Outlook and Insights

Perception of residential greenery in multi-storied housing estates of Berlin

Thesis

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submitted by

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Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig und eigenhändig sowie ohne unerlaubte fremde Hilfe und ausschließlich unter Verwendung der aufgeführten Quellen und Hilfsmittel angefertigt habe.

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Zusammenfassung

Der Blick aus dem Fenster auf Natur kann Gesundheit und Wohlbefinden fördern. Sie sind der Hauptkontakt zur Natur für viele Menschen und trotzdem sind viele Aussichten nicht vorteilhaft. Für viele Bewohner von zentraleuropäischen Städten besteht die aus dem Fenster sichtbarer Natur größtenteils aus Wohnumfeldgrün. Trotzdem wurde bisher in keiner Studie verglichen, welche Elemente auf einer Fläche vorhanden sind und welche davon aus dem Fenster zu sehen sind. In vorherigen Studien konnte gezeigt werden, dass sich viele Bewohner ein ruhiges Abstandsgrün zu ihren Nachbarn wünschen. Andere Bewohner hingegen wollen das Wohnumfeldgrün aktiv nutzen. Daher untersuchen wir hier den potenziellen Interessenkonflikt zwischen der passiven Fensterperspektive und sichtbaren Nutzungen des Wohnumfeldgrüns.

Dazu wurden 504 Fotos der Ausblicke von 32 Untersuchungsgebieten angefertigt. Das sichtbare Grün und Strukturelemente wurden gezählt und mit den Ergebnissen der ebenerdigen Kartierung verglichen. Die Fensterperspektive der vier typischen mitteleuropäischen Stadtstrukturtypen auf das Wohnumfeldgrün wurde charakterisiert. Um die Wahrnehmung der sichtbaren Elemente zu untersuchen, wurde eine Umfrage durchgeführt. Dabei sortierten 98 Teilnehmende, einschließlich Senioren, Laien und Experten, 24 Fotos nach persönlicher Präferenz.

Die Fensterperspektive unterscheidet sich signifikant von der ebenerdigen Perspektive auf Wohnumfeldgrün. Insgesamt sind weniger Pflanzen und Strukturelemente vom Fenster aus sichtbar. Spezifische Zusammensetzungen der Elemente wurden für die Stadtstrukturtypen identifiziert, aber auch die große Variabilität innerhalb der Typen wurde untersucht. Vegetation wird als sehr positiv wahrgenommen und Bäume positiver als Büsche. Die Wahrnehmung der Strukturelemente ist jedoch unterschiedlich. Strukturen, die sich für Erholung eignen, werden positiv wahrgenommen. Hingegen werden Strukturen, die einen praktischeren Nutzen haben (z.B. Abfalllagerung und Parkplätze), negativ bewertet.

Insgesamt erscheinen mehr Bäume vorteilhaft für das Wohnumfeldgrün, aber auch Fassaden- und Dachbegrünungen, vor allem für kleinere Flächen. Diese könnten auch nachteilige Strukturelemente verbergen. Weiterhin sollten mehr Möglichkeiten für Erholung integriert

werden (z.B. Mietergärten, Spielplätze, Wege, Lampen und Bänke). Allerdings müssen für die variablen Perspektiven variable Lösungen gefunden werden, die die Größe der Grünfläche und die Bedürfnisse der Anwohner einbeziehen. Dadurch können Aussichten aus dem Fenster geschaffen werden, die sich wohltuend auf die Bewohner auswirken. Damit hat das Wohnumfeldgrün die Möglichkeit, unterschiedliche Interessen zu vereinigen. Ein intelligentes, multifunktionales Design kann Raum zur Erholung und gleichzeitig ästhetisch ansprechende Fensteraussichten bieten. Auf diesem Wege kann der Blick auf Wohnumfeldgrün eine wichtige Ressource darstellen, um Gesundheit und Wohlbefinden zu fördern.

Abstract

Window views to nature can foster health and well-being. They are the main nature contact for many people, yet many views are not favorable. For most residents in Central European cities the natural content in their window view stems from residential greenery. Nonetheless, no study has yet compared the elements visible from a window with the presence of elements in the area looked at. Furthermore, no study has distinguished between recognizable elements in the view of residential greenery. Previous studies demonstrated that many residents want their residential greenery to be a calm, unused distance to their neighbors. Other residents want to actively use the green space. Here, we investigate a potential conflict of interest between the passive window perspective and visible usage of residential greenery.

504 photos of the window views were taken at 32 study sites. We analyzed the view content to characterize the window perspective on residential greenery for the four main central European building types. Visible green and structural elements were counted from the window perspective and compared to the presence recorded in a status quo analysis on the ground. To explore the perception of the visible elements 98 participants, including elderly, lay people, and professionals, ranked 24 representative photos according to preference.

The window perspective is significantly distinct from the perspective at ground level. In general, lower numbers of plants and structural elements are visible. We revealed specific compositions for the building types but also a high variability within them. Vegetation is perceived as highly positive, trees more so than groups of shrubs. Perception of structural

elements is differential. Structures for recreation are perceived positively. Structures for practical use like waste storage and parking are perceived negatively.

Generally, more trees, but also green walls and roofs in smaller spaces would be beneficial. Besides, they can conceal unfavorable elements. More structures for recreation (i.e. gardens, playgrounds, paths, lamps, and benches) should be included. However, the highly individual perspectives require individual solutions according to the available size and the resident's needs. This can help to create window views that are beneficial for residents, since preference is a strong predictor of restoration. Therefore, residential greenery has the potential to reconcile different interests. A smart, multifunctional design can provide recreational space for active users and aesthetically pleasing window views. Consequently, the window views of residential greenery can be an essential resource for promoting health, and well-being.

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Introduction

Windows are connections between inside and outside. They provide contact with the world beyond a building to urban or rural environments and play a crucial role when architects and psychologists use daylighting and windows to assure human well-being. The view on 'Healing Gardens' or 'therapeutic landscapes' from a hospital window has been recognized to improve recovery since long (Bell et al. 2018; Ulrich 1984). There is growing evidence that just the sight of nature can be beneficial for humans (Velarde et al. 2007).

For two thirds of inhabitants in Berlin and other central European cities the nature in their window view comes mainly from the residential greenery. Residential greenery is defined as small-scale semi-public green spaces, surrounding residential buildings (Säumel and Butenschön 2018). They are highly prevalent in Central European cities and important for providing inhabitants with ecosystem services (Battisti et al. 2019). Säumel et al. (2020) demonstrated that many residents rarely use public parks, therefore the main contact to nature they have on a daily basis is the residential greenery. Furthermore, more than half of the respondents stated to prefer a quiet and unused distance to their neighbors. They mainly use the green spaces passively, such as viewing it through the window. In contrast, other residents want to actively engage with their residential greenery. We therefore expect a strong conflict of interests.

Until now, the residential greenery has received much less attention than public green spaces such as parks. So, there is little research and data on perception and preference of residential green spaces. But the importance of and demand for accessible small green spaces is only expected to rise with the densification of cities and climate change. In particular, during the COVID-19 pandemic there is an acute need for decentralized green infrastructure (Honey-Roses et al. 2020). Furthermore, the COVID-19 lockdown and stay at home orders put emphasis on the importance of natural, aesthetically pleasing window views. Poor views increased the risk for depressive symptoms during home confinement (Amerio et al. 2020). This need for attractive window views also applies for less mobile people, such as the elderly, and even more so in the colder seasons. Green views can be an essential opportunity for nature experiences (Kearney and Winterbottom 2006).

Several studies have been published about the perception and impact of window views in different settings. Natural window views have been linked to enhanced restoration, cognition (Engell et al. 2020), and less anxiety (Chang and Chen 2005). At office workplaces a view of a green environment can increase work ability, job satisfaction (Lottrup et al. 2015), thermal comfort, positive emotions and concentration (Ko et al. 2020). In educational facilities natural window views can improve attention and stress recovery of students (Li and Sullivan 2016). A green window view in patient rooms in medical facilities is deemed more desirable (Nezamdoost and Modarres Nezhad 2020), and can promote physical and mental health (Raanaas et al. 2012). Ulrich (1984) found that it can even support the recovery from surgery. Few studies also exist about the window view from home. The hair cortisol level was lower for residents with a greener and more diverse sight (Honold et al. 2016). Neighborhood satisfaction and well-being (Kaplan 2001), and self-discipline of children living in crowded inner cities are related to a window view on natural elements (Taylor et al. 2002).

The published studies are often not specific regarding the type of nature and urban structures. Only few distinguish beyond the nature – human-made dichotomy (Bratman et al. 2015; Velarde et al. 2007).

To our knowledge, no study has compared so far, the elements visible from a window compared to the general presence of these elements in the area looked at. Furthermore, no study has distinguished between recognizable elements in the windows view on the residential greenery. Therefore, we aim to explore the following questions: 1. How is the window view perspective on residential greenery characterized and how does it differ to the ground level perspective? 2. How does the window perspective on residential greenery differ among the four building types? 3. How are specific types of green and the elements of active use perceived from a passive window perspective? 4. Are there conclusions to deal with above mentioned conflicts of interest?

Our hypotheses are:

1. The window view is a distinct perspective.
2. The building types are perceived differently.
3. The view of natural elements is perceived positively while elements of use are perceived more negatively.

Methods

Review

A review was conducted to assess the current relevant literature on perception of residential greenery from the windows perspective. Web of Science, PubMed and Scopus were used to search for the following keywords: "residential green*”/” urban nature/green” AND perception/rating/preference/window view. Additionally, "window view*" AND perception/rating/preference was searched for. Search using the snowball principle revealed some additional literature regarding the assessment of landscapes, their components and visual quality. Overall, 169 scientific papers were analyzed. In a first step, we screened the titles and abstracts of the articles and eliminated articles that are not related to our topic, in case of doubts, we kept the article for the next step of the review process. Second, we eliminated articles without access to the full text version and sent requests to the most relevant ones. Third, we made a full text review of the remaining (57) articles to gather the relevant information for our analysis and discussion.

