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SOUNDSCAPE ASSESSMENT OF DIFFERENTLY CLASSIFIED URBAN PARKS IN BERLIN

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ABSTRACT

Three parks in Berlin with different classification status according to the current noise action plan are compared by means of acoustical and perceptual analyses. One park is officially treated as a quiet area, another is classified as an inner-city green and recreational area, whereas the third does not belong to a specific category defined by the noise action plan. The park areas were evaluated by means of in-situ surveys and acoustic measurements. Additionally, conventional noise maps were calculated. This combined approach allows insights as to how users perceive the respective soundscapes and whether this perception is consistent with basic acoustic indicators and the formal classification of the park. To assess park perception, a translated version of the Perceived Restorativeness Soundscape Scale (PRSS) was applied. Although it has not been possible to determine all FACE components in this study, the restoration level was reliably measured. As expected, results show that the reported restoration level does not comply with the measured and calculated L_{Aeq} values. The data suggests that the applied criteria, which only consider physical aspects of sound, may not be sufficient to identify city areas that help relieve people's stress.

Keywords: *restoration, quiet areas, soundscape*

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1. INTRODUCTION

The benefit of quiet areas for restoration and relaxation in cities is indisputable. These areas are explicitly visited for relaxation and leisure activities [1]. Green areas in cities are helpful to allow residents to escape from routine, improving restoration, emotional resilience, social connection and cognitive development across social groups [2]. Though such areas and city parks foster a closer relationship to nature and promote biodiversity, it is still unclear whether and to what extent their acoustic properties support relaxation and restoration as well [3].

In this context, the Attentional Restoration Theory (ART) [4] and the Stress Recovery Theory (SRT) [5] attract much attention in the scope of soundscape research, cf. [6]. According to Kaplan [4], the Attentional Restoration consists of four fundamental components called *fascination*, *being away*, *extent*, *compatibility* (FACE). These components were confirmed for the soundscape context as well and a Perceived Restoration Scale was revised into the Perceived Restoration Soundscape Scale (PRSS) to account for the aspects of sound in the context of restoration [6] but also on the effects of a fascinating, freeing, compatible and wide soundscape, which needs to be protected. [7] This insinuates that restorative places in cities do not necessarily have to be quiet in the sense of the absence of sounds. Accordingly, Salomon et al. defines the value of such areas as follows: *A quiet outdoor area implies a pleasant soundscape where people enjoy staying for a while* [8]. Unfortunately, established (acoustic) criteria for identifying quiet areas and for determining the pleasantness and restoration still seem to be deficient and incomplete to this day, cf. [11]. Therefore, this paper in-

vestigates how people perceive Berlin' park soundscapes and examines whether this perception is consistent with conventional acoustic indicators and park classifications.

1.1 Quiet areas according to the Berlin's noise action plan

The Berlin noise action plan identifies quiet areas or areas that should be protected from noise to provide a better quality of life and restoration possibilities for the local population. The Berlin noise action plan specifies three types of areas to be protected from noise: *quiet area* (Ruhiges Gebiet), *inner-city green and recreational areas* (Innerstädlische Grün- und Erholungfläche) and *urban rest and recreational spaces* (Städliche Ruhe- und Erholungsräume) [9]. A quiet area is defined as a contiguous natural area and open space such as forests, green spaces, parks, fields, meadows and pastures, partly also in connection with metropolitan area-wide connections to neighboring landscape areas that have low sound pressure levels. The noise criterion is that the overall noise (L_{DEN}) should not exceed 55 dB(A) and the area size should be larger than 100 ha. Smaller areas are considered to be inner-city green and recreational areas that do not necessarily have low sound pressure levels, but are believed to act as important public spaces within walking distance to residential locations and are at least significantly quieter in their inner parts compared to the periphery. Here selection criteria like level difference of at least 6 dB(A) (center to the edge) are applied and the areas need a minimum size of 30 ha. Using these selection criteria Berlin has twelve quiet areas and twenty-six inner-city green and recreational areas [9]. Criteria for a third category (urban rest and recreational spaces) are not defined yet, but are currently being discussed. Due to the accelerated growth of the city, this additional category might gain in significance in particular in areas which are under-supplied in terms of larger quieter, restorative areas.

