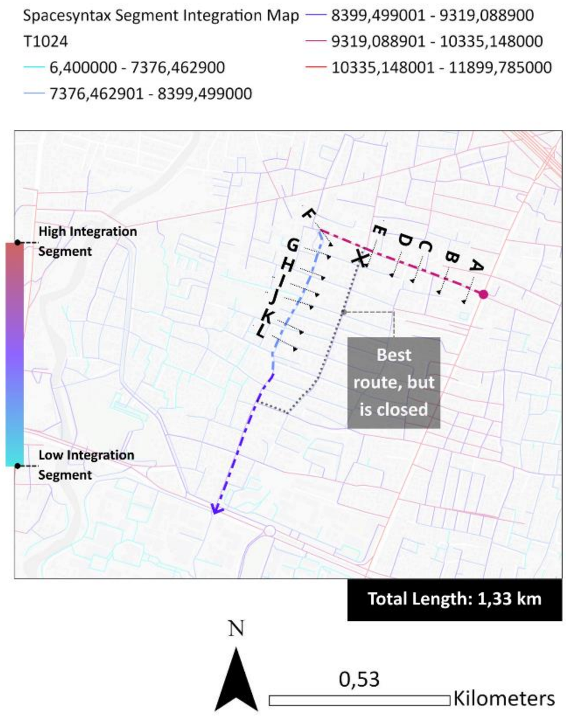

Figure 1. Selected Route
(Source: Author's Document, 2025)

Figure 2. Survey's Video: https://youtu.be/4ucPu1qYtQA?si=dpy3IieVrhiTOtCi
(Source: Author's Document, 2025)

Data Collection

Data was collected using a Google Form equipped with a video of a walking journey along the route. The video was recorded with a wide-angle smartphone camera from a first-person perspective, providing a visual experience closely resembling an actual walk through the location. All respondents accessed and watched the same video independently from start to finish.

This method follows the approach used by Liao et al. (2022), who employed virtual reality technology, and Singleton (2024), who incorporated documentary footage as an initial stage of field observation to simulate pedestrian spatial experiences before administering a perception survey. While the technology used in the present study is comparatively simpler, the data collection principle remains similar—offering respondents an indirect spatial experience that is then followed by assessments based on their visual perceptions of the observed environment.

Following the video viewing 362 respondents were asked to complete a Likert-scale questionnaire. The questionnaire items were adapted from relevant study which identified the following indicators:

1. **Visual Comfort**
   It is assumed that high light intensity significantly increases thermal discomfort. Individuals perceiving lighting as excessively bright are 15.76 times more likely to feel hot compared to those in shaded areas (Lam et al., 2024).
2. **Psychological Condition**
   Individuals experiencing negative emotional states, such as irritability, are 4.18 times more likely to perceive thermal conditions as unacceptable. Physical fatigue also raises this likelihood by 1.81 times (Lam et al., 2024).

Additionally, two measurement factors were adapted from Dzyuban et al. (2022): perceived pleasantness and the estimated level of street shading. The final questionnaires are as depicted in Table 1.

Table 1. Questionnaire for Data Collection

Questionnaire	Answer Type
In which city have you lived the longest until now?	Urban/Rural
How bright is the overall route shown in the video?	1-6 Likert Scale (6 is the brightest)
Based on your estimation, what percentage of the route is shaded?	a. <30% b. 30-50% c. 51-75% d. >75%
Does this route feel pleasant to walk along?	1-6 Likert Scale (6 is the most pleasant)
If you were tired and in a bad mood, would you choose this route for walking in between morning and afternoon?	Yes/No
If you were in a good condition, would you choose this route?	Y/N

Results from the questionnaires were analyzed using Structural Equation Modeling (SEM), a statistical method that can simultaneously test multiple relationships between different factors. This approach makes it possible to see not only direct effects but also indirect influences, such as how psychogeography shapes both visual comfort and psychological condition. The analysis was carried out using the *semopy* library in Python.

RESULTS AND DISCUSSION

The model demonstrates a very good fit to the data. The chi-square test is non-significant ($\chi^2 = 9.92$, $p = 0.27$), indicating no substantial difference between the hypothesized model and the observed covariance matrix. Given the sensitivity of the chi-square statistic to sample size, further fit indices were examined. Both the Comparative Fit Index (CFI = 0.99) and the Tucker–Lewis Index (TLI = 0.97) exceed the conventional cutoff of 0.95, suggesting excellent incremental fit. The Root Mean Square Error of Approximation (RMSEA = 0.026) is well below the threshold of 0.05, further confirming the model's close fit. Collectively, these results provide strong evidence that the proposed model adequately represents the underlying data structure.

