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THE LUISENPLATZ STUDY:
The relationship between Visual fields and perceived stress in a public transport hub

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ABSTRACT

This paper investigates the relationship between visual fields and subjective ratings of perceived stress in an open public space (OPS) and transportation hub. The aim of this paper is to investigate how these characteristics influence pedestrians' subjectively perceived stress. To achieve this goal, the sample is described with a visibility graph analysis and isovist properties. The constructed data is then paired with participants' ratings of perceived stress.

This article uses data from surveys conducted in Darmstadt, a town of 120,00 in Germany, in summer 2015. Subject is the Luisenplatz, the city's main public square. It houses various amenities, services and residency, and is as well a central transportation hub, where the majority of the tram and bus lines meet. Previous research suggested that the Luisenplatz in its current state is perceived as one of the most stressful OPS in Darmstadt.

Correlation between visual fields and statements about perceived stress show that users are more likely to feel stressed when in areas with high visibility, while visual complexity may contribute to less stressful scenarios. The method presented in this article is been shown effective to analyse how variables of the built environment may contribute to perceived stress in public transport hubs. It will be useful to further interdisciplinary research that sets out to better understand the role of the built environment as integral contributors to stress in urban mobility.

KEYWORDS

Isovist, public transport hub, perceived stress, spatial perception, configuration

1. INTRODUCTION

In spite of the many positive aspects of life in cities, several others may harm health and wellbeing of its residents, the so-called "environmental stressors" (Evans and Cohen, 1987). Especially in the city, some of these stressors – such as noise, pollution, crowds and high traffic – are often intense and take a notable toll on the people who work and live in them.

Emerging research spurs the discussion how visual field characteristics relate to complex emotions in the built environment (Knöll, 2016, Knöll et al., 2014, Kuliga et al., 2013, Bielik et al., 2015). In this article, researchers investigate how visual fields – commonly used in space syntax research to describe places – relate to users perception of an OPS and major public transport hub as being stressful, and how they interact with further environmental stressors such as noise and lack of vegetation. The authors focus on Isovist properties such as total area, jaggedness,

number of vertices and symmetry as indicators for the perception of spaciousness, openness, complexity and order of open spaces.

The article uses data from surveys and observations conducted in Darmstadt, a town of 120,00 inhabitants in Germany, in summer 2015. Subject is the Luisenplatz, which was renovated in 1980 and has been since then praised for its value as a "framework to balance potentially conflicting functions – a large public transport terminal versus a recreational square for pedestrians" (Gehl and Gemzøe, 2008). Previous research assessing the spatial perception of its users, suggested that the square in its current state is perceived as one of the most stressful OPS in Darmstadt (Knöll et al., 2014). Currently the space is subject to various redevelopment plans as part of the town's master plan 2030. Identifying the parameters that spike stress and compromise users' behaviour and wellbeing, delivers relevant understanding for future planning.

This paper seeks to contribute a set of subjective spatial experience data (which has been gathered as part of a larger, extensive spatial perception and psychophysiological effects study) to the on-going discussion between the space syntax community and spatial, environmental researchers and planners.

2. BACKGROUND

2.1 STRESSFUL OPS

In an online survey among students in 2014, the Luisenplatz was rated as the most stressful place in the city (Knöll et al., 2014). From the study, loudness, heavy traffic and poor vegetation where identified as determinant environmental factors for "stressful" OPS. In a later study, Knöll and colleagues found relations between street network characteristics and the users' ratings of stress and spatial qualities in OPS (Knöll et al., 2015). Building on these studies, Knöll et al. (2017) presented a set of environmental factors related to perceived stress in open public spaces including building coverage, street network and isovist characteristics and open space typologies (see table 1). Overall, the model achieves a predictive power for perceived

	Dependent Vatiable: Urban Stress Level (*)		
	Standardized Beta Coeficient (SBC)	Percent of the absolute sum of all SBC	Sum
Building Density			**17.17%**
Building Coverage Ratio	0.514**	17.17%	
Street Network			**20.18%**
Ln Citywide Integration	0.210**	7.02%	
Ln Local Integration	-0.394**	13.16%	
Isovist			**36.99%**
Visibility	0.321**	10.73%	
Ln Perimeter	0.417**	13.93%	
Square Vertices Number	-0.369**	12.33%	
Open Space Typology			**25.66%**
Park (park=1)	-0.140*	4.68%	
Heavy traffic streets	0.100	3.34%	
Courtyard	-0.223**	7.45%	
Medium traffic street	-0.124*	4.14%	
Pedestrian street	-0.181**	6.05%	

Notes: a) Random-effects GLS regression [[corr(u_i, X) = 0 (assumed)]** and * indicate significance at the 1% and 5% level.

