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Subtypes of Park Use and Self-Reported Psychological Benefits Among Older Adults: A Multilevel Latent Class Analysis Approach

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Abstract

Healthy aging is a global health priority. Urban parks and green space have been demonstrated to provide mental health benefits to older adults. Despite growing interest in prescribing nature and park visits by physicians, we do not know what type of park visit is most effective for the psychological benefits. This lack of knowledge prevents planners and designers from making informed decisions to promote mental health. We collected field data from 200 visitors from 15 different parks in Shanghai, China. The participants completed pre-visit and post-visit surveys, wearing a GPS and a pedometer while visiting the park. A multilevel latent class analysis (LCA) yielded a three-class structure of park use patterns: the active park lingerer, the active walker, and the passive scanner. Paired-sample t-test and ANCOVA tests showed that affective states (i.e., anxiety, depression, relaxation, contention) were enhanced after park visits for all subtypes. However, the active park lingerer displayed significantly higher levels of relaxation and contention, compared to the active walker and the passive scanner. The findings offer insights into park design characteristics that could promote the mental health of older adults.

Keywords

Older adults; patterns of park use; duration of visit; psychological benefits

1. Introduction

The world's population is aging: by 2050, the population aged 60 years or over is projected to double and reach 22% of the total population (World Health Organization, 2018). Older adults are more vulnerable to mental health issues, as these issues often coincide with other diseases or life events that occur as people age. Worldwide, approximately 15% of adults over 60 years old suffer from a mental or neurological disorder, such as depression, anxiety, and mood disorder (World Health Organization, 2017). As society begins to pay attention to

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healthy aging, research in the past decade has highlighted the significance of the built environment in older adults' health and well-being (Frank, Kerr, Rosenberg, & King, 2010; Iwarsson et al., 2007; Rodiek, 2013).

Globally, there is increasing concern over the mental well-being of older adults. With a growing interest in identifying cost-effective and accessible ways to impact senior people's mental health, recent research has demonstrated the benefits of exposure to nature (Wolf & Housley, 2016). Two theoretical frameworks explain the mechanisms of the mental health benefits of nature: attention restoration theory (ART) and stress reduction theory (SRT). ART states that directed attention, which is critical to higher-level cognitive functioning, becomes fatigued with prolonged use. Nature, as a form of soft fascination, can help restore this mechanism (Berman, Jonides, & Kaplan, 2008; Kaplan, 1995). Relatedly, SRT posits that humans respond positively to natural environments as evidenced by changes in their emotional states and physiological markers (Ulrich et al., 1991).

Empirical evidence based on these theories has indicated that older adults report enhanced cognitive capabilities and experience recovery of stress during activities in nature. It has been observed that older adults who spend time in an outdoor garden have significantly lower cortisol levels (Rodiek, 2002). Also, the recreational use of parks has been associated with the physiological and psychological health of older adults (Orsega-Smith, Mowen, Payne, & Godbey, 2004). In studies with middle-aged and older participants, hostility and depression levels decreased significantly after participation in forest bathing, and the effects existed across groups with different physical activity levels (Morita et al., 2007). For middle-aged and older adults, when their residential proximity to the nearest park increased, the odds of depressive symptoms increased (Reklaitiene et al., 2014).

Based on these findings, public health providers have advocated for prescribing nature as an alternative to other preventive and treatment options for promoting mental health (Charles, 2017; Jordan, 2015). A pioneering study evaluated park prescriptions in formal recommendations made by physicians and established screening and assessment protocols (Razani et al., 2016). However, many details regarding the optimal nature exposure are unknown (Frumkin, 2013; Sullivan, Frumkin, Jackson, & Chang, 2014), which hinder the application and evaluation of park prescriptions.

An unspecified park prescription may not guarantee the benefits because the types of park environments and the subjective experiences derived from these environments may differ among individuals (Sang, Knez, Gunnarsson, & Hedblom, 2016). The design characteristics and the spatial configurations of different environments vary significantly among parks. Most research on nature and health examine binary categories (nature versus urban), with urban parks and green space classified as nature, although several researchers have called for attention beyond the nature versus urban dichotomy. However, a closer look at urban parks reveals that they vary considerably regarding conditions such as total area of trees, shrubs, and ground vegetation, as well as in the lengths of available paths and trails. According to Gibson's affordances theory, different design characteristics and spatial arrangements lead to different possibilities for actions, which are recognized by people through perceiving the affordances of the objects or events entailed by the environment (E. J. Gibson, 2000; J. J.

Gibson, 1979). Empirical evidence also suggests that there are key interconnections between environmental affordances in green space and participants' preferences for each scene (Hadavi, Kaplan, & Hunter, 2015).

Research has demonstrated the comparative importance of different features of open space in influencing older people's recreational walking, life satisfaction, and other aspects of positive environment-behavior interaction and health (Sugiyama & Thompson, 2008; Sugiyama, Thompson, & Alves, 2009; Thompson, Aspinall, & Bell, 2010). An emerging approach that is particularly relevant to studying the comparative importance of environmental attributes in influencing older people's place-based preferences is choice-based conjoint analysis (CBC) (Alves et al., 2008; P Aspinall, 2010; PA Aspinall et al., 2005). Compared to traditional methods, CBC allows respondents to make choices of combinations of environmental attributes for given scenarios, and therefore better represent the kind of choices made in real world settings (Alves et al., 2008; P Aspinall, 2010; Thompson et al., 2010). Studies exploring older people's preferences for, and choices of neighborhood open spaces have revealed several critical environmental factors: free of nuisances, presence of facilities and utilities, and abundance of trees and plants (P. A. Aspinall et al., 2010). Another study conducted in Norway showed that factors related to grass, trees and other people were most influential on park choices for participants across ages. However, for older adults, the presence of flowers and water were much more important (Nordh, Alalouch, & Hartig, 2011). Designs that reflect these environmental attribute preferences can have an enormous influence on the behavioral patterns and health outcomes of older adults.