Study sites

The study was conducted in Berlin, Germany. Two thirds of the 3.7 million inhabitants live in four main Central European building types: in the dense and closed block-edge developments (1870s to 1920s), in the block-edge development with large green backyards (1920s to 1940s), in parallel and free row development (1920s to 1970s), and in large housing estates with high rise buildings (1960s to 1980s). Of these building types, the most disadvantaged neighborhoods were identified, based on the Environmental Justice Map of Berlin (SenStadtWohn 2020). Eight neighborhoods (“Kieze”) were chosen as study sites, which are characterized by high environmental burdens (noise, air pollution, bioclimatic stress), low access to green spaces, and low social status indexes. For the closed block development Sprengelkiez, Wedding and Ideal-Passage, Neukölln were chosen. For the block-edge development General-Barby-Siedlung, Reinickendorf was selected. For the row development Alte-Jakobstraße, Kreuzberg-Mitte; Haselhorst, Spandau; and Paul-Hertz Siedlung, Charlottenburg were picked. Marzahn and Gropiusstadt, Neukölln were designated for the large housing estate. In each neighborhood four sample plots were randomly selected, resulting in 32 plots total. Subsequently, structural elements and woody species were mapped and related ecosystem services and disservices identified (Battisti et al. 2019). The mapping data represents the ground level perspective in this study.

Data collection

Photographs

To analyze the window perspective on the residential greenery, 504 photographs were taken at all plots (n = 32) from 126 third floor windows. To protect the privacy of the residents, all pictures were taken through windows in the staircases. The photographs were taken at four different angles (-15°, -20°, -25°, -30° from eye level at 1.50 m) to account for differences in the field of vision of the sites (Fig. 1 A). A Nikon D5100 digital reflex camera was used to take the photos and a digital spirit level application ("Wasserwaage", PixelProse SARL) was used for measuring the angles. In addition, photos were taken at the ground level, directly underneath the windows (Fig.1 B). All pictures were taken in cloudy weather and in daylight to standardize light conditions. Because of the relevance of window views in the colder seasons, the pictures were taken between the end of October and the beginning of November, over the course of 3 weeks. No people could be seen on any photograph to avoid this as a confounding factor.

Figure 1 (**A**) Photos taken at Sprengelkiez, Wedding with an angle of -15°, -20°, -25°, -30°, respectively. (**B**) Example for the difference between the window view and the ground level perspective; photographs taken at the same location at Alte-Jakobstraße, Kreuzberg-Mitte.

Ranking of photographs

24 pictures from 7 different study areas (3-4 per area) were chosen for the survey (Fig. 2). They were printed on 10 x 15 cm photo paper. The photographs were selected to represent the characteristics of the study areas, and to display the diversity and range of the residential greenery. The pictures differed in the number of visible elements for usage (e.g. benches) in the type and extension of vegetation and the architecture of the surrounding buildings.

Elderly participants, professionals, and lay persons were intentionally included in the study. This is due to the importance of window views for older people. Also, participants with a professional background in the subject matter have been shown to differ in their rating from lay people in some studies (Hofmann et al. 2012). The personal preference rating was done with 98 participants at three public events and at a senior residence (Fig. 3). Age, gender, and profession were recorded for each participant. The mean age of the participants was 43.9 years (SD = 20.58 years), including 12 persons over 69 years, 54 women participated and 43 men. This is representative for Berlin, with a mean age of 42.6 years and slightly more female than male citizens (Amt für Statistik Berlin-Brandenburg 2019). Among the participants were 20 individuals with a profession related to the subject matter and 78 lay people.

Participants were informed that the interview would be confidential and anonymous. Next, they were asked to sort the pictures according to personal preference into a matrix with 24 squares in 11 rows, associated with 11 ranks. This matrix enabled the pictures to be sorted into a fixed quasi-normal distribution (Fig. 3 A). The participants were instructed to think about to what extend they would like it, if the depicted views were the view from their own home. The first row was to contain the picture with the most preferred view, indicated by a plus sign. The last row was to contain the picture with the least preferred view, indicated by a minus sign. The middle row, on the other hand, was reserved for pictures the participants were indifferent to or had no strong opinions about. This diamond-shaped layout has been shown to be intuitive for participants (Milcu et al. 2014). The participants were given as much time as they needed but were nonetheless instructed to follow their first intuitive choice. While the participants ranked the photos, additional attention was given to the explanations for the decisions. After they completed the sorting task, they were asked whether they would like to change anything and if they were content with the overall impression of their result. The results were digitally photographed by the interviewer (Fig. 3 A).

Figure 2 Photographs used in the ranking task. (**1**) Dense and closed block development: (**a-d**) Sprengelkiez,Wedding; (**e-g**) Ideal-Passage, Neukölln; (**2**) Block-edge development with large backyards: (**h-k**) General-Barby-Siedlung, Reinickendorf; (**3**) Parallel and free row development: (**l-n**) Alte-Jakobstraße, Kreuzberg-Mitte; (**o-q**) Haselhorst, Spandau; (**4**) Large housing estates: (**r-u**) Marzahn; (**v-x**) Gropiusstadt, Neukölln. One study area, Paul-Hertz could not be included because all pictures had to be taken parallel to the buildings, leading to a limited view and were therefore not comparable to the pictures of the other areas.

This method has been used previously and was adapted from Q-Methodology (Hofmann et al. 2012; Milcu et al. 2014; Sáenz de Tejada Granados et al. 2020). Photographs have been shown to be adequate representations of visual landscapes, that can substitute for on-site perception (Gao et al. 2019). This is especially true for passive environmental experiences where sight is the main sense used (Steen Jacobsen 2007), which is obviously the case for window views. Additionally, the use of photographs constitutes no technical barrier and is therefore inclusive to different demographics and ages (Weber et al. 2008).

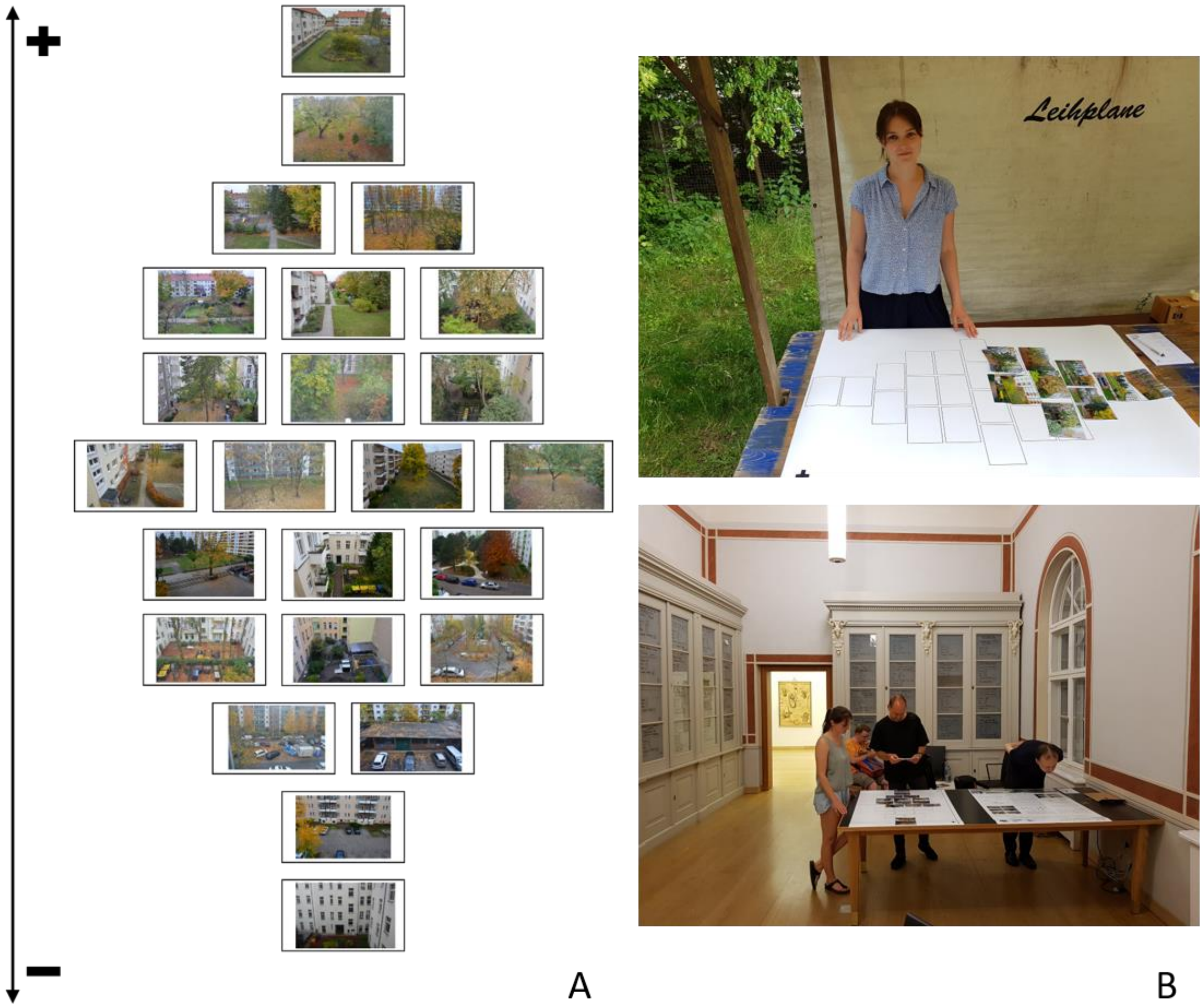

Figure 3 (**A**) Matrix used for survey, including an exemplary ranking of the photos. (**B**) Examples of the conduction of the survey at the “Moabit for Future” festival for education (top) and the Long Night of the Sciences in the Tieranatomisches Theater der Humboldt-Universität zu Berlin (bottom).