2. METHODS

The restoration level of four different urban parks in Berlin was investigated using a mixed-methods approach. Data collection took place in early autumn 2021 and included repeated acoustic measurements and the collection of in-situ-ratings by means of translated versions of the Perceived Restoration Soundscape Scale in German and Spanish. Since only few Spanish questionnaires were filled out at one location and no systematic difference was obvious, these samples were merged to the data collected with the German questionnaire. Moreover, noise maps for the current situation as well as for 2030 were calculated.

2.1 Sample

In total, 82 persons took part in the interviews (54.3% female, 44.3% male, 1.3% non-binary) with an average age of 31.1 years (standard deviation: 3.4 years, range: 15-71 years). Altogether, 74.1% of the participants were native German speakers. The participants indicated that they usually do exercises, meet friends, read books or take a walk when visiting the parks (see Figure 1). Among others, activities like walking with dog, yoga or mediation were also frequently mentioned.

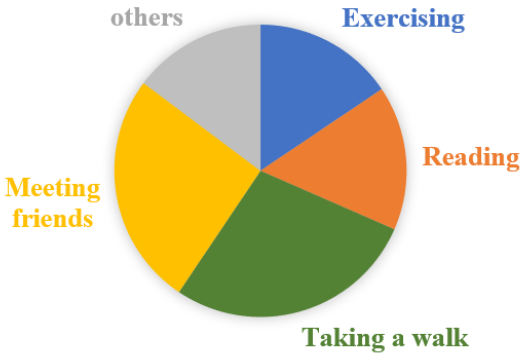

Figure 1. Activities that participants indicated to usually do in the investigated parks.

2.2 Locations

The surveys were conducted in three parks of Berlin: *Viktoriapark*, *Volkspark Hasenheide* and *Tempelhofer Feld*. According to the Berlin noise action plan, Volkpark classifies as an *urban green and recreational area* and Tempelhofer Feld is recognized as a *quiet area*. The third park, Viktoriapark, is not considered in the Berlin noise action plan due to its small size with only 12.8 ha.

The noise map of Tempelhofer Feld (see Figure 2, top) shows that the area with L_{DEN} lower than 55 dB(A) is larger than 100 ha as outlined by the Berlin noise action plan for quiet areas. It should be noticed that Loc. 1.1 (East measurement point) was not in the quieter part of the park relatively close to park periphery. The measurement point was chosen as this part of the area is frequently used by park visitors. In the case of Volkspark Hasenheide (Loc

Table 1. Level indicators (measured and calculated including prognosis for 2030) in dB(A) and loudness N_5 according to ISO 532-1 in sone for the locations under scrutiny.

	Loc 1.1	Loc 1.2	Loc 2	Loc 3
L_{Aeq}	50.4	51.8	51.2	52.1
N_5	8.1	10.2	9.0	8.6
L_{DEN}	61.2	51.8	57.9	55.0
L_{DEN} *prognosis*	62.0	53.1	58.7	55.8

2), the noise map shows that there was a greater level difference (more than 6 dB) when comparing the edges of the park to the inner area, as is required in [9]. For Viktoriapark (Loc 3), the noise map indicated that most of the area shows a L_{DEN} between 55 dB(A) and 60 dB(A). According to the noise maps, the Viktoriapark seems to be the loudest park of the considered Berlin parks (see Figure 2). Given that parks are mainly visited over the day, L_D noise maps were also calculated, yielding identical park rankings. A noise prognosis for the year 2030 using a slightly higher amount of traffic volume would approximately lead to an increase of about 1 dB in average in the three parks. Table 1 shows a comparison between the measured L_{Aeq} (determined with a XL2 sound level meter) and the calculated L_{DEN} at the locations (at the respective measurement points). As can be noted that the measured L_{Aeq} was lower in Loc 1.1 and Loc 2 than the calculated L_{DEN}. This might indicate that the repeated measurements were not fully representative, either because of a reduced road and train traffic volume (perhaps as a result of COVID 19), or due to an interfering wind direction. This discrepancy could also result from neglecting the night noise exposure during the repeated measurements during the day. Interestingly Loc 1.2 and Loc 3 yielded L_{Aeq} values closer to the L_{DEN} values, perhaps due to the stronger impact of anthropogenic noise.