Even within the same park, some visitors may be attracted to one area and derive joyful a experience, while other visitors may be indifferent or feel an opposite way about the same area (J. Finlay, Franke, McKay, & Sims-Gould, 2015). Researchers increasingly have embraced the idea that the salutary effects of nature only come into effect when people view and interact with them in certain ways (Conradson, 2005; J. M. Finlay, 2018). The space itself does not guarantee a positive health outcome; rather, it is the "transaction" between people and their environment that eventually becomes therapeutic (Conradson, 2005; J. M. Finlay, 2018). However, we know little about how the types of park visit, especially the duration of activity in different park zones, influences the restorative experience. As such, the definition of an effective nature visit remains unspecified, which hinders the translation of the theory into an operational framework. Filling this knowledge gap would also help public health practitioners fine-tune their prescriptions of nature to include instructions for the types of green space and the duration of the visits.

The development of GPS tracking and spatial analysis offers vast potential in filling these gaps. To our knowledge, no study has examined the extent to which the actual trajectories and activity patterns of older adults in parks are related to the effects of stress recovery and mood enhancement. Previous studies have used the public participation geographic information system (PPGIS) to explore the importance of urban green space and parks to communities (Gregory Brown, 2008; Hawthorne et al., 2006), activities in which visitors participate, and the different physical activity and non-physical benefits that different types of parks offer (Gregory Brown, 2008; Greg Brown, Schebella, & Weber, 2014).

Investigations using PPGIS that scaled up from individual parks also found that urban dwellers use both medium-quality parks that are close by and high-quality parks that are farther away (Bijker & Sijtsma, 2017). However, to our knowledge, no study using PPGIS or other forms of GPS tracking has scaled down to various park zones (e.g., lawn, water body, plaza, vegetated areas) and examined older adults' activity in these zones. The scale of sub-park zones is of particular interest to urban and landscape designers, especially in the context of public health.

The aim of this study is to answer questions regarding older adults' activity patterns in parks, especially the duration of activity in different park zones and their self-reported stress recovery. We used continuous GPS tracking to record the duration of stay in different park zones and to identify latent subgroups of park use patterns. Then, we examined the extent to which the effects of stress recovery associated with park visits varied among the different subgroups of users. We answer three specific questions:

Q1. What are the subgroups of older park users based on duration of activities in different environments and total physical activity?

Q2. Do all types of park users experience stress recovery and positive affective states after their visits to parks?

Q3. To what extent does the psychological benefits derived from park visit differ across subgroups of park users?

2. Methods

2.1 Sites and Participants

To maximize the variations in environmental conditions and demographic characteristics of the nearby neighborhood, 15 mid-sized parks in Shanghai, China were studied (Figure 1). The population age structure is shifting rapidly in China, exacerbated by the one-child family policy, while health care capacities are limited. Shanghai is the fastest aging city in China: the percent of total population aged 60 years old and over was 22% in 2009 and predicted to rise to 40% by 2030 (SCDC, 2012). Over the 10-year period between 2000 and 2011, the Shanghai metropolitan area witnessed an increased total green space of 37.1 km² and an increased green space per capita of 13.1 m² (Bureau, 2011). Due to high density living environments, urban parks serve as primary destinations for residents' recreational activities. Research found that access to parks in urban Shanghai was better than in the city's peripheral areas. As such, disadvantaged groups, such as low-income groups in the center, actually enjoyed better access than the wealthier communities (Xiao, Wang, Li, & Tang, 2017).

We selected each park based on the criteria: the park had an average area between 1 ha and 10 ha (Table 1), was easily accessible from primary and secondary roads, and was considered to primarily serve local residents' recreational and exercise purposes. The average percentage of hard surface was 13% (SD = 6%), while the percentage of tree cover

was 49% (SD= 10%). Twelve of the 15 parks had water bodies, and the average percentage of waterscape cover was 4% (SD = 3%). Figure 2 shows the plans for the selected parks.

Participants were recruited on site. Researchers were stationed at the main entrances or the most frequently used park entrances, and older adults were invited to participate in the study as they entered the parks. The inclusion criteria included 1) aged 60 or older; 2) no difficulty walking and did not use walking aids; 3) planned to use the park for recreational purposes instead of only passing through.

Initially, 257 older adults were included in the study. We excluded from the study those who did not complete their visit, returned with the devices off, and whose self-reported park use was inconsistent with the GPS and pedometer records. Among the 257 initial participants, 234 (91%) returned with valid post-visit surveys. Among these 234 participants, only 200 (78%) had consistent and valid GPS and pedometer records. Thus, we used the data provided by 200 participants for the analysis. The included and excluded groups did not show statistically significant differences in their pre-visit anxiety, depression, relaxation, or content measures.

2.2 Research Procedure

The data were collected on sunny or cloudy weekdays during three weeks in October, 2017; daily temperatures ranged from 17 °C to 26 °C. We collected park users' trajectories with an easy-to-use GPS device, coupled with recall questions after the visit. This approach is particularly well suited for research with older adults compared with other approaches of PPGIS mapping and participatory data collection. PPGIS usually requires participants to accurately recall and locate specific places of interest, and it often involves smartphone apps and online surveys (Greg Brown, 2012; Ertiö, 2015), which may be particularly challenging for older adults who may have some level of memory loss and are less technology savvy.