Data Analysis

Photographs: Visible green and structural elements

Visible green and other structural elements (e.g. benches, bike racks, bioswales, car parks, clotheslines, green balconies, green walls, lamps, paths, playgrounds, private gardens, trees). Additionally were counted on all photographs, in accordance to the mapping at ground level by Battisti et al. (2019). The percentage of visible green and the number of groups of shrubs and garbage cans were recorded.

In a first step, the respective number of elements were compared to characterize the window perspective in contrast to the perspective at ground level. Shapiro-Wilk test and Levene's test revealed the sample to not be normally distributed and the two levels to be heteroscedastic. The influence of the level on the number of elements was therefore analyzed using the Kruskal-Wallis rank sum test. Furthermore, the two datasets are unbalanced due to the multiple perspectives on the plots from the window level and the single dataset from the ground level. The test was hence conducted twice: once in an unbalanced design and once with mean values to represent the average window view per plot. The use of the average window view leads to a loss of degrees of freedom and in consequence less significant results.

In a second step, we analyzed how the neighborhoods and building types differ in the number of elements visible from the windows. Descriptive statistics and non-parametric tests were performed, due to the heterogeneity of the variances and the non-normal distribution. Kruskal-Wallis rank sum test was used to test the effect of the factors building type, neighborhood, and view angle on the variation in the number of elements. In a pairwise post-hoc analysis, employing the Wilcoxon rank sum test with Holm adjustments, the differences between the factor levels were analyzed.

Ratings of photographs

The possibility to access the results in line with Q-Methodology was examined by Scree test and Horn's Parallel Analysis of Principal Components/Factors. Only one component could be retained, therefore Principal Component Analysis was deemed statistically unsuitable. The distribution of ranks was compared between the building types, neighborhoods, and photographs. Statistical significance was ensured with the Kruskal-Wallis rank sum test, and differences within the factors were checked with the Wilcoxon rank sum test with Holm adjustments. Finally, the impact of the number of structural elements and visible green on the ranking was analyzed. Multivariate linear models were the main tests, non-parametric tests were used to verify the results, since the requirements for linear models were not fully met. The ranking data are ordinal scaled and exhibit a quasi-normal distribution. The treatment of ordinal data as interval has been successfully done before, especially with a higher number of categories like in the present study (11 categories, ranks range from -5 to +5) (Arriaza et al. 2004). Spearman´s rank correlation coefficient was calculated for the dependent variable (rank) and each element individually. The boxplots of the distribution of ranks at different counts of the explanatory variables (elements) showed partially U-shaped or inverse U-shaped relations. Therefore, multiple regression analysis was conducted with and without including squared terms. Additionally, a generalized linear model and an Ancova, including the factors were computed. The best explanatory variables were selected by means of stepwise backward selection with the Akaike Information Criterion (AIC). The statistical analyses were executed with R (R Core Team 2019).

Results

Characterization of the window views in contrast to the ground level

Descriptive statistics showed that, across all sample plots, different amounts of visible green and other structural elements can be observed from the window perspective compared to the ground level (Fig.1). In general, this effect is significant (Table 1). The extent varies with the building type and neighborhood, but also with the type of element. The number of benches, bike racks, green balconies, green walls, lamps, paths, playgrounds, and trees differ significantly. When the design is balanced by calculating with the average window view per plot, less elements differ significantly (i.e. bike racks, green balconies, paths, and trees; $p<0.05$; Kruskal-Wallis rank sum test). This may be due to the loss of degrees of freedom. While in general higher numbers of the investigated elements can be seen by mapping at the ground level, for the number of paths, this relation is inverse.

Table 1 Count of elements from the window perspective and mapping at ground level. Significantly different counts at the window level are bold (p-value <0.05, Kruskal-Wallis rank sum test).

Elements	Level	Minimum	Maximum	Mean	Standard Deviation
Benches	**Window**	**0**	**7**	**0.42**	**1.22**
	Ground	0	10	1.74	2.44
Bike racks	**Window**	**0**	**4**	**0.41**	**0.77**
	Ground	0	9	2.03	2.12
Bioswales	Window	0	1	0.03	0.18
	Ground	0	2	0.13	0.43
Car parks	Window	0	1	0.16	0.37
	Ground	0	1	0.29	0.46
Clotheslines	Window	0	1	0.03	0.18
	Ground	0	1	0.10	0.30
Green balconies	**Window**	**0**	**33**	**3.54**	**4.67**
	Ground	0	98	25.58	23.87
Green walls	**Window**	**0**	**1**	**0.02**	**0.15**
	Ground	0	2	0.13	0.43
Lamps	**Window**	**0**	**5**	**0.89**	**1.23**
	Ground	0	7	1.74	1.81
Paths	**Window**	**0**	**6**	**1.00**	**0.98**
	Ground	0	2	0.35	0.55
Playgrounds	**Window**	**0**	**1**	**0.16**	**0.37**
	Ground	0	2	0.48	0.63
Private gardens	Window	0	9	0.44	1.38
	Ground	0	12	0.45	2.17
Trees	**Window**	**0**	**46**	**7.45**	**7.58**
	Ground	1	58	15.71	13.46

Regarding the building type and neighborhood, across all elements the window perspective differs significantly between the block-edge and row development (block development for average window view; $p<0.05$; Kruskal-Wallis rank sum test). All things considered it can be said that, in Berlin, at the four main European building types, the window perspective is significantly different from the perspective at the ground level.

Characterization of the building types and neighborhoods from a window perspective

Across all green and structural elements, the type of building, the neighborhood, and the sample plot have a significant impact on the number of visible elements ($p<0.05$; Kruskal-Wallis rank sum test). A pairwise post-hoc analysis showed that all four building types differ significantly from each other ($p<0.05$; Wilcoxon rank sum test; Holm adj.), except for the block-edge development from the large housing estates. Within the building types and across all elements Sprengelkiez, Wedding, and Ideal-Passage, Neukölln (Block development), Marzahn ,and Gropiusstadt (Large housing estate), Alte Jakobstraße, Kreuzberg-Mitte, and Paul-Hertz Siedlung, Charlottenburg (Row development) are significantly different. There is a significant variability between the sample plots within the following neighborhoods: Gropiusstadt, Neukölln, Alte-Jakobstraße, Kreuzberg-Mitte, Marzahn, and Sprengelkiez, Wedding ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

When analyzing the number of elements separately, the pattern becomes more complex (Fig. 4). The window view of dense block development is characterized by a significantly lower percentage of green (mean=36.1%, SD=17.6). The number of trees (mean=3.1, SD=2.0), number of groups of shrubs (mean=5.3, SD=2.9), and number of green balconies (mean=0.7, SD=1.3) is also significantly lower than at any other type. Moderate numbers of benches, paths and lamps can be observed from the window. No car parks are visible, but the number of bike racks (mean=0.8, SD=1.0) and garbage cans (mean=6.5, SD=5.3) are significantly higher compared to all other building types ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

The block-edge development with large backyards features, from the window perspective on average, the second highest green percentage (mean=57.0%, SD=17.6) and second highest number of trees (mean=7.4, SD=3.7). The number of groups of shrubs is significantly higher compared to the other building types (mean=29.6, SD=16.4). A high number of green balconies can be observed (mean=5.3, SD=5.5) and the significantly highest number of private gardens (mean=2.1, SD=2.4), paths (mean=1.8, SD=1.5), and lamps(mean=1.4, SD=1.5) ($p<0.05$; Wilcoxon rank sum test; Holm adj.). Moderate numbers of playgrounds, benches, and garbage cans can be seen, almost no bike racks, and car parks, while no clothesline is visible from the windows.

Parallel and free row development is mainly defined by low and moderate numbers of trees, groups of shrubs, and structural elements (green balconies, private gardens, playgrounds, clotheslines, benches, bike racks, car parks). The percentage of visible green is on average the highest (mean=57.3, SD=21.7) of all building types, but the difference from the block-edge development and large housing estates is not significant (Fig. 4). Bioswales (mean=0.1, SD=0.3) are only present at this building type and can be observed from some windows. The number of paths (mean=0.6, SD=0.6), lamps (mean=0.7, SD=1.2), and garbage cans (mean=0.9, SD=2.3) is significantly lower at the row development compared to the other building types ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

Large housing estates have the significantly highest number of trees (mean=14.3, SD=10.9) and playgrounds (mean=0.3, SD=0.5), but also car parks (mean=0.3, SD=0.5) from the window perspective ($p<0.05$; Wilcoxon rank sum test; Holm adj.). Additionally, here are the only green walls observed in our study (mean=0.1, SD=0.3). The number of groups of shrubs (mean=17.9, SD=10.7) and bike racks (mean=0.5, SD=0.9) are the second highest observable counts on average. Furthermore, regarding other elements, the window view at large housing estates contains moderate to high numbers in comparison (Fig 4).

Nonetheless, the building types are not homogenous, there is significant variability among the neighborhoods. Sprengelkiez, Wedding has a significantly higher green percentage, a higher number of trees, green balconies, benches, lamps, playgrounds, paths, and garbage cans than Ideal-Passage, Neukölln (Block development) ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

Within the row development Alte Jakobstraße, Kreuzberg-Mitte has a significantly higher percentage of green visible and number of trees, and clotheslines than the other neighborhoods of this building type. In contrast, at Haselhorst, Spandau significantly more bioswales, green balconies, and groups of shrubs are visible from the window perspective than at the other neighborhoods of the row development. At the Paul-Hertz Siedlung, Charlottenburg significantly more paths, private gardens, but less bike racks, and percentage of green are visible ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

The window view at Marzahn (Large housing estate) features significantly more car parks, green walls, garbage cans, groups of shrubs, green balconies, lamps, trees, but less bike racks, and playgrounds than Gropiusstadt, Neukölln ($p<0.05$; Wilcoxon rank sum test; Holm adj.).