2.3 Procedure

A questionnaire was prepared including socio-demographic questions, questions regarding typical park activities and a translated version of the PRSS questionnaire [7]. In addition, ratings regarding the perceived affective quality according to the protocol from the ISO/TS 12913-2 [10] and the audibility of sound sources [10] were collected.
The participants had to indicated what of the three sound source categories (sounds of technology, sounds of nature, sounds of human beings) can be heard in the area and how dominant they are. Moreover, open questions regarding what visitors like or dislike about the park were considered. The questionnaire was filled out by paper and pen by participants in-situ and took approximately 10-15 minutes.

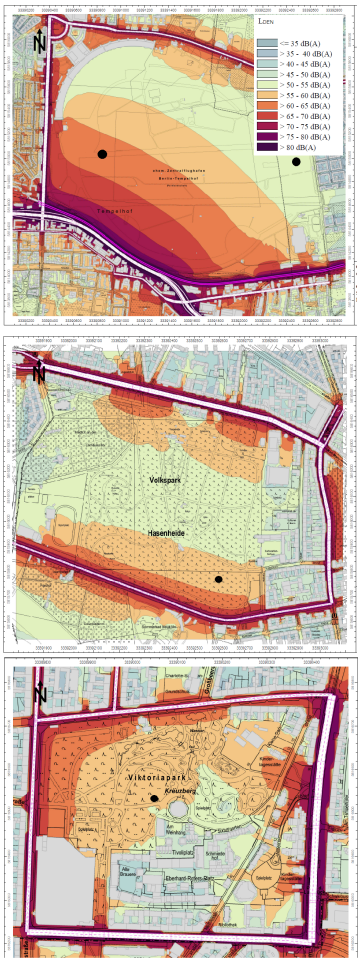

Figure 2. Noise maps of investigated Berlin parks showing L_{DEN} (all with the same color range, see top map) and the measurement points from table 1 (black dots). From top to bottom: Tempelhofer Feld (Loc 1), Volkspark Hasenheide (Loc 2), and Viktoriapark (Loc 3).

The questionnaire data was analyzed with IBM SPSS Statistics, MS Excel and Statgraphics Centurion. Correlation analyses based on the Spearman's rank correlation were conducted considering the ordinal questionnaire data as proposed in [13]. In addition, the PRSS data was subject to a factor analysis including the determination of reliability using Cronbach's α, KMO tests, and communalities.

3. RESULTS

The analysis of the free comments showed that traffic noise was repeatedly mentioned as most critical in all locations (see 4), however this was less frequently named in the smallest park (Loc 3). When comparing the positive (Figure 3) and negative free comments (Figure 4) in terms of word clouds, it is obvious that some sound sources appear in both clouds as they were ambiguously connoted.

For example, *music* was mostly negatively connoted, whereas *music* contributed in a more positive way to Hasenheide (Loc 2). As expected the majority of positive comments related to relaxation and restoration refer to biophonic (birds, dogs) and geophonic (wind, water sounds), whereas mechanical (sirens, traffic, construction noise) and certain anthropogenic sounds (loud people, screaming, children crying) were considered to be negative aspects of the park soundscape, in particular with respect to restoration.

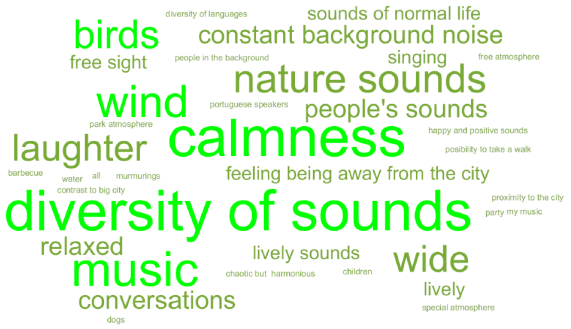

Figure 3. Word cloud: Positive aspects of soundscapes mentioned by participants (all parks).