Each participant wore an Yamax Power Walker EX-510 pedometer to record total steps and a Meitrack MT90 GPS device for continuous recordings of the geolocations at a temporal resolution of ten seconds. After that, participants were instructed to use the parks as they would normally do, spend whatever time they wanted, engage in any activities they would like, and return to us when they were ready to leave the parks. In the case that the participant planned to leave from a different park entrance, we arranged a researcher to meet him/her at the entrance of his/her choosing.

At the baseline (pre-visit) survey, the questionnaire included questions about the respondent's age, gender, income, marital status, weight height, perceived general health, stress and affective states. At the second (post-visit) survey, the questionnaire included the same sets of questions on stress and affects, along with a few park activity recall items for triangulation. The study received approval from the Research Ethics Committee of [name of university removed for double-blind review] University.

2.3 Measures

Typology of park activity—Previous reviews called for critical investigations of the density of nature and the duration of nature exposure as related to health benefits (Sullivan et

al., 2014). Therefore, we focused on the durations of stay in various types of environments and total steps taken in the parks to represent park-use patterns. Activity location and duration were developed based on the primary types of environments in the parks and how long the participants stayed in the seven types of environments, i.e., hard surface, lawn, tree cover, water, path/trail, children's playground, and designated fitness area. First, plans and land cover survey maps of the parks in CAD format were obtained from Shanghai's local green space management bureaus and park administration. The maps were edited manually when the actual conditions differed from the official datasets. Second, we converted the maps into shapefiles and imported them into R as spatial data frames. GPS locations of participants were also uploaded and imported into R. Third, using R packages, the number of GPS points falling into each type of environment, or in the case of water, within 20 meters of the water, and the total time duration were calculated. Figure 3 shows examples of the participants' trajectories.

Variables were categorized for latent class analysis. For time on hard surface, lawn, under tree cover, in water and on the trail, the categories were 0 to 5 minutes, 5.1 to 15 minutes, 15.1 to 30 minutes, and more than 30.1 minutes. Since only a fraction of the parks had children's playground and fitness areas, the final two environmental variables were coded as dichotomous ones, i.e., visited or not visited.

In addition, the total steps for each participant was recorded during the park visit using a Yamax Power Walker EX-510 pedometer (Yamax Corp., Tokyo, Japan), which shows high accuracy in step counts (Cruz, Brooks, & Marques, 2016). Existing research has proven the validity and accuracy of pedometers in measuring physical activity (Tudor-Locke, Williams, Reis, & Pluto, 2002, 2004) and for older adults in particular (Webber, Magill, Schafer, & Wilson, 2014).

Self-reported pre- and post-visit stress and affect—We used the Visual Analogue Scale (VAS) to measure self-reported pre-visit and post-visit affective states, i.e., anxiety, depression, relaxation and contentment. The VAS has been used extensively as a reliable measurement of subjective well-being (Bond & Lader, 1974; Monk, 1989), and is especially sensitive to fluctuations in mood and stress (Cella & Perry, 1986). In previous studies involving the VAS, researchers measured calmness, elatedness, stress, anxiety, depression, and avoidance, along with a variety of mood indicators (Childs & De Wit, 2006; Jiang, Li, Larsen, & Sullivan, 2016). The VAS consists of a 100-mm horizontal line with the anchors “not at all” (0 mm) on the left, and “extremely” (100 mm) on the right. To measure anxiety, for instance, we asked the question, “How anxious do you feel right now?” Participants placed a mark (“|”) on each line indicating the degree of anxiety they felt at that moment. The marked values were measured and scaled to 0–10, with 0 being least anxious and 10 being most anxious.

2.4 Statistical Analysis

Data preparation and statistical analysis were conducted using R and Mplus (Muthén, 1998). Latent class analysis (LCA) was used to detect groups of senior park users with different patterns of behavior in the parks and to understand the groups' characteristics. The variables

used in the models include time spent on hard surface, lawn, under tree cover, in water, on the trail, in children's play areas, and in fitness areas, as well as total steps in the park. LCA has been widely used to model the underlying latent subgroups within a population. However, a critical assumption of the traditional LCA is that observations are independent of each other. Since the participants were drawn from 15 different parks, the data displayed a clustered structure of individuals nested within parks. To allow for the probability of class membership to vary across parks, we also used the multilevel latent class analysis method developed by Henry and Muthén (2010).

We tested a series of traditional (fixed structure) LCA models with latent class counts from one to five sequentially. The model was selected based on four groups of criteria (Table 2), i.e., (1) Bayesian information criteria (BIC) and sample-size adjusted BIC, which are indicators of model fit; (2) standardized entropy, which is a measure of classification certainty; (3) Lo-Mendell-Rubin Adjusted LRT Test (LMR LRT) and bootstrapped likelihood ratio test (Bootstrap LRT) for the current model (n class) versus the previous model (n-1 classes); and (4) whether the model entails substantive interpretability and theoretical meaning. The 3-class, 4-class, and 5-class solutions demonstrated small BIC and adjusted BIC values, but when we used LMR LRT, the 4-class and 5-class models did not display a better fit than the previous models. In addition, the 3-class model provided substantive interpretability of park behavior. Therefore, we selected the 3-class solution as the best model.

Based on the 3-class model we selected, we added a random effect to the fixed model to allow the latent class intercepts to vary across different parks. In some parks there may be a larger probability that an individual will belong to a specific latent class compared to the other parks. The AIC and BIC increased slightly while the entropy improved slightly from the fixed model. In addition, the variances were statistically significant, indicating that different parks indeed vary in their probability that a visitor belongs to a certain class. Based on this final model, we examined the characteristics of each class. We then investigated the probability of individuals in each class spending a certain amount of time in each type of environment.