The block-edge development with large backyards consists of only one neighborhood, the General-Barby-Siedlung, Reinickendorf, in this study. But even there, variability can be found between the sample plots.

Overall, the different structure types and neighborhoods ("Kieze") differ in the number of elements visible from a window perspective. The design of the residential greenery is individual and highly varied.

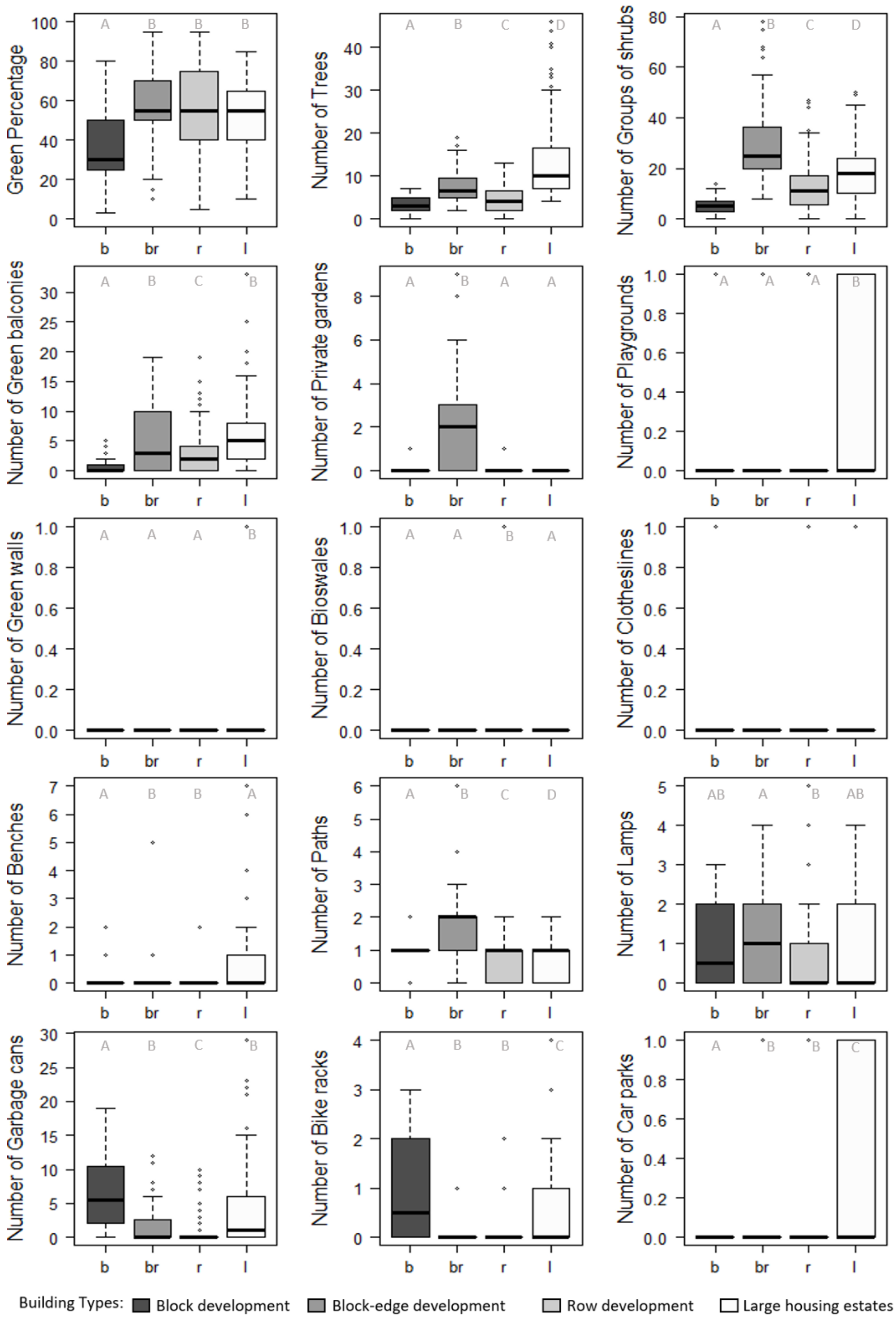

Figure 4 Numbers of visible green and structural elements per building type. Light grey letter codes (A-D) indicate significant differences. ($p<0.05$, Pairwise comparisons using Wilcoxon rank sum test, Holm adjustments)

Qualitative results: Conversations with residents

Residents were sometimes suspicious of me taking pictures from their staircase, especially in the General-Barby-Siedlung, Reinickendorf (photos 2h-2k, Fig. 2), the 1st plot (photo 3l, Fig. 2), and 2nd plot (photo 3m, Fig. 2) at Alte-Jakobstraße, Kreuzberg-Mitte, and plot number 3 at Gropiusstadt, Neukölln (not pictured). These residents were mostly elderly people and often told me they feared break-ins and vandalism. Some expressed concerns with their neighbors or residents in adjoining areas and few even racist stereotypes. On the other hand, in buildings with a high number of apartments, to many residents it did not matter who and why someone wanted to enter their building. They often opened without inquiring through the intercom. Then again, several residents were very interested in what I was doing, wanted to talk to me and speak their mind. Some even were hopeful that this investigation would lead to an improvement of the greenery.

Perception of the window views

How are the building types and neighborhoods perceived from a window perspective?

In general, the photographs of the building types are ranked significantly different ($p<0.05$; Kruskal-Wallis rank sum test; Table 3). On average, photos of the dense block development were ranked the lowest (mean= -0.7, SD=2.4), while photos of the block-edge development were ranked the highest (mean=1.6, SD=1.7; $p<0.05$; Wilcoxon rank sum test; Holm adj.). There is no significant difference between the valuation of the row development (mean= -0.1, SD=2.8) and the large housing estate (mean= -0.2, SD=2.3; Fig.5).

Within the block developments, the Ideal Passage, Neukölln is significantly lower ranked (mean= -1.4, SD=2.3) than Sprengelkiez, Wedding (mean= -0.1, SD=2.2), and received also the lowest ranks over all the neighborhoods. Alte Jakobstaße, Kreuzberg-Mitte is perceived more positive (mean=0.6, SD=3.1) than Haselhorst, Spandau (mean= -0.7, SD=2.3), and achieved overall the second highest valuation. General-Barby-Siedlung, Reinickendorf, as the only neighborhood of the block-edge development, was ranked the highest (mean=1.6, SD=1.7) among all neighborhoods. Within the large building estates views from Marzahn's windows were rated significantly lower (mean= -0.4, SD=2.5) compared to those from Gropiusstadt, Neukölln (mean=0.1, SD=2.0; $p<0.05$; Wilcoxon rank sum test; Holm adj.; Fig.5). Interestingly, Sprengelkiez, Wedding was not ranked significantly different from the neighborhoods of the large housing estates (Fig. 5).

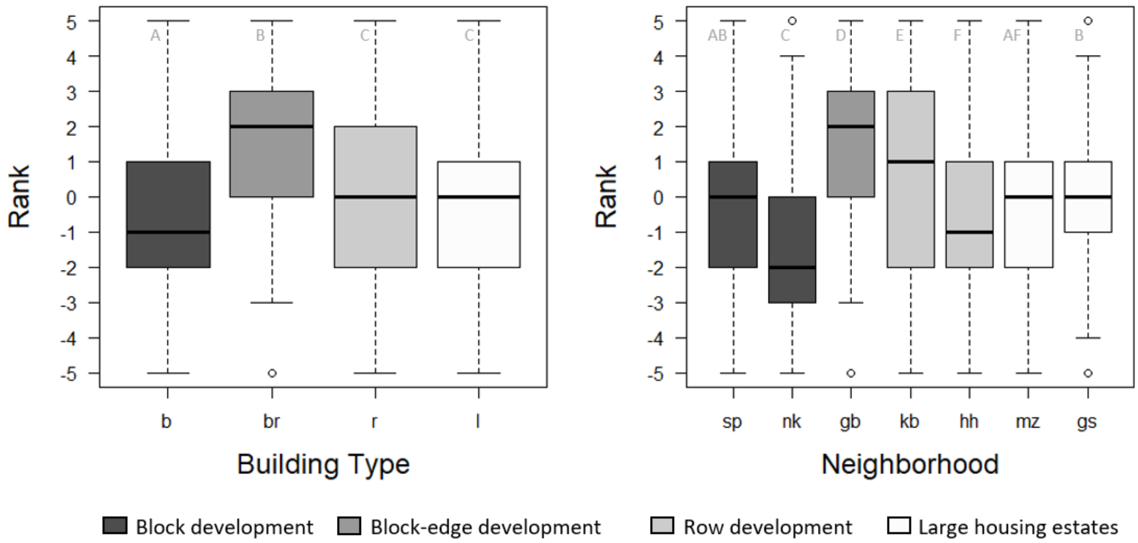

Figure 5 Distribution of ranks per building type and neighborhood. (**sp**) Sprengelkiez,Wedding; (**nk**) Ideal-Passage, Neukölln; (**gb**) General-Barby-Siedlung, Reinickendorf; (**kb**) Alte-Jakobstraße, Kreuzberg-Mitte; (**hh**) Haselhorst, Spandau; (**mz**) Marzahn; (**gs**) Gropiusstadt, Neukölln. Light grey letter codes (A-E) indicate significant differences (p<0.05, Pairwise comparisons using Wilcoxon rank sum test, Holm adjustments)

The picture 3l (Fig.2, Fig.6 A) of Alte-Jakobstraße, Kreuzberg-Mitte is by far the most preferred photograph, with significantly higher average ranking (mean=3.2, SD=1.9) than the other photos ($p<0.05$; Wilcoxon rank sum test; Holm adj.). 3l is characterized by a high percentage of green (95%), 6 trees and 4 groups of shrubs, no structural elements are visible. The photographs ranked second, and third highest are 2i of General-Barby-Siedlung, Reinickendorf (mean=2.0, SD=1.6) and 4s of Marzahn (mean=1.8, SD=2.2), respectively (Fig. 2). Photograph 1g (Fig.2, Fig.6 B) is significantly the least popular (mean= -3, SD=2.3) among all ($p<0.05$; Wilcoxon rank sum test; Holm adj.). 1g is characterized by a low percentage of green (15 %), no visible trees, 7 groups of shrubs, 5 garbage cans, and a path. The second lowest (mean= -2.9, SD=1.6) ranked photo is 3n of Alte-Jakobstraße, Kreuzberg-Mitte (Fig.2). 4r of Marzahn is the third lowest ranked photo (mean= -2.8, SD=2.1; Fig.2).