Table 1 - Taken from Knöll et. al (2017).

urban stress of R2= 54,6% from a combination of built environment factors commonly used in planning and research. The model seems robust for central European cities, since it covers a broad spectrum of open spaces, but it is also exploratory, as it needs validation for wider user groups and cities of different sizes, cultural and climatic backgrounds.

2.2 THE LUISENPLATZ

The OPS was selected for a more detailed analysis because of its importance to the everyday urban life and manifold surrounding land uses. In spite of being free of car-traffic, it is the central transfer point in the city, adding to a total of about 2100 buses and trains running daily through it.

The Luisenplatz recorded the highest frequency for bus lines as well as trams in comparison to the service stations within the 500 m range, positioning itself as a dense transport service station with the highest number of diverse pedestrians utilizing the service.

2.3 MEASURES

A key aspect for analysing the built environment seems to be users' perception of an OPS's amenity quality, which expresses how attractive a space in particular can be for its users; e.g. if it's perceived as relaxing, enjoyable or maybe stressful, discomforting. In order to obtain spatially detailed data about the amenity quality of the Luisenplatz, participants were encouraged to use the context-sensitive mobile application MoMe, which allowed them to rate spatial qualities and stress perception through eight core aspects of environmental and behavioural properties using a ten-step scale. The application records quantitative and qualitative data by making use of the context-awareness of mobile devices, which consists of GPS tracks and waypoints with time-stamp (navigation), and photographs and ratings (perception) (Halblaub Miranda et al., 2015).

English		German	
Low extreme (1)	**High extreme (10(**	**Minimum (1)**	**Maximum (10)**
not stressfull	maximum stressfull	überhaupt nicht stressig	maximal stressig
not relaxing	maximum relaxing	überhaupt nicht entspannend	maximal entspannend
poor vegetation	much vegetation	viel Vegetation	wenig Vegetation
poorly maintained	well maintained	schlecht Instand gehalten	gut Instand gehalten
low traffic	high traffic	wenig verkehr	viel verkehr
quet	loud	leise	laut
no seating available	seating available	keine Sitzgelegenheit	viele Sitzgelegenheit
unsafe	safe	unsicher	sicher

Table 2 - Adjectives used by participants to rate perception of OPS on a 10-point interval. Original adjectives-scales and their translation to English.

The set of bipolar adjectives (table 2) was the basis for qualitative data on perception of public spaces and was first presented by Knöll et al. (2014).2.4 Research Questions

The previous findings revealed many open questions, in particular with respect to visual fields and stress perception. How do the chosen environmental and spatial parameters influence the perception of the built environment and its users' behaviour?

Hypothesis 1: **Visibility** correlates positively to perceived stress

The authors assume that high visibility, defined as the relative rate of the area that can be overseen from a given location in OPS, has a positive correlation to perceived stress.

Hypothesis 2: **Vertices number** is negatively related to perceived stress.

In this study, the authors propose that low and high rates of visual complexity mediate perceived stress, while medium rates of visual complexity are negatively related to stress ratings in sub areas that are loud and highly exposed to tram and bus traffic.

3. DATA SETS AND METHODS

A combination of Visibility Graph Analysis (VGA) and point isovist analysis was constructed and paired with participants' ratings of perceived stress. Both VGA and isovist measures have been limited to a 250-meter radius from the square centre. Environmental properties such as loudness and exposure to traffic were controlled with structured observations. In a further step, linear correlation coefficients were calculated.