After fitting the model, we assigned subjects to the latent classes based on posterior probabilities and explored the extent to which individuals who engaged in different patterns of park use differed in psychological benefits after their park visits. A paired sample T-test was used to examine whether the different classes displayed significantly better affect states after the park visit. ANCOVA models were used to compare the pre-visit VAS across the classes. Pre-visit VAS scores were used as the covariates of each model. Levene's test and normality checks were conducted. Based on the ANCOVA results, post-hoc comparisons with LSD were used to examine the pairwise differences across the classes.

3. Results

3.1 Descriptive Statistics

Table 3 presents the descriptive statistics for all variables used in the analyses. The average age of participants was approximately 70. Of the 200 participants, 53% were males and 75%

were married. About half of the participants fell within the 5,000 to 10,000 RMB (~\$700 to \$1,400) per month income bracket, and about 20% earned more than 10,000 RMB per month.

Among the participants, 20% reported that their health was good, and 55% said it was fair. Approximately 65% of the participants visited a park almost every day. The average total steps in the park were 2437, with a minimum of 158 and a maximum of 10,320.

3.2 Can we identify subgroups of older park users based on durations of activities in different environments?

To answer this question, we conducted a multilevel parametric latent class analysis (LCA) to test different class structures. The final selected 3-class model identifies three subtypes of activity patterns displayed by older park users, which we refer to as the active park lingerer, the active walker, and the passive scanner (Table 4).

The active park lingerer.—This subgroup constituted 29.4% of the population. This subgroup spent a lot of time under tree cover, on trails and plazas, and some time on lawns. The majority of them completed more than 1000 steps and a number of them reported more than 5000 steps. Given an individual belonged to this group, the probabilities of him/her staying under tree cover and on trails for more than 30 minutes were 100% and 68%, respectively. A visual examination of the GPS tracks showed that they tended to linger in areas with good vegetation cover, and also walked along trails and paths.

The active walker.—This subgroup constituted 48.9% of the population. Although this group was similar to the first group regarding total steps, they spent much less time on the lawn or close to the water. The majority showed more than 1000 steps, and the percentage of participants with more than 3000 steps is similar to that of the first subgroup. However, they barely used the lawn or the water. For an individual in this group, the probability of her/him spending more than 30 minutes under tree cover was only 15%. There is a large probability that he/she will spend between 5 and 15 minutes on the trail. A visual inspection of the GPS tracks showed that this group tended to use specific park paths/trails for walking (often multiple loops) and did not visit the other areas much.

The inactive scanner.—This subgroup constituted 21.6% of the sample. Participants in this group took fewer steps and did not spend a considerable amount of time in any environment. For an individual in this group, he/she has a large probability of using plazas, lawn, vegetated areas, and trails for less than five minutes. He or she also displays a low probability of going to a children's playground or fitness area. The GPS tracks showed that this subgroup visited some park areas and left without lingering or repeating the same paths.

Descriptive statistics of the actual activities and durations of stay of the three sub-types (Table 5) revealed that the mean durations of stay for the active lingerer, the active walker, and the passive scanner were about 68 min, 46 min, and 21 min, respectively. The mean step counts of the lingerer and walker were around 2500, whereas the passive scanner had a mean step count of 1373. Compared to the lingerer and the walker, the scanner spent the least total time in all types of environments, except by the water.

3.2 Do All Types of Park Users Experience Lower Stress and Better Affective States After Park Visits?

To answer this question, we conducted a paired sample T-test to examine the differences in affective states before and after the visits (Table 6). When the entire sample was considered, we saw significant lower anxiety ($t = -3.75, p = 0.000$), depression ($t = -2.96, p = 0.004$), higher relaxation ($t = 4.89, p = 0.000$), and contentment ($t = 4.20, p = 0.000$) after the park visit. After conducting the tests by class, we found that most comparisons were still either significant or marginally significant, with the exception of changes in depression and relaxation for the active walkers (class 2) and a decrease in anxiety for the inactive scanners (class 3).

3.3 To what extent does the psychological benefits derived from park visit differ across subgroups of park users?

We conducted four ANCOVA models to examine the relationships between subclasses of the park use pattern and stress recovery after park visits. The means and standard errors of VAS measures are displayed in Figure 4, and the ANCOVA results are shown in Table 7. The level of post-visit anxiety did not differ significantly across user groups ($F = 1.87, p > 0.05$), after adjusting for pre-visit anxiety (Model 1). Similarly, the level of post-visit depression displayed no significant difference across user groups ($F = 0.61, p > 0.05$) (Model 2). Regarding relaxation, the results showed significant group differences in post-visit levels of relaxation ($F = 3.09, p = 0.048$) (Model 3). Post-hoc comparisons (Table 8) showed that the active park lingerers (class 1) displayed significant higher relaxation levels than the active walkers (class 2) ($MD = 0.65, p = 0.022$). For the level of contentment, there were marginally significant differences in the post-visit level (Model 4) ($F = 2.56, p = 0.080$), and the differences also existed between the active park lingerers and the active walkers ($MD = 0.53, p = 0.044$).

4. Discussion

This study confirmed that, for older adults, visiting a park for recreational purposes is associated with significant stress reduction and mood enhancement. Furthermore, older users of parks generally reported being more relaxed, more content, and less anxious or depressed after visiting the parks. These findings were in agreement with previous studies that investigated the psychological benefits of nature visits (J. Barton, Hine, & Pretty, 2009; Perkins, Searight, & Ratwik, 2011). Recent literature has focused mostly on neighborhood greenness and residents' mental health (Alcock, White, Wheeler, Fleming, & Depledge, 2014; Carter & Horwitz, 2014; Vogt et al., 2015).