Interestingly, comments with respect to the *diversity of sounds* as a positive contributor to the place were frequently mentioned, which indicates that silence is not necessarily the ultimate goal for certain types of restorative city places. According to Schafer this specific

Figure 4. Word cloud: Negative aspects of soundscapes mentioned by participants (all parks).

property, allowing to recognize and distinguish several sound sources, can be considered as an important element of an hi-fi soundscape [12].

Figure 5 shows that the perceived affective quality of the soundscape measured by the ISO/TS 12913-2 protocol is quite similar over all measurement points and locations respectively. Loc 2 was judged as being slightly more calm, i.e. less pleasant and less eventful and thus deviates a bit from the other locations.

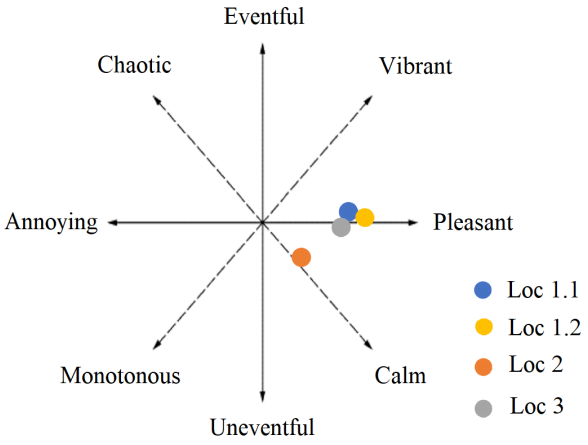

Figure 5. Perceived affective quality of the soundscape at each location according to ISO/TS 12913-3 [13].

Determining the respective values of the dimensions *fascination*, *being away*, *compatibility* and *extent* (FACE), the investigated areas do not differ considerably (see Figure 6). This is consistent with the results from the affective

quality ratings shown in Figure 5.

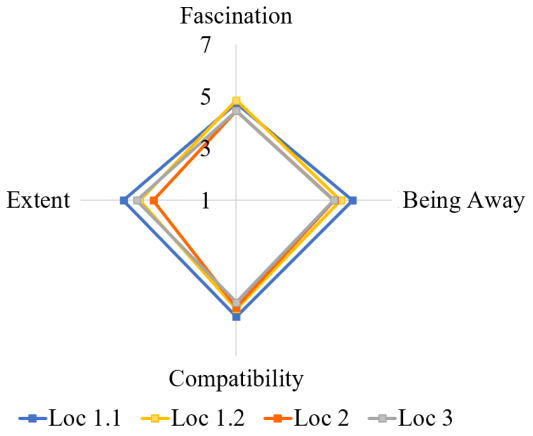

Figure 6. Average score of FACE dimensions based on PRSS questionnaire [7]. Scores range from 1 (completely disagree) to 7 (completely agree).

Table 2. Comparison of mean values (arithmetic) of the audibility ratings of sound sources (scores range from 1 (not at all) to 5 (dominates completely))

Source type	Loc 1.1	Loc 1.2	Loc 2	Loc 3
Traffic noise	2.4	2.0	3.0	2.3
Human sounds	2.9	4.1	3.5	3.5
Natural sounds	2.9	3.0	2.2	3.7

The resulting restoration scores as sum scores of the FACE dimensions show that Loc 1.1 (Tempelhofer Feld) was the location with the highest perceived restoration level, followed by Loc 3, Loc 1.2 and Loc 2. Location 2 showed the lowest perceived restoration level. The items 'pleasant' and 'vibrant' showed a significant positive correlation with the restoration level, whereas 'annoying' and 'monotonous' correlated negatively with the perceived restoration. Moreover, the ratings of the 'sounds from humans' audibility as well as the dimensions 'fascination' and 'natural sounds' correlates significantly with the 'restoration level'. Ratings of 'traffic noise' did not reach any statistically significant correlation with any FACE dimension or the restoration level.