3.1 USERS' RATINGS

The assessment was done on-site by a group of visiting international students (n=17). Participants were asked to walk freely within the OPS and mark distinctively stressful and relaxing areas, and rate environmental and behavioural properties using the smartphone application *MoMe*.

This paper presents the areas identified as stressful and their specific ratings along spatial quality and emotional perception.

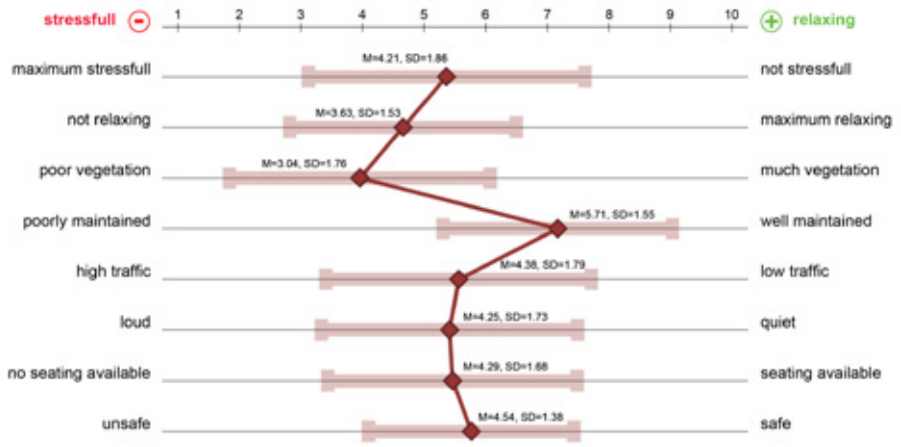

Table 3 - Profile of the Luisenplatz. Representation of the aggregated ratings of the stressful areas in the OPS.

3.2 VISIBILITY GRAPH ANALYSIS (VGA)

VGA has been used to calculate the visual integration of the space itself (Turner, 2001). The urban space has been reduced to a grid system of a 1-meter mesh in order to construct the visual relations and the OPS's relation to its surroundings. This dense mesh allows sufficient representation of every urban element and narrow street in the vicinity, as presented by Cutini (2003).