Our analysis identified three distinct latent classes of park use typology in older adults in China: the active park lingerer, the active walker, and the inactive scanner. Although there is no previous body of research regarding latent subgroups of actual park use typology, our results generally are in agreement with previous research regarding the heterogeneity in park and green space preferences. For example, research identified three classes of trail preferences based on the physical and social environments (Arnberger, Aikoh, Eder, Shoji, & Mieno, 2010). By comparing older people's preference among different types of park

space and affordance, research classified older park users into four segments using types of parks, accessibility to parks, and facilities and affordances (Kemperman & Timmermans, 2006). Another article used three class segments to represent the user preferences and patterns of park visits (Veitch et al., 2017).

A major contribution of this research is that the activity subclasses were identified based on objective measures of an individual's actual activity patterns within the park. We used GPS tracking to accurately determine a person's duration of stay in the different types of environments. Compared to previous research investigating preference at the between-park level, this approach captures fine-scaled characteristics of the activities and the comparative importance of different park zones.

In addition to identifying the class segments, we tested the pre- and post-visit affect states of the groups. The findings suggest that the overall sample displayed significant stress recovery after the park visit, but the specific dimension of mood affected and the magnitude differed across the classes. In comparing the two active groups, the active park lingerers displayed significantly higher levels of relaxation and contentment than the active walkers. One explanation is related to the overall longer duration of stay in the parks of the lingerer group, as literature has pointed to the associations between duration of stay and restorative benefits received from nature exposure (Hansmann, Hug, & Seeland, 2007; White, Pahl, Ashbullby, Herbert, & Depledge, 2013). However, the scanners which had even shorter durations of visit did not display significantly lower restorative effects than the lingerer. It may be that the dose-response relationship between duration and the restorative benefits is not linear. For example, a meta-analysis of multiple studies suggested the greatest benefits of green exercise was obtained for 5 min of activity, and the benefits actually decreased between 10 and 60 minutes (Jo Barton & Pretty, 2010). However, these studies differed from the current study in that the participants engaged in designated types of green exercises, such as farming. Also, they used mostly green space in the countryside, such as forests, woodland and wild habitats, whereas our study tested the duration of the stays in different park zones of the participants' choosing. Another explanation is that the walkers might be more motivated to do exercise than the lingerers and scanners, which may prevent them from fully engaging the natural environment and relax. The motivation of conducting leisure opportunities, especially whether the activity is driven by serious or causal leisure (Csikszentmihalyi & LeFevre, 1989; Mannell, Zuzanek, & Larson, 1988), also influences the perceptions and the benefits derived from it, which may explain why those who were committed to exercising showed different affects.

Since exposure to nature suggests a cost-effective method of enhancing the mental health of older adults, this study provides important information for public health providers and urban and landscape designers. Since older adults who lingered longer in parks showed significantly higher positive moods and lower negative moods across all four measures (whereas the other two groups only received partial benefits), it may be helpful for health providers to encourage older adults to stay and engage the environments in parks, rather than get the exercise and leave, as they prescribe nature walks to counter mental distress and negative moods.

For environmental planners and urban designers, this study pointed at possible design strategies and calls for evidence-based plan evaluation approaches (Horney, Dwyer, Vendrell-Velez, & Newman, 2019) that improves community health. First, older adults displayed different activity patterns in parks, which requires diversified type of environments and affordances. Second, those who walked but did not linger received less mental health benefits from their visits, which suggests that parks should contain elements that grab and hold people's attention and invite them to linger around. For example, enlarging areas with vegetation and providing spacious rest areas with sufficient seating, shade, and visibility may encourage users to spend more time in vegetated areas.

This study is one of the first to examine the typologies of patterns of older adults' use of parks and to link mental health benefits with these patterns. However, this study has several limitations. First, our aim was to identify the latent classes based on the activity duration in different types of park environments and the number of steps and examine whether the psychological benefits differed based on the subtypes. The LCA models used all variables simultaneously to establish class structure, and class memberships were associated with different effects. Therefore, we were not able to parse out the effect sizes of individual variables such as duration. We were also not able to take into account many factors that also help define older adults' park use patterns, such as social interactions in parks. Studies have highlighted how green space may promote residents' mental health through the mechanism of social interaction (Van den Berg, Maas, Verheij, & Groenewegen, 2010). In recent literature, it has been reported that the relationship between greenness and mental health was partly accounted for by social coherence (Sugiyama, Leslie, Giles-Corti, & Owen, 2008). Furthermore, our study did not measure attention restoration or the perceived restorative qualities of the environment for older adults. Compared to young adults, older adults typically show decreases in different attention mechanisms (Commodari & Guarnera, 2008; Fortenbaugh et al., 2015) and sometimes suffer from diseases such as dementia. Studies have identified differences in the restorative experiences of people at different life stages (Scopelliti & Giuliani, 2004; Scopelliti & Giuliani, 2006). For the most part, the literature examines the environmental characteristics that are restorative for adults. Older adults' attention restoration in urban parks and neighborhood green space has been understudied. Studies with a life-long approach (Miller, 2008; Scopelliti & Giuliani, 2004) or focusing specifically on older adults' psychological states in open spaces, are warranted. In addition, as we focused on the design characteristics of parks, we did not take into consideration the characteristics of the visitors to the parks, the purposes of their visits, or their preferences as variables in the latent class analysis. We also did not consider the social aspect of visitor groups and the benefits of park visits for minority groups, which has been demonstrated in previous research (Stodolska, Shinew, Acevedo, & Izenstark, 2011).