SEM Results

Table 2. Fit Indices

Fit Indices	Value
Chi² value	9.924187
Chi² p-value	0.270387
CFI	0.990227
TLI	0.971903
RMSEA	0.025812

Table 3. SEM Main Model

lval-op-rval	Est	Std.Err	z-val	p-val
shade ← brightness	0.0426	0.047	0.908	0.364
shade ← fatigue_bad_mood	0.376	0.086	4.354	0.000013*
shade ← urban_area_percentage	0.005	0.002	2.655	0.008*
shade ← good_mood	0.158	0.116	1.366	0.172
brightness ← fatigue_bad_mood	0.061	0.097	0.634	0.526
brightness ← urban_area_percentage	0.001	0.002	0.595	0.552
brightness ← good_mood	-0.064	0.129	-0.492	0.623
pleasantness ← fatigue_bad_mood	0.579	0.101	5.742	0*
pleasantness ← good_mood	0.901	0.132	6.807	0*
pleasantness ← brightness	0.239	0.053	4.478	0.000008*
pleasantness ← shade	0.469	0.059	7.897	0*

* Significant, with 95% confidence level

SEM model and datasets related to this research can be found by using the following link:

https://drive.google.com/drive/folders/1SX4VdJu644UMBWj-W6FkwSkWAfG9ryUA?usp=sharing

Interpretations

The model confirms several key findings:

1. **Shade is Not Predicted by Brightness**
   Shade was not predicted by brightness (non-significant effect). This suggests that shade may be more closely tied to the presence of shadows or physical elements rather than brightness intensity.

Figure 3. One of Shaded Segments
(Source: Author's Document, 2025)

2. **Signs of Psychological Homeostasis**

   Fatigue and bad mood significantly increased shade perception (estimate = 0.376), indicating that individuals in a negative state became more sensitive to protective elements in the environment. This effect was reinforced by the role of urban area percentage, albeit weak, (estimate = 0.005), where respondents from more urbanized backgrounds showed higher adaptation to urban settings, reducing negative perceptions of physical shortcomings. Together, these effects illustrate homeostatic adjustment, where psychological strain amplifies the salience of restorative spatial cues.

Figure 4. Segment with Poor Pedestrian's Facilities (Source: Author's Document, 2025)

3. **Link Between Fatigue and Pleasantness**

   Interestingly, fatigue and bad mood also showed a direct positive association with pleasantness (estimate = 0.580). This counterintuitive result can be understood through homeostasis: when fatigue is present, restorative cues such as shade may trigger recovery, enabling a fatigued state to still contribute positively to the overall walking experience.

4. **Role of Psychogeography**

   A good mood was a strong predictor of pleasantness (estimate = 0.902), followed by shade (estimate = 0.469), and then brightness (estimate = 0.240). This pattern highlights that both internal psychological states and environmental perceptions jointly construct walking comfort, in line with psychogeographic perspectives.

Figure 5. The Absence of Dedicated Pedestrian's Path (Source: Author's Document, 2025)

CONCLUSION

The findings of this study confirm the signs of a homeostatic process indicative of thermal alliesthesia, while also aligning with previous psychogeographic research that foregrounds walking as the experiential medium through which spatial perceptions are shaped (Singleton, 2024; Wilson, 2024; Kunchuliya & Eckardt, 2024; Mohite et al., 2024; Vasilikou & Nikolopoulou, 2019). In line with these studies, the present results highlight that sensory comfort and route pleasantness are not fixed physical outcomes but adaptive responses shaped by regional background and lived experience. By demonstrating that such adjustments can also be detected through virtual exposure, this study extends the convergence between psychogeography and thermal alliesthesia identified by Cabanac (1971), Peng et al. (2022), and Dzyuban et al. (2022), while addressing the gap noted by Liao et al. (2022) on the potential of virtual methods to capture affective and thermal perceptions.

Although limited by the indirect measurement of temperature perception, the results provide indications that bodily responses to environmental stimuli remain observable even when mediated digitally. This opens opportunities for applied use, such as assessing the potential of specific areas to attract visitors and informing place branding strategies that integrate psychogeographic and homeostatic insights. Nonetheless, the likelihood of repeat visits will ultimately depend on the quality of the on-site experience.

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