Visitors' emotional expression in urban forest parks: What can we know about on-line facial images from the Social Networking Services?

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Urban forests can attract visitors by the function of well-being improvement, which can be evaluated by analyzing the big-data from the social networking services (SNS). In this study, 935 facial images of visitors to nine urban forest parks were screened and downloaded from check-in records in the SNS platform of Sina Micro-Blog at cities of Changchun, Harbin, and Shenyang in Northeast China. Images were recognized for facial expressions by FaceReader™ to read out eight emotional expressions: neutral, happy, sad, angry, surprised, scared, disgusted, and contempt. The number of images by women was larger than that by men. Compared to images from Changchun, those from Shenyang harbored higher neutral degree, which showed a positive relationship with the distance of forest park from downtown. In Changchun, the angry, surprised, and disgusted degrees decreased with the increase of distance of forest park from downtown, while the happy and disgusted degrees showed the same trend in Shenyang. In forest parks at city center and remote-rural areas, the neutral degree was positively correlated with the angry, surprised and contempt degrees but negatively correlated with the happy and disgusted degrees. In the sub-urban area the correlation of neutral with both surprised and disgusted degrees disappeared. Our study can be referred to by urban planning to evaluate the perceived well-being in urban forests through analyzing facial expressions of images from SNS.

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Subjects:

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Abstract

Urban forests can attract visitors by the function of well-being improvement, which can be evaluated by analyzing the big-data from the social networking services (SNS). In this study, 935 facial images of visitors to nine urban forest parks were screened and downloaded from check-in records in the SNS platform of Sina Micro-Blog at cities of Changchun, Harbin, and Shenyang in Northeast China. Images were recognized for facial expressions by FaceReader™ to read out eight emotional expressions: neutral, happy, sad, angry, surprised, scared, disgusted, and contempt. The number of images by women was larger than that by men. Compared to images from Changchun, those from Shenyang harbored higher neutral degree, which showed a positive relationship with the distance of forest park from downtown. In Changchun, the angry, surprised, and disgusted degrees decreased with the increase of distance of forest park from downtown, while the happy and disgusted degrees showed the same trend in Shenyang. In forest parks at city center and remote-rural areas, the neutral degree was positively correlated with the angry, surprised and contempt degrees but negatively correlated with the happy and disgusted degrees. In the sub-urban area the correlation of neutral with both surprised and disgusted degrees disappeared. Our study can be referred to by urban planning to evaluate the perceived well-being in urban forests through

analyzing facial expressions of images from SNS.

Keywords: Emotion; Trees; Stress restoration; Selfie; Ecosystem services

INTRODUCTION

Urbanization is accelerating worldwide. By 2050 the ratio of urban to world populations may reach 70-86% (*United Nations, 2012*). Rapid urbanization brings about not only economy and social developments, but also meanwhile negative impact on air quality, climate change, and local amenities (*Pronczuka and Surdub, 2008; Tomao et al., 2016*). For city dwellers, urbanization can have negative impact on mental health and individuals' life quality in the corresponding form of heart disease, depression and mental fatigue (*World Health Organization, 2010; Malan et al., 2012*). Urbanization can shape a geographical distribution of areas at different urbanization intensities along the regions of urban, sub-urban and remote-rural, which can result in different perceived responses (*Triguero-Mas et al., 2009; Carvalho-Ribeiro and Lovett, 2011; Erol et al., 2012; Casado-Arzuaga et al., 2013; Dou et al., 2017*). The greening space in a city plays a key role in improving mental well-being of the citizens due to the positive effect of natural experience on psychological and physiological symptoms (*Bratman et al., 2015*). Both evidence and political interest are increasing in benefitting public health through managing the natural enviornment (*European Commission, 2014; World Health Organization, 2016*). Currently the high-level urban planning is evaluated to fully motivate the positive effect of urban green space on both natural conservation and citizens' perception.