A second limitation is that the participants' physical health and ability level was not assessed. We made sure that our participants did not have physical challenges in walking or require mobility aids, but some participants may be closer to needing mobility aids than others, and some may have conditions that prevent them from staying in the park for prolonged periods. Future studies may investigate how age, physical health and ability of older adults influence their park use patterns and the psychological benefits they derive from visits.

A third limitation is the small sample size and the limited geographic context. Although we used 15 different parks that are popular and representative of small and medium sized parks in central Shanghai, we acknowledge that the patterns we identified may not be applicable to smaller cities, suburbs, or rural areas in China or to park users in Western countries. Due to the unique high-density apartment living conditions and recreational needs, community and urban parks may be more important for older adults' physical and mental health in China, compared to the West. Future studies that expand the geographic context and compare older adults' park use patterns across different cultures may provide more insights.

A final limitation is the observational nature of this study. Although we obtained pre- and post- measures from participants and found significant affect enhancement, we were not able to establish causal links between park use patterns and the magnitude of stress recovery. It is entirely possible that people who belonged to the different subclasses had other differences that led to different levels of stress recovery after their visits. Also, similar to other cross-sectional studies examining the environment-behavior interaction, this study is subject to selective bias, which refers to the phenomena that people self-select into certain residential neighborhoods ("selective residential bias") or visit places of certain characteristics ("selective daily mobility") with prior preferences or intended activities. This study serves as a first exploration in the area of park activity patterns and mental health benefits. Future studies could build on the findings and design quasi-experimental designs controlling for more factors to clarify these relationships. Studies that test multiple links among the sub-park level environments, activity patterns, subjective evaluations, and mental health outcomes also would enhance our ability to advocate for park design guidelines that would provide maximal mental and physical benefits.

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Appendix

Appendix 1.

Full model results of the selected final 2-Level 3-Class model

Measures	Class 1			Class 2			Class 3		
	Estimate	SE	Estimate/ES	Estimate	SE	Estimate/ES	Estimate	SE	Estimate/ES
Plaza									
<5 Min	-2.439	0.824	-2.961 **	0.189	0.247	0.765	2.413	0.591	4.084 ***
5 –15 Min	-0.468	0.337	-1.389	1.503	0.319	4.706 ***	15	0	NA
15 –30 Min	0.317	0.355	0.894	3.772	0.717	5.259 ***	15	0	NA
Lawn									
<5 Min	0.315	0.289	1.092	2.697	0.538	5.018 ***	3.026	0.766	3.951 ***
5 –15 Min	1.535	0.352	4.364 ***	4.116	1.088	3.783 ***	3.744	1.041	3.596 ***

Measures	Class 1			Class 2			Class 3		
	Estimate	SE	Estimate/ES	Estimate	SE	Estimate/ES	Estimate	SE	Estimate/ES
15–30 Min	2.377	0.447	5.32 ^{***}	15	0	NA	3.744	1.041	3.596 ^{***}
Tree cover									
<5 Min	−15	0	NA	−13.811	0.308	−44.847 ^{***}	1.774	1.099	1.614
5–15 Min	−15	0	NA	0.032	0.322	0.099	12.74	2.12	6.011 ^{***}
15–30 Min	−10.558	4.266	−2.475 [*]	1.697	0.577	2.941 ^{**}	15	0	NA
Trail									
<5 Min	−15	0	999 ^{***}	−1.819	0.511	−3.562 ^{***}	1.839	0.485	3.789 ^{***}
5–15 Min	−2.376	1.171	−2.028 [*]	1.349	0.281	4.799 ^{***}	15	0	NA
15–30 Min	−0.764	0.45	−1.696 ⁺	2.952	0.518	5.694 ^{***}	15	0	NA
Steps									
<5 Min	−1.389	0.365	−3.804 ^{***}	−1.956	0.376	−5.2 ^{***}	−0.677	0.412	−1.642
5–15 Min	0.474	0.291	1.632	0.611	0.23	2.656 ^{**}	2.167	0.612	3.54 ^{***}
15–30 Min	2.06	0.476	4.324 ^{***}	2.675	0.501	5.337 ^{***}	2.608	0.653	3.994 ^{***}
Water									
<5 Min	1.85	0.432	4.283 ^{***}	4.571	1.015	4.502 ^{***}	15	0	NA
5–15 Min	3.347	0.741	4.516 ^{***}	15	0	NA	15	0	NA
Children area									
No	0.853	0.308	2.764 ^{**}	0.853	0.247	3.46 ^{***}	2.237	0.543	4.124 ^{***}
Fitness area									
No	−0.476	0.308	−1.545	0.185	0.258	0.718	1.441	0.601	2.397 [*]
Means									
C#1	−3.734	0	NA						
C#2	0.108	0.445	0.243						
C#1 with C#2	−22.368	2.71	−8.254 ^{***}						
Variances									
C#1	46.928	18.61	2.522 [*]						
C#2	10.662	4.122	2.587 ^{**}						

⁺ p<.1,
^{*} p<.05,
^{**} p<.01,
^{***} p<.001

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Figure 1.
Locations of the fifteen parks that were selected in this study.

Figure 2.
Illustrative plans of selected parks showing the different park environments.

Figure 3.
Examples of participants' trajectories when visiting Guilin Park.

Figure 4.
A comparison of pre- and post-visit stress levels (anxiety, depression, relaxation, and content) by class of visitor

Table 1.