Figure 6 (**A**) most popular photo (Alte-Jakobstraße, Kreuzberg-Mitte, Row development) and (**B**) least popular photo (Ideal-Passage, Neukölln, Block development) and their respective ground level views.

How are the green and structural elements perceived?

The visible green and structural elements show distinct relations with the ranks of the photos (Fig. 7, Table 3). The strongest positive correlation was found for green percentage ($p<0.05$; rho=0.60; Spearman´s rank correlation coefficient). Furthermore, trees, private gardens and paths are positively correlated with preference ($p<0.05$; rho>0.2; Spearman´s rank correlation coefficient). To a lesser extent, but still significantly positive correlated are groups of shrubs, playgrounds, benches, lamps, and clotheslines (Table 3). Interestingly, the number of many elements with a positive correlation decreases at the highest rank (Fig.7) In contrast, car parks exhibit the strongest negative correlation ($p<0.05$; rho= -0.38; Spearman´s rank correlation coefficient). Garbage cans are also negatively correlated with preference ($p<0.05$; rho= -0.23; Spearman´s rank correlation coefficient).

Correlation among the dependent variables (visible green and structural elements) was calculated and revealed a high correlation (rho>0.8; Spearman´s rank correlation coefficient) between benches and playgrounds (Table 2). Therefore, benches were omitted from the multivariate analysis.

Table 2 Correlations between the predictor variables (The column numbers indicate the variable, corresponding to column 1) employing Spearman´s rank correlation coefficient

Variables		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Green percentage	1.00	0.28	-0.02	-0.07	0.25	0.03	0.02	0.32	0.13	0.14	-0.34	0.02	-0.47
2	Trees		1.00	0.21	0.41	0.26	0.38	0.36	0.17	0.21	-0.37	0.21	0.24	0.17
3	Groups of shrubs			1.00	0.74	0.45	0.06	0.07	-0.32	-0.50	0.55	-0.03	-0.11	0.16
4	Green balconies				1.00	0.25	0.20	0.05	-0.25	0.23	-0.41	-0.04	0.10	0.24
5	Private gardens					1.00	0.07	0.03	-0.08	0.61	-0.37	-0.15	0.19	-0.17
6	Playgrounds						1.00	**0.84**	-0.12	0.14	-0.25	0.09	0.10	-0.26
7	Benches							1.00	-0.14	0.22	0.23	0.02	0.06	-0.31
8	Clotheslines								1.00	-0.26	-0.16	-0.25	-0.11	-0.09
9	Paths									1.00	0.55	0.01	0.09	-0.28
10	Lamps										-1.00	0.34	0.08	-0.10
11	Garbage cans											1.00	0.17	0.16
12	Bike racks												1.00	-0.23
13	Car parks													1.00

Stepwise backwards selection (AIC) of the generalized linear model (GLM; Table 3) revealed 10 elements to be significant. High green percentage, high number of groups of shrubs, playgrounds, paths or garbage cans, and low numbers of green balconies, private gardens, lamps, bike racks and car parks are good predictors of preference. The minimal linear regression analysis (Table 4) has a similar result. 8 variables remain significant: green percentage, groups of shrubs, playgrounds, and negative terms of green balconies, clotheslines, lamps, bike racks, car parks. Together, they explain 42% of the variation (R^2 =0.42, adj. R^2 =0.42, F=191.1, $p < 2.2e-16$). Additionally, a regression model including squared terms was calculated (Table 4). Groups of shrubs, lamps, and bike racks become non-significant, while trees, paths and garbage cans become significant. Beyond that, squared terms of groups of shrubs and paths and negative squared terms of trees, private gardens, lamps, garbage cans, and bike racks proved to be significant. Overall, the model explains 46% of the variation in preference (R^2 =0.46, adj. R^2 =0.46, F=132, $p < 2.2e\text{-}16$).

Qualitative results: Conversations with test subjects

The conversations with the participants during the sorting task allowed for the collection of factors with individual importance for the perception. Mentions included the following: familiarity, architecture, associated living environment, range of vision, light, openness, colors, neatness, symmetry, garbage, cars, streets, expected noise, greenness, plants, trees. Statements, like below-mentioned, were made about the choices: "The cars also have to go somewhere", "The construction site is only temporary […and therefore does not affect my judgement]", "Even though the view is not that nice, I prefer this because it suggests a young, lively neighborhood in the city center, and "Altbauwohnungen" (apartments in old buildings with high ceilings and wooden floors)", "It is really nice when you look out your window and it is green.", "I would enjoy watching the children play at the playground.", "The colors are beautiful".

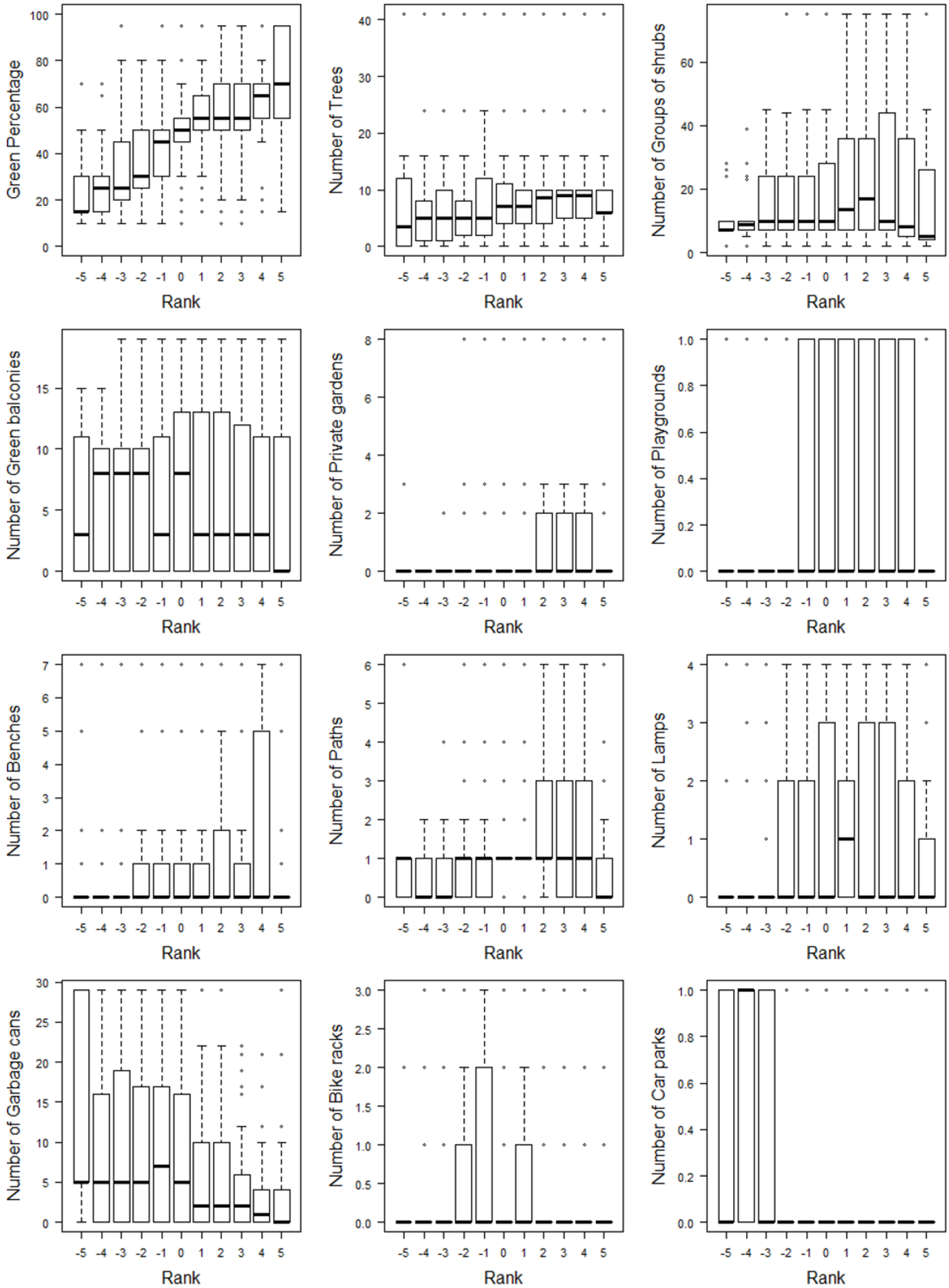

Figure 7 Presence of the respective number of visible green and structural elements at different ranks.

Table 3 Statistical results of the non-parametric analysis of the significance of the predictor variables on the ranking of the photos. Significant p-values (<0.05) are bold. GLM calculated using Poisson distribution; Null deviance: 3437.8 on 2351 df, Residual deviance: 2136.0 on 2340 df.