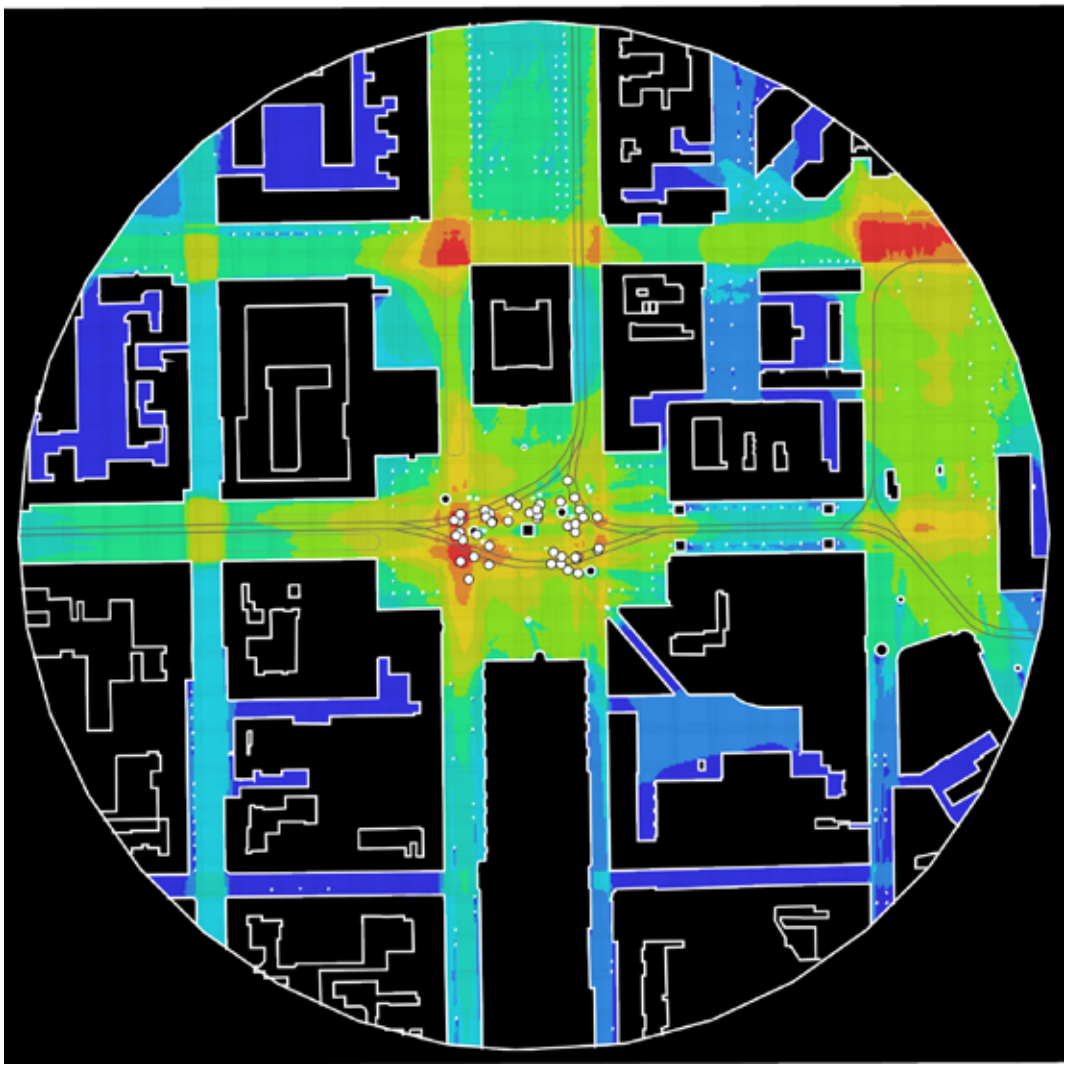

Figure 1 - Visibility Graph Analysis (VGA) for the Luisenplatz and its surroundings in a 250 meter radius, coloured by Isovist Integration (high=red, low=blue). White spots represent the photographed areas.

3.3 ISOVISTS

The photographed motifs were clustered by themes and spatial proximity in areas of 10-metre radius, delivering vantage points, which are chosen according to how often the areas – and not phenomena such as crowding or litter – were rated as stressful.

4. RESULTS

The data shows that visibility has a positive relation to perceived stress. A weak relation has been found between visibility and the vertices density of isovists to ratings of safety. The data corroborates the findings in Knöll et al. (2017) regarding the ambiguity of visibility as the relative size of an area that one can oversee and the area from which one can be seen at a specific point. Here, high visibility was assumed as key factor for actual pedestrian safety (Stoker et al., 2015) . But data shows that areas with high visibility and higher motorized traffic are still perceived as stressful. This is so, even though the isovist properties are similar to an area with lower motorized traffic. This can be examined well in the Luisenplatz, since it is a symmetrical OPS, where the only unbalanced elements are the train tracks and transit areas fur buses.

On the other hand, the complexity of the isovist shape has a strong relation to perceived stress: high number of vertices indicates a place that has lower rating as stressful (Hypothesis 2).

Figure 2 - Isovists from different vantage points – those most often rated as stressful. From highest to lowest rating.

Visibility and perimeter –which describe the shape of the OPS–, and vertices number –which indicate the complexity of the shape– are important characteristics to explain perceived stress.

These findings have potential implications in the redevelopment including location and shape of street furniture, such as roofing and seating along the waiting areas near high-motorized traffic.

5. CONLUSIONS

The current study has provided user ratings about the Luisenplatz in order to explore how OPS users describe complex emotional appraisal of OPS, the areas users identify as maximum stressful, and to what extent space syntax measures correspond to user statements.

This line of thought will have to be validated with bigger samples of OPS and in further cities of different size and cultural context.

A further aim is to deliver "high definition" measurement of psychophysiological effects on site to expand emerging theoretical frameworks to explain built environment factors on pedestrians' wellbeing. While the focus was on spatial perception and stress perception, other behavioural data, such as participants' heart rate, has to be the focus of further research.

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