Statistics describing park size and type of environments of the 15 parks selected in this study

Size	Park Name	Total Area (ha)	Total Number of visitors 2015 ^I	Plaza Area (m ²)	Lawn Area (m ²)	Canopy Area (m ²)	Water Area (m ²)	Playground Area (m ²)	Outdoor Fitness Area (m ²)	Trail Length (m)
Total area < 3 ha	Songhe Park	1.6	712,604	329.81	0	8604.44	1009.33	0	847.07	925.41
	Liyuan Park	1.7	323,092	4161.42	5406.59	4874.42	0	0	0	533.27
	Huaihai Park	2.5	1,942,450	4168.10	1490.80	12644.80	0	0	0	1105.36
Total area 3–5 ha	Penglai Park	3.2	186,016	3041.00	0	18151.00	884.00	1326.00	1042.00	1620.92
	Minxing Park	3.2	834,982	2044.16	2347.81	18127.30	2121.67	388.67	308.50	1697.71
	Guilin Park	3.6	242,040	3239.94	2844.21	14997.58	1838.94	0	0	2332.86
	Caoxi Park	3.8	624,430	2647.29	3398.52	23344.81	1797.76	0	285.79	2434.01
	Sipingkeji Park	3.8	398,122	3065.33	4020.93	23671.69	0	150.38	1092.98	2296.15
	Douxiang Park	3.8	291,363	7519.48	2685.24	19049.07	1897.78	360.14	709.83	1791.14
	Jiangpu Park	3.8	1,228,734	4709.00	4321.00	18395.00	3328.00	0	626.00	1242.27
	Sichuanbeilu Park	4.5	10,723,216	4115.01	0	29699.96	915.03	0	0	2561.08
Total area 5–10 ha	Quyang Park	6.2	1,468,108	1915.00	7132.00	25661.00	7749.00	933.00	3405.00	2821.46
	Fuxing Park	6.5	7,515,059	5959.19	8229.77	22218.38	758.77	1480.94	0	3493.11
	Nanyuan Park	8.6	1,012,700	6820.69	4684.52	40920.41	2207.76	625.49	0	3120.56
	Xujiahui Park	8.9	12,157,350	4788.23	2837.21	42433.72	4762.96	146.35	1625.95	6048.12

^I Data Obtained from Shanghai Municipal Greening Administration, 2016 Report.

Table 2.

A comparison of the model fit statistics for each 1-level and 2-level model specification

		Log-likelihood	AIC	BIC	Adjusted BIC	LMR LRT	Bootstrap LRT	Entropy	Number of free parameters
1-Level Models	1-Class	-1418.81	2875.62	2938.29	2878.10				19
	2-class	-1287.40	2652.80	2781.43	2657.87	260.37***	-1418.81***	0.88	39
	3-class	-1237.99	2593.98	2788.58	2601.67	97.89*	-1287.40***	0.89	59
	4-class	-1211.84	2581.68	2842.24	2591.96	51.82	-1237.99***	0.91	79
	5-class	-1191.25	2580.50	2907.03	2593.39	40.78	-1211.84*	0.89	99
2-Level Models	2-Class	-1286.22	2652.44	2784.37	2657.65	262.82***		0.88	40
	3-Class	-1237.83	2599.67	2804.16	2607.74	92.76	-1284.63***	0.89	62
	4-Class	-1210.67	2591.33	2871.69	2602.40	40.98	-1231.34	0.91	85

* Significant at the 0.05 level

*** Significant at the 0.001 level

Table 3.

Descriptive statistics of variables included in the analyses

Variable	Mean	SD	Frequency	Percentage
Age	69.49	7.52		
Weight (kg)	63.23	10.26		
Height (cm)	163.79	8.47		
Gender				
Male			105.00	0.53
Female			83.00	0.42
Not reported			12.00	0.06
Single				
Single			36.00	0.18
Married			149.00	0.75
Not reported			15.00	0.08
Income (RMB)				
Below 1000			8.00	0.04
1000–3000			14.00	0.07
3000–5000			53.00	0.27
5000–10000			92.00	0.46
Above 10000			21.00	0.11
Not reported			12.00	0.05
Visit frequency				
Less than once per week			7.00	0.04
1–2 times per week			14.00	0.07
3–4 times per week			33.00	0.17
Almost every day			134.00	0.67
Not reported			12.00	0.05
Self-reported health				
Excellent			5.00	0.03
Very good			25.00	0.13
Good			39.00	0.20
Fair			109.00	0.55
Poor			10.00	0.05
Not reported			12.00	0.04
Time on plaza				
Less than 5 min			98.00	0.49
5–15 min			48.00	0.24
15–30 min			27.00	0.14
More than 30 min			27.00	0.14
Time on lawn				
Less than 5 min			167.00	0.84
5–15 min			20.00	0.10

Variable	Mean	SD	Frequency	Percentage
15–30 min			7.00	0.04
More than 30 min			6.00	0.03
Time under tree cover				
Less than 5 min			37.00	0.19
5–15 min			56.00	0.28
15–30 min			33.00	0.17
More than 30 min			74.00	0.37
Time close to water				
Less than 5 min			191.00	0.96
5–15 min			7.00	0.04
15–30 min			2.00	0.01
More than 30 min			0.00	0.00
Time on trail				
Less than 5 min			51.00	0.26
5–15 min			75.00	0.38
15–30 min			29.00	0.15
More than 30 min			45.00	0.23
Activity on playground				
No			149.00	0.75
Yes			51.00	0.26
Activity in outdoor fitness area				
No			111.00	0.56
Yes			89.00	0.45

Table 4.