	Kruskal Wallis		Spearman		GLM	
Variables	Chi-squared	p-value	Estimate rho	p-value	Estimate	p-value
(Intercept)					0.718	**7.78E-42**
Building Type	248.44	**1.43E-47**				
Neighborhood	338.28	**5.06E-64**				
Degree	371.78	**2.86E-74**				
Green percentage			**0.601**	**1.94E-231**	0.014	**4.99E-92**
Trees			0.207	**4.11E-24**	-0.002	0.121
Groups of shrubs			0.064	**0.002**	0.013	**1.01e-11**
Green balconies			0.027	0.199	-0.010	**0.002**
Private gardens			0.275	**6.03E-42**	-0.032	**0.005**
Playgrounds			0.119	**6.48E-09**	0.233	**5.22E-08**
Benches			0.082	**7.64E-05**		
Clotheslines			0.132	**1.28E-10**		
Paths			0.219	**6.21E-27**	0.017	**0.046**
Lamps			0.160	**5.67E-15**	-0.066	**8.94E-07**
Garbage cans			-0.233	**2.72E-30**	0.004	**0.041**
Bike racks			-6.29E-05	0.998	-0.025	**0.035**
Car parks			-0.375	**1.31E-79**	-0.244	**2.18E-09**

Table 4 Statistical results of the parametric analysis of the significance of the predictor variables on the ranking of the photos. Significant p-values (<0.05) are bold.

Linear regression: RSE: 1.89 on 2342 df, Multiple R^2: 0.42, Adj. R^2: 0.42.

Regression analysis with squared terms: RSE: 1.83 on 2336 df, Multiple R^2: 0.46, Adj. R^2: 0.46

	Linear Regression		Regression Squared Terms	
Variables	Estimate	p-value	Estimate	p-value
(Intercept)	-3.583	**5.14E-131**	-4.281	**1.98E-58**
Green percentage	0.068	**9.84E-159**	0.069	**2.09E-64**
Trees			0.174	**5.79E-06**
Groups of shrubs	0.036	**1.61E-15**		
Green balconies	-0.020	**0.033**	-0.051	**0.004**
Private gardens				
Playgrounds	0.681	**3.129E-08**	1.889	**5.38E-24**
Clotheslines	-0.494	**0.026**	-1.052	**0.001**
Paths	0.070	0.070	-0.791	**5.23E-05**
Lamps	-0.236	**6.9117E-09**		
Garbage cans			0.213	**2.97E-16**
Bike racks	-0.147	**0.001**		
Car parks	-0.780	**2.444E-09**	-0.819	**0.001**
Trees ^{2}			-0.005	**3.33E-08**
Groups of shrubs^2			0.002	**5.46E-15**
Private gardens^2			-0.062	**5.41E-06**
Paths^2			0.171	**1.46E-07**
Lamps^2			-0.225	**1.67E-28**
Garbage cans^2			-0.008	**3.64E-17**
Bike racks^2			-0.058	**0.001**

Discussion

Residential greenery - the window view

This study compares for the first time the perspectives on the Residential Greenery from the windows view compared to the general presence of these elements in the area looked at. It proves significant differences between both and highlights the need to include the window perspective into urban design, landscaping, and policy.

Less trees can be seen from the windows than are present at the plots. This is in line with the work from Cox et al. (2019), who found a highly skewed contribution of a small number of trees to the majority of indirect nature experiences (sight of tree). Elements which are small, such as benches, bike racks, and lamps, are often harder to discern from the window, especially if they are located close to the building (Table 1). . This is the case as well for elements related to walls, like green facades and balconies. Those can logically only be seen on opposing walls. Green facades, green roofs or bioswales remain generally very rare in Berlin's residential areas, although numerous support measures for mainstreaming these ecological measures have been implemented in Berlin since the 1980s (e.g. SenStadtUm; 2007). Elements with a larger surface area, such as car parks, private gardens, and paths, are highly visible from above. Paths are the only structure more easily recognizable from the window perspective (Table 1). This is probably due to their unique spatial configuration, leading the whole along plot.

Perception of building types from the window

Dense block development is the building type with a very little developed greenery when seen from above. This is in accordance with the results from the status quo analysis (Battisti et al. 2019). Less trees, less shrubs, and no lawn were found. Lawn was not recorded directly in this study, but influences the green percentage, which was also lower. But the window perspective intensifies this pattern, even less trees can be seen than are present at the plots. There are little visible indications for recreational usage. The window view shows mainly the storage facilities for bicycles and garbage cans, which was perceived negatively by participants

(Fig. 4). The small size of the courtyards limits the possible interventions, but the negative perception reveals a need for action.

The window view of the residential greenery of the block-edge development with large backyards is defined by diverse plants and elements intended for recreation, such as private gardens, green balconies, paths, and lamps. Simultaneously, elements for practical usage (garbage cans, bike racks, car parks, clotheslines) are less visible. This combination was perceived as highly favorable in the survey and can be used for inspiration. Parallel and free row developments have some of the greenest residential spaces, when seen from the window. However, the number of trees and groups of shrubs are in comparison rather low. Recreational elements as paths, benches, playgrounds, private gardens, or green balconies are seldom visible. Also, garbage cans, bike racks, car parks are rarely observable (Fig. 4). The design concept of the "park landscape" (Battisti et al. 2019) is thus even more apparent from the window. This was perceived differentially, from the most preferred view, to some of the least preferred views. This suggests that there is a great potential, which is not fully exploited at many residential greeneries.

The residential greenery of the large housing estates contains many plants as well as many structural elements. Among them, there are elements for recreation as playgrounds, green balconies, benches, and lamps. Moreover, many parking lots for cars, and high numbers of garbage cans, and bike racks are visible (Fig. 4). . This is partly due to the large size of the residential areas but also choice of design (Battisti et al. 2019). Participants perceived this as relatively neutral. The large spaces provide a unique possibility to create landscapes that unify a beneficial window view with many different uses.

In general, particular residential greenery composition of the building types are apparent from the window perspective. Nonetheless, there is a high variability of individual window perspectives. This is evident in the significant differences of element counts between the neighborhoods, and even sample plots within building types. This result is not surprising, since there are no common guidelines for the design or maintenance of residential greeneries (Battisti et al. 2019).

Conversations with residents revealed, that some residents do not feel safe in their residential greeneries. Interestingly, these spaces were among the greenest and most well-kept ones in the study, while also achieving the highest ratings in the survey. Similar results were found for Alte-Jakobstraße, Kreuzberg-Mitte (Row development) in interviews with residents (Säumel et al. (2020). However, they also found inverse results for the General-Barby-Siedlung, Reinickendorf (Block-edge development), where all respondents indicated feeling safe at their residential greenery. Scared residents in well-kept, highly rated plots contradicts the connection of overgrown vegetation and fear (Bixler and Floyd 1997). This explanation may be too simple. But more research is necessary to explore this further since this is only anecdotal evidence.

Elements of perception

The proportion of green visible in the window view was the strongest predictor for preference. This is emphasized by the fact that the building type ranked lowest also is the least green. This result is in line with many publications who stress the importance of natural views (Kaplan 2001; Lottrup et al. 2015; Nezamdoost and Modarres Nezhad 2020) and amount of vegetation for preference of settings (Anderson and Schroeder 1983; Arriaza et al. 2004; Mao et al. 2020; Qiu et al. 2013). But this is also the element with the broadest definition, consisting of all visible vegetation.

The number of trees was also a significant predictor. Furthermore, the amount visible from the window diverts from the number of trees present. This is especially relevant, since they have been linked to aesthetic preference (Wang et al. 2019) and view satisfaction (Lottrup et al. 2015). Additionally, to the linear relation, a negative squared relation was found. This might be because too many trees can obstruct the view and people care about openness as much as greenness (Jiang et al. 2014).

In our study, presence of shrubs is positively related to preference (Fig. 7/ Table 3). This is similar to other studies, which have found shrubs to be connected to preference and well-being (Deng et al. 2020; Gilchrist et al. 2015). Besides, squared terms were significant in the regression model. This means that both high and low numbers of shrubs are predictors of preference, but higher numbers more so. This could be related to distinct preferences of participants, some might enjoy more diverse natural environment, while others prefer tidy and manicured vegetation. Some neighbors are concerned with orderliness of the residential greenery, whereas others favor more wilderness in the greeneries (Weber et al. 2014; Säumel et al. (2020). However, the strong connection of vegetation and high ranks supports our hypothesis that greener window views of residential greenery are preferred.

The strongest negative predictor for preference were the car parks. This is not surprising since several studies have linked cars and parking lots with negative perception (Anderson and Schroeder 1983; Kaplan 2001; Nezamdoost and Modarres Nezhad 2020). As expected for elements of practical usage, garbage cans and bike racks are negatively related to preference. This is in line with the negative perception of human-made elements, (Anderson and Schroeder 1983; Nezamdoost and Modarres Nezhad 2020; Qiu et al. 2013). However, bike racks can be neglected, since they are rarely visible from the window.

Surprisingly, the other visible elements (i.e. Private gardens, Playgrounds, Clotheslines, Paths, Lamps) had a positive influence on preference. This was unanticipated and showed that the perception of residential greenery is more nuanced than our hypothesized relation of active vs. passive use facilities. Few studies have already shown that some built views can also be restorative (van Esch et al. 2019), and that some human-made elements can be perceived as positive (Arriaza et al. 2004), at least if they are mixed with a high natural proportion (Nezamdoost and Modarres Nezhad 2020). But no studies have demonstrated this for the view of residential greenery and moreover, to what anthropogenic elements this applies, specifically in this context.