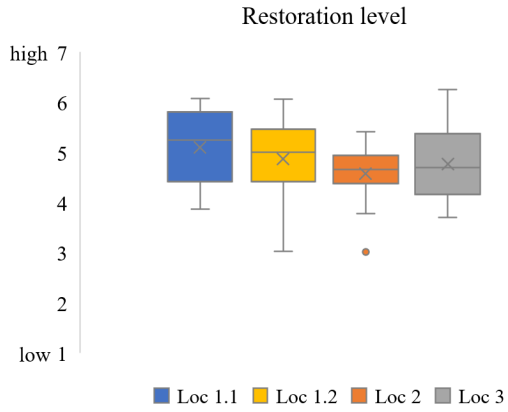

Figure 7. Restoration level as a sum score of the PRSS questionnaire data [7].

4. DISCUSSION

The study has shown that all three Berlin parks, although belonging to different categories according to the Berlin noise action plan, act as recreational areas possessing a certain level of restoration quality. In general, the park users' ratings regarding the soundscapes of the Berlin parks (i.e. the perceived affective quality and the restoration level) do not differ strongly. This emphasizes the general value of urban park areas, which might only to a certain extent be related to absolute requirements like L_{DEN} threshold values or minimum park sizes. This means that park size ranging here from 300 ha to only 12.8 ha does not seem to play a significant role for the perceived affective quality of the soundscape.

The location 2 results yielded a slightly lower perceived restoration level. Apparently, the perceived amount of traffic noise and the perceived relatively low amount of natural sounds led to a reduction of the restoration level (see Table 2). Moreover, anthropogenic noises do not seem to reduce the measured restoration level considerably in the investigated parks. A closer examination of the data from Tempelhofer Feld revealed that the level of restoration was almost equal at both measurement points (Loc 1.1 and Loc 1.2) relatively independent from the different level of human sounds.

A factor analysis of the questionnaire data suggested that the perceived restoration in parks is composed by four dimensions [14], which appear to be similar but were not identical to the PRSS dimensions reported in [6], [7]. For example, the being-away dimension related to the initial scales dispersed into two other dimensions. Thus, a 'new' dimension emerged with variables (scales) related to a factor which might be interpreted as 'personal/individual escape from routine'. Thus, this factor is a combination of being away and compatibility. This might be described as a dimension accounting for free-time aspects. Based on the Cronbach's alpha this new factor shows a good reliability.

All in all, due to the relative small sample sizes and the consideration of only three parks, the collected data provided some insights into the mechanisms of perceived restoration in city areas, but do not allow for a determination of causal relationships between the acoustic quality described by certain indicators and self-reported human responses towards the acoustic environment. Further investigations on larger scale must be performed to clarify in detail the links between acoustic (and non-acoustic) properties of city areas and resulting restoration capabilities.

5. CONCLUSIONS

The survey showed that the L_{Aeq} values in the parks lie in a similar range. A comparison with calculated noise maps illustrated the traffic noise exposure in the park, which was slightly higher than the L_{Aeq} values resulting from the acoustic measurements. The perceived affective quality and restoration level were similar for all three parks. Only location 2 (Hasenheide) was assessed in-situ slightly less restorative by the participants, although this location possessed a lower L_{Aeq} than location 1.2 (Tempelhofer Feld) and location 3 (Viktoriapark). This might be related to the stronger dominance of traffic noise and lower audibility of natural sounds (see Table 2), indicating the need of further acoustic indicators for valid evaluations of these areas.

All in all, the field study, although based on a relative small sample size, provided meaningful results, as the perceived affective quality items and the source ratings are linked to the FACE dimensions in a plausible way. These outcomes underline the importance of urban parks for recreational and restorative purposes, even if they are comparatively small and not particularly quiet.

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