LCA model results in probability scale demonstrating differences in activities in the various park environments

	Class 1: The active park lingerer (29.4%)	Class 2: The active walker (48.9%)	Class 3: The inactive scanner. (21.6%)
Plaza			
<5 Min	0.08	0.55	0.92
5 –15 Min	0.31	0.27	0.08
15 –30 Min	0.19	0.16	0.00
>30 Min	0.42	0.02	0.00
Lawn			
<5 Min	0.58	0.94	0.95
5 –15 Min	0.25	0.05	0.02
15 –30 Min	0.09	0.02	0.00
>30 Min	0.09	0.00	0.02
Tree			
<5 Min	0.00	0.00	0.85
5 –15 Min	0.00	0.51	0.15
15 –30 Min	0.00	0.34	0.00
>30 Min	1.00	0.15	0.00
Trail			
<5 Min	0.00	0.14	0.86
5 –15 Min	0.09	0.65	0.14
15 –30 Min	0.23	0.16	0.00
>30 Min	0.68	0.05	0.00
Step			
<1000	0.20	0.12	0.34
1000–3000	0.42	0.53	0.56
3000–5000	0.27	0.29	0.03
>5000	0.11	0.06	0.07
Water			
<5 Min	0.86	0.99	1.00
5 –15 Min	0.10	0.01	0.00
15 –30 Min	0.03	0.00	0.00
Children			
No Activity	0.70	0.70	0.90
Some Activity	0.30	0.30	0.10
Fitness			
No Activity	0.38	0.55	0.81
Some Activity	0.62	0.45	0.19

Table 5.

Descriptive statistics of the differences in activities in the various park environments of the three subgroups

		The Active Lingerer		The Active Walker		The Passive Scanner	
		Mean	SD	Mean	SD	Mean	SD
Duration of Stay	On Plazas	18.74	15.38	9.78	11.17	3.98	5.06
	On Lawns	5.39	7.84	2.60	5.10	1.45	3.38
	Under Tree	42.34	16.34	25.39	18.07	4.55	3.16
	On Trails	27.68	14.69	14.21	9.86	6.34	4.38
	By Water	2.00	2.68	0.94	1.31	1.29	2.34
	On Playgrounds	0.29	0.46	0.3	0.46	0.1	0.3
	In Fitness Areas	0.29	0.46	0.3	0.46	0.1	0.3
Total Visit Duration ^I		68.36	22.90	46.59	24.96	20.92	15.11
Total Number of Steps		2590.85	1698.50	2511.66	1428.56	1373.47	805.68
Number of Participants		58		101		41	

^ITotal visit duration accounts for the time spent in structures and all other areas

Table 6.

Means and SEs of the change of stress after park visits by class membership

		Mean Difference ^I	SE	df	CI (95%)	t
Anxiety						
	Full Sample	-0.28	0.08	180	(-0.43, -0.13)	-3.75***
	Class 1	-0.48	0.18	52	(-0.85, -0.11)	-2.63*
	Class 2	-0.25	0.10	91	(-0.44, -0.07)	-2.65**
	Class 3	-0.07	0.10	35	(-0.28, 0.14)	-.69
Depression						
	Full Sample	-0.20	0.07	179	(-0.34, -0.07)	-2.96**
	Class 1	-0.31	0.18	51	(-0.67, 0.05)	-1.72 ⁺
	Class 2	-0.13	0.08	90	(-0.29, 0.03)	-1.57
	Class 3	-0.24	0.09	36	(-0.44, -0.05)	-2.58*
Relaxation						
	Full Sample	0.81	0.17	182	(0.48, 1.13)	4.89***
	Class 1	1.15	0.28	53	(0.59, 1.70)	4.13***
	Class 2	0.34	0.23	92	(-0.12, 0.79)	1.47
	Class 3	1.51	0.40	35	(0.72, 2.31)	3.85***
Content						
	Full Sample	0.64	0.15	181	(0.34, 0.94)	4.20**
	Class 1	0.91	0.33	54	(0.25, 1.57)	2.77**
	Class 2	0.36	0.20	92	(-0.03, 0.76)	1.82 ⁺
	Class 3	0.96	0.28	33	(0.39, 1.52)	3.44**

^I Mean Difference is calculated as Post-visit score – pre-visit score.⁺ P<.1,

* p<.05,

** p<.01,

*** p<.001

Table 7.

Results of ANCOVA models predicting post-visit stress using class membership

	Model 1 - Anxiety			Model 2 - Depression			Model 3 - Relaxation			Model 4 - Content		
	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Corrected	33.45	11.15	25.77***	58.00	19.33	47.86***	98.35	32.78	12.24***	179.47	59.82	25.05***
Intercept	5.13	5.13	11.85***	1.92	1.92	4.75*	510.65	510.65	190.59***	400.65	400.65	167.73***
Pre-Visit ^I	32.63	32.63	75.39***	57.80	57.80	143.11***	87.22	87.22	32.55***	168.76	168.76	70.65***
Class	1.62	0.81	1.87	0.50	0.25	0.61	16.55	8.27	3.09*	12.21	6.10	2.56 ⁺
Error	76.61	0.43		71.09	0.40		479.61	2.68		425.18	2.39	
Total	150.94			161.05			12003.99			11524.26		
Corrected	110.06			129.08			577.96			604.65		

^IPre-visit VAS measure corresponds to the outcome of each model, e.g., the anxiety model uses pre-visit anxiety as the covariate; the depression model uses pre-visit depression as the covariate.

⁺P<.1,

*p<.05,

**p<.01,

***p<.001

Table 8.

Results of post-hoc comparisons between classes for the Relaxation and Content models

Relaxation				Content		
Comparison	Mean Difference	SE	CI	Mean Difference	SE	95% CI
Class 1 vs. Class 2	.65 [*]	.28	(.09, 1.20)	.53 [*]	.26	(.01, 1.05)
Class 2 vs. Class 3	-.53	.33	(-1.17, 0.12)	-.49	.31	(-1.10, 0.12)
Class 1 vs. Class 3	.12	.36	(-.58, 0.82)	.04	.34	(-.62, 0.71)

*
p<.05