The structural elements with a positive impact on the ranking of the views share a characteristic: they are all related to recreational activities. Private gardens and green balconies are used for personal recreation. Playgrounds are used for public recreation, as well as paths and lamps. The latter are also essential for movement in the residential areas and for feeling save in the dark (Svechkina et al. 2020). The only exception from this pattern are clotheslines. But they are relicts, which are not used anymore (Battisti et al. 2019). They may even evoke feelings of nostalgia in residents, since there were times when laundry was dried in the semi-public laundry area and no one was afraid it would be stolen. This could mean that the view from home is not only rated for visual quality (Qiu et al. 2013) but also for the visual possibility of recreational activities. Then again it could be that the general impression of the scenery is more important for preference than single elements. Moreover, considering the comments of the participants during the sorting task, feelings of attachment and belonging regarding the view or the architecture could also affect the judgement.

Implications

In this study, components of residential greenery were identified that influence preference. This can help to create window views that are beneficial for residents, since preference is a strong predictor of restoration (Lindal and Hartig 2015; Wang et al. 2019). Moreover, enhancing the window view of residents can mitigate the extinction of experience. Which in turn can foster well-being and a positive attitude towards nature conservation (Soga and Gaston 2016). Thus, aligning ecological goals with aesthetic experiences (Gobster et al. 2007).

The most and least popular photos can be used as an example for how to design from a window perspective. At the most preferred window view the elements of use and recreation are close to the building and not observable from the window. The space between the buildings is planted with lawn, trees, and some shrubs. The tall trees conceal the opposing building wall. At the least preferred window view the groups of shrubs that enhance the space at ground level are not visible from the window, due to the low height of the plants. Obviously, there is not as much space available, but research has shown that building greening and tall trees are important design features for denser neighborhoods (Barron et al. 2019). At this plot too, a tree or a green wall would have a big impact. Furthermore, garbage cans can be hidden under trees or a shed with a green roof. And even though distant views are more preferred, for natural view content this is not as important. Therefore, if creating a distant view is not possible, natural elements can compensate (Kent and Schiavon 2020). The inclusion of structures for private or public recreation can also be beneficial for the window view. In dense neighborhoods, smaller elements such as benches can be implemented. At building types with more space, more “park landscapes” could be integrated, as well as larger recreational elements such as playgrounds and private gardens. Car parks might be partially concealed with tall trees. When designing the vegetation or planting new trees in a residential greenery, ecosystem services and disservices should be considered (Battisti et al. 2019) as well as the seasonality (Barron et al. 2019). The high variability requires the individual perspectives to be considered in design interventions. Instead of developing generalized solutions for all residential greeneries, residents should be included in co-creation to assure a design on residents needs and foster place attachment and belonging (Säumel et al. 2020).

Methodology and limitations

The survey was generally well received, since the sorting of pictures is an intuitive, playful task (Sáenz de Tejada Granados et al. 2020). This could also be observed in the fact that children thought the survey was a game and wanted to participate. Most adults (18 – 69 years) had no problem in understanding and completing the task in a few minutes. For this demographic it would even have been possible to include more pictures, allowing for an analysis of subjectivity by Q-Methodology. Some senior citizens (>69 years), on the other hand, were overwhelmed, for them there were too many photographs, and the differences between them not stark enough. Often, I was told to sort the pictures how I needed them to be. For some participants with visual impairment the pictures were too small. The use of only 24 photographs lead to only one extractable component. This means that there was a high consensus among the participants regarding the perception of the photos. A high consensus has been linked to a high visual aesthetic quality (Wang et al. 2005). This could mean that the window views were overall positively regarded. It could also mean that the selection of the photos was not heterogeneous enough. On the other hand, the qualitative results suggest a highly subjective and individual perception. At a higher number of photographs maybe these views could have emerged in distinct groups. Additionally, a separate analysis of building types regarding the predictors of preference would have been possible and should be included in further research.

The influence of demographic factors was not tested, evidence of such an influence is mixed but would be interesting to analyze in future studies (Weber et al. 2008; Cox et al. 2017; Jiang et al. 2014).

The use of photos of existing residential greeneries makes the results highly applicable. At the same time, no control of confounding factors was possible, limiting the validity. The distance of the view can have an impact on the perception (Kent and Schiavon 2020). The architecture and specific features of the buildings in sight can also be important (Lindal and Hartig 2015). Complementary, the commentaries of participants suggest that the type of building they grew up in or want to live in could be influential. In future research, more seasons should be investigated, and how the perceptions changes with them (Barron et al. 2019). In this study, the size of elements was not recorded nor their position in the view. Furthermore, there were no humans visible. So, the question remains if the elements of recreation are perceived differently when they are being used. Then again, Kearney and Winterbottom (2006) found that more often than not senior residents preferred to see people from their window.

Conclusion

The significant difference between the window perspective from the perspective at ground level has implications for the design of residential greenery. The window view has to be explicitly included, since relevant components are often less visible from above.

The building types differ in their composition of visible elements. Nonetheless, the window perspective is highly varied even within building types and neighborhoods. Therefore, variable solutions should be found for the variable perspectives and according to the available size. Co-creation can be a valuable and low-cost tool to achieve a favorable outcome.

While vegetation is the single best predictor for preference, structures for recreation are also perceived positive. This means that residential greenery has the potential to reconcile different interests. A smart, multifunctional design can provide recreational space for active users and simultaneously aesthetically pleasing window views. These window views are the main contact with nature for many residents, especially during the current COVID-19 pandemic. Consequently, the window views of residential greenery can be an essential resource for promoting health and well-being.

Publication bibliography

Amerio, Andrea; Brambilla, Andrea; Morganti, Alessandro; Aguglia, Andrea; Bianchi, Davide; Santi, Francesca et al. (2020): COVID-19 Lockdown: Housing Built Environment's Effects on Mental Health. In *International Journal of Environmental Research and Public Health* 17 (16). DOI: 10.3390/ijerph17165973.

Amt für Statistik Berlin-Brandenburg (Ed.) (2019): Bevölkerung in Berlin 2018. Statistischer Bericht. Potsdam (A I 3 - j / 18). Available online at https://www.statistik-berlin-brandenburg.de/publikationen/stat_berichte/2019/SB_A01-03-00_2018j01_BE.pdf, checked on 7/8/2020.

Anderson, L. M.; Schroeder, Herbert W. (1983): Application of wildland scenic assessment methods to the urban landscape. In *Landscape Planning* 10 (3), pp. 219–237. DOI: 10.1016/0304-3924(83)90049-7.

Arriaza, M.; Cañas-Ortega, J. F.; Cañas-Madueño, J. A.; Ruiz-Aviles, P. (2004): Assessing the visual quality of rural landscapes. In *Landscape and Urban Planning* 69 (1), pp. 115–125. DOI: 10.1016/j.landurbplan.2003.10.029.

Barron, Sara; Nitoslawski, Sophie; Wolf, Kathleen L.; Woo, Angie; Desautels, Erin; Sheppard, Stephen R. J. (2019): Greening Blocks: A Conceptual Typology of Practical Design Interventions to Integrate Health and Climate Resilience Co-Benefits. In *International Journal of Environmental Research and Public Health* 16 (21). DOI: 10.3390/ijerph16214241.

Battisti, Luca; Pille, Lauranne; Wachtel, Thomas; Larcher, Federica; Säumel, Ina (2019): Residential Greenery: State of the Art and Health-Related Ecosystem Services and Disservices in the City of Berlin. In *Sustainability* 11 (6), p. 1815. DOI: 10.3390/su11061815.

Bell, Sarah L.; Foley, Ronan; Houghton, Frank; Maddrell, Avril; Williams, Allison M. (2018): From therapeutic landscapes to healthy spaces, places and practices: A scoping review. In *Social science & medicine (1982)* 196, pp. 123–130. DOI: 10.1016/j.socscimed.2017.11.035.

Bixler, R. D.; Floyd, M. F. (1997): Nature is Scary, Disgusting, and Uncomfortable. In *Environment and Behavior* 29 (4), pp. 443–467. DOI: 10.1177/001391659702900401.

Bratman, Gregory N.; Daily, Gretchen C.; Levy, Benjamin J.; Gross, James J. (2015): The benefits of nature experience. Improved affect and cognition. In *Landscape and Urban Planning* 138, pp. 41–50. DOI: 10.1016/j.landurbplan.2015.02.005.

Chang, Chen-Yen; Chen, Ping-Kun (2005): Human Response to Window Views and Indoor Plants in the Workplace. In *HortScience* 40 (5), pp. 1354–1369.

Cox, Daniel T.C.; Bennie, Jonathan; Casalegno, Stefano; Hudson, Hannah L.; Anderson, Karen; Gaston, Kevin J. (2019): Skewed contributions of individual trees to indirect nature experiences. In *Landscape and Urban Planning* 185, pp. 28–34. DOI: 10.1016/j.landurbplan.2019.01.008.

Cox, Daniel T.C.; Hudson, Hannah L.; Shanahan, Danielle F.; Fuller, Richard A.; Gaston, Kevin J. (2017): The rarity of direct experiences of nature in an urban population. In *Landscape and Urban Planning* 160, pp. 79–84. DOI: 10.1016/j.landurbplan.2016.12.006.

Deng, Li; Luo, Hao; Ma, Jun; Huang, Zhuo; Sun, Ling-Xia; Jiang, Ming-Yan et al. (2020): Effects of integration between visual stimuli and auditory stimuli on restorative potential and aesthetic preference in urban green spaces. In *Urban Forestry & Urban Greening* 53, p. 126702. DOI: 10.1016/j.ufug.2020.126702.

Engell, Thomas; Lorås, Håvard W.; Sigmundsson, Hermundur (2020): Window view of nature after brief exercise improves choice reaction time and heart rate restoration. In *New Ideas in Psychology* 58, p. 100781. DOI: 10.1016/j.newideapsych.2020.100781.

Gao, Tian; Liang, Huiyi; Chen, Yuxuan; Qiu, Ling (2019): Comparisons of Landscape Preferences through Three Different Perceptual Approaches. In *International Journal of Environmental Research and Public Health* 16 (23). DOI: 10.3390/ijerph16234754.

Gilchrist, Kathryn; Brown, Caroline; Montarzino, Alicia (2015): Workplace settings and wellbeing. Greenspace use and views contribute to employee wellbeing at peri-urban business sites. In *Landscape and Urban Planning* 138, pp. 32–40. DOI: 10.1016/j.landurbplan.2015.02.004.

Gobster, Paul H.; Nassauer, Joan I.; Daniel, Terry C.; Fry, Gary (2007): The shared landscape: what does aesthetics have to do with ecology? In *Landscape Ecol* 22 (7), pp. 959–972. DOI: 10.1007/s10980-007-9110-x.

Hofmann, Mathias; Westermann, Janneke R.; Kowarik, Ingo; van der Meer, Elke (2012): Perceptions of parks and urban derelict land by landscape planners and residents. In *Urban Forestry & Urban Greening* 11 (3), pp. 303–312. DOI: 10.1016/j.ufug.2012.04.001.

Honey-Roses, Jordi; Anguelovski, Isabelle; Bohigas, Josep; Chireh, Vincent; Daher, Carolyn; Konijnendijk, Cecil et al. (2020): The Impact of COVID-19 on Public Space: A Review of the Emerging Questions. Available online at https://osf.io/rf7xa, checked on 9/21/2020.510Z.

Honold, Jasmin; Lakes, Tobia; Beyer, Reinhard; van der Meer, Elke (2016): Restoration in Urban Spaces. In *Environment and Behavior* 48 (6), pp. 796–825. DOI: 10.1177/0013916514568556.

Jiang, Bin; Chang, Chun-Yen; SULLIVAN, WILLIAM C. (2014): A dose of nature: Tree cover, stress reduction, and gender differences. In *Landscape and Urban Planning* 132, pp. 26–36. DOI: 10.1016/j.landurbplan.2014.08.005.

Kaplan, Rachel (2001): The Nature of the View from Home. In *Environment and Behavior* 33 (4), pp. 507–542. DOI: 10.1177/00139160121973115.

Kearney, Anne R.; Winterbottom, Daniel (2006): Nearby Nature and Long-Term Care Facility Residents. In *Journal of Housing For the Elderly* 19 (3-4), pp. 7–28. DOI: 10.1300/J081v19n03_02.

Kent, Michael; Schiavon, Stefano (2020): Evaluation of the effect of landscape distance seen in window views on visual satisfaction. In *Building and Environment* 183, p. 107160. DOI: 10.1016/j.buildenv.2020.107160.

Ko, Won Hee; Schiavon, Stefano; Zhang, Hui; Graham, Lindsay T.; Brager, Gail; Mauss, Iris; Lin, Yu-Wen (2020): The impact of a view from a window on thermal comfort, emotion, and cognitive performance. In *Building and Environment* 175, p. 106779. DOI: 10.1016/j.buildenv.2020.106779.

Li, Dongying; Sullivan, William (2016): Impact of views to school landscapes on recovery from stress and mental fatigue. In *Landscape and Urban Planning* 148, pp. 149–158. DOI: 10.1016/j.landurbplan.2015.12.015.

Lindal, Pall J.; Hartig, Terry (2015): Effects of urban street vegetation on judgments of restoration likelihood. In *Urban Forestry & Urban Greening* 14 (2), pp. 200–209. DOI: 10.1016/j.ufug.2015.02.001.

Lottrup, Lene; Stigsdotter, Ulrika K.; Meilby, Henrik; Claudi, Anne Grete (2015): The Workplace Window View: A Determinant of Office Workers' Work Ability and Job Satisfaction. In *Landscape Research* 40 (1), pp. 57–75. DOI: 10.1080/01426397.2013.829806.

Mao, Qizheng; Wang, Luyu; Guo, Qinghai; Li, Yuanzheng; Liu, Min; Xu, Guanghua (2020): Evaluating Cultural Ecosystem Services of Urban Residential Green Spaces From the Perspective of Residents' Satisfaction With Green Space. In *Frontiers in public health* 8, p. 226. DOI: 10.3389/fpubh.2020.00226.

Milcu, Andra Ioana; Sherren, Kate; Hanspach, Jan; Abson, David; Fischer, Joern (2014): Navigating conflicting landscape aspirations: Application of a photo-based Q-method in Transylvania (Central Romania). In *Land Use Policy* 41, pp. 408–422. DOI: 10.1016/j.landusepol.2014.06.019.

Nezamdoost, Amir; Modarres Nezhad, Majedeh (2020): Vitamin V: Evaluating the benefits of view quality in hospital patient rooms using a large-scale human factors study. In *Building Services Engineering Research and Technology* 41 (2), pp. 153–166. DOI: 10.1177/0143624419889548.

Qiu, Ling; Lindberg, Stefan; Nielsen, Anders Busse (2013): Is biodiversity attractive?—On-site perception of recreational and biodiversity values in urban green space. In *Landscape and Urban Planning* 119, pp. 136–146. DOI: 10.1016/j.landurbplan.2013.07.007.

R Core Team (2019): R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Available online at https://www.R-project.org.

Raanaas, Ruth Kjærsti; Patil, Grete Grindal; Hartig, Terry (2012): Health benefits of a view of nature through the window: a quasi-experimental study of patients in a residential rehabilitation center. In *Clinical rehabilitation* 26 (1), pp. 21–32. DOI: 10.1177/0269215511412800.

Sáenz de Tejada Granados, Carlota; Santo-Tomás Muro, Rocío; Rodríguez Romero, Eva J. (2020): Exploring landscape preference through photo-based Q methodology. Madrid seen by suburban adolescents. In *International Research in Geographical and Environmental Education* 8 (2), pp. 1–24. DOI: 10.1080/10382046.2020.1804134.

Säumel, Ina; Butenschön, S. (2018): HealthyLiving: Strategie und Planungsinstrument für gesundheitsförderndes Wohnumfeldgrün in der Stadt der Zukunft. In Rainer Fehr, Claudia Hornberg (Eds.): Stadt der Zukunft - gesund und nachhaltig. Brückenbau zwischen Disziplinen und Sektoren. München: oekom (Edition nachhaltige Gesundheit in Stadt und Region, Band 1).

Säumel, Ina; Hogrefe, Jan; Battisti, Luca; Wachtel, Thomas; Larcher, Federica (2020): The healthy green living room at one's doorstep? Use and perception of residential greenery in Berlin, Germany. In *Urban Forestry & Urban Greening*.

SenStadtWohn (Ed.) (2020): Umweltatlas Berlin. Senatsverwaltung für Stadtentwicklung und Wohnen Berlin. Berlin. Available online at https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/, checked on 7/7/2020.

Soga, Masashi; Gaston, Kevin J. (2016): Extinction of experience. The loss of human-nature interactions. In *Front Ecol Environ* 14 (2), pp. 94–101. DOI: 10.1002/fee.1225.

Steen Jacobsen, Jens K. (2007): Use of Landscape Perception Methods in Tourism Studies: A Review of Photo-Based Research Approaches. In *Tourism Geographies* 9 (3), pp. 234–253. DOI: 10.1080/14616680701422871.

Svechkina, Alina; Trop, Tamar; Portnov, Boris A. (2020): How Much Lighting is Required to Feel Safe When Walking Through the Streets at Night? In *Sustainability* 12 (8), p. 3133. DOI: 10.3390/su12083133.

Taylor, A. F.; Kuo, F. E.; Sullivan, W. C. (2002): VIEWS OF NATURE AND SELF-DISCIPLINE: EVIDENCE FROM INNER CITY CHILDREN. In *Journal of Environmental Psychology* 22 (1-2), pp. 49–63. DOI: 10.1006/jevp.2001.0241.

Ulrich, R. S. (1984): View through a window may influence recovery from surgery. In *Science (New York, N.Y.)* 224 (4647), pp. 420–421.

van Esch, Emmy; Minjock, Robert; Colarelli, Stephen M.; Hirsch, Steven (2019): Office window views: View features trump nature in predicting employee well-being. In *Journal of Environmental Psychology* 64, pp. 56–64. DOI: 10.1016/j.jenvp.2019.05.006.

Velarde, Ma.D.; Fry, G.; Tveit, M. (2007): Health effects of viewing landscapes – Landscape types in environmental psychology. In *Urban Forestry & Urban Greening* 6 (4), pp. 199–212. DOI: 10.1016/j.ufug.2007.07.001.

Wang, Jiongjiong; Rao, Hengyi; Wetmore, Gabriel S.; Furlan, Patricia M.; Korczykowski, Marc; Dinges, David F.; Detre, John A. (2005): Perfusion functional MRI reveals cerebral blood flow pattern under psychological stress. In *Proceedings of the National Academy of Sciences of the United States of America* 102 (49), pp. 17804–17809. DOI: 10.1073/pnas.0503082102.

Wang, Ronghua; Zhao, Jingwei; Meitner, Michael J.; Hu, Yue; Xu, Xiaolin (2019): Characteristics of urban green spaces in relation to aesthetic preference and stress recovery. In *Urban Forestry & Urban Greening* 41, pp. 6–13. DOI: 10.1016/j.ufug.2019.03.005.

Weber, Frauke; Kowarik, Ingo; Säumel, Ina (2014): A walk on the wild side: Perceptions of roadside vegetation beyond trees. In *Urban Forestry & Urban Greening* 13 (2), pp. 205–212. DOI: 10.1016/j.ufug.2013.10.010.

Weber, Ralf; Schnier, Jörg; Jacobsen, Thomas (2008): Aesthetics of Streetscapes: Influence of Fundamental Properties on Aesthetic Judgments of Urban Space. In *Percept Mot Skills* 106 (1), pp. 128–146. DOI: 10.2466/pms.106.1.128-146.

World Health Organization (2007): Large analysis and review of European housing and health status (LARES). Preliminary Overview. Available online at https://www.euro.who.int/__data/assets/pdf_file/0007/107476/lares_result.pdf, checked on 9/11/2020.