Urban forests are ahead of the global change 'response curve' among forest systems in the local region (*Carreiro and Tripler, 2005*). Urban forests account for one of the largest greening spaces in a city. In recent decades, the social and psychological functions of urban forests have drawn more and more attention in aspects of restoration, leisure, recreation and aesthetics (*Chen and Jim, 2010*). Researchers

54 from the Asian countries, especially Japan and Korea, dominated the field of psychological response to
55 urban forest experience (*Stigsdotter et al., 2017*). Numbers of Asian studies have indicated that to spend
56 some time in an urban forest can effectively reduce mental stress and decrease anxiety relative to the
57 participants' feelings before they stepped into the forest area (*Morita et al., 2007; Kim et al., 2009; Park*
58 *et al., 2011; Ochiai et al., 2015; Song et al., 2016; Chun et al., 2016*). This effect was concluded as the
59 term of "forest bathing", i.e. spending some time of walking, viewing, and breathing in the forest
60 atmosphere (*Li et al., 2007; Morita et al., 2007; Lee et al., 2009; Tsunetsugu et al. 2010*). Furthermore,
61 other set of studies revealed that participants felt mental restorative from forest bathing compared to that
62 from the time when participants were walking in an urban environment (*Park et al., 2007; 2009; 2011;*
63 *Lee et al., 2009; 2014; Song et al., 2013; 2014; 2015; Ochiai et al., 2015; Sonntag-Öström et al., 2015;*
64 *Sung et al., 2012; Bratman et al., 2015; Chun et al., 2016; Stigsdotter et al., 2017*). Although these studies
65 repeated to demonstrate the restorative effect of the forest experience on mental health, quite few of them
66 have clarified whether the urban and forest environments for the comparison were at the similar
67 urbanizing-level. It seemed that Asian studies preferred to choose the forest at the peri-urban area (or
68 remote montane regions) in the comparison with the fully urbanized environment (e.g. *Song et al., 2015;*
69 *Li et al., 2016*). Both *Bratman et al.* (*2015*) and *Stigsdotter et al.* (*2017*) conducted the screening for the
70 urban environment choice to study perceived response but still insufficient to state the urbanizing level of
71 the chosen forest location. The expectation and perception can be represented in the term of urban
72 emotions, which both change with the geographical locations (*Choudhury et al., 2016*). In the condition of
73 unclear urbanization intensity, the difference of perceived restoration between the urban and forest
74 environments may be determined either by the contribution of natural degree or by the geographical
75 distribution. Therefore, to assess the emotional response of visitors to urban forests at the different

locations with different urbanizing levels would be an alternative approach to better clarify the effect of urban forest on well-being.

Former studies indicated that dwellers had different demands for forests locating at different city regions. Due to the fact of dense population in the central urban area, forests near the city center were usually taken as a scarce resource, which were perceived with great "non-material value" of cultural ecosystem services (*Casado-Arzuaga et al., 2013; Dou et al., 2017*). Therefore, the forests in the fully urbanized area were perceived to be protected and improved for bio-diversity and nature conservation activities (*Triguero-Mas et al., 2009; Erol et al., 2012*). Also perceived by urban dwellers was water conservation in the urban area with the purpose to promote citizens' well-being and life quality by providing aesthetic and recreational services (*Carvalho-Ribeiro and Lovett, 2011; Erol, 2012; Dou et al., 2017*). In contrast, forests at less urbanized areas were mainly valued in material ecosystem services by locals for timber harvest and non-woody production (*Carvalho-Ribeiro and Lovett, 2011; Erol, 2012; Casado-Arzuaga et al., 2013*). Data from these studies were mainly collected through face-to-face interview or questionnaire survey. However, the respondents were mainly limited by the locals leaving visitors to be largely ignored (*Dou et al., 2017; Mukherjee et al., 2017; Stigsdotter et al., 2017*).

Urban forests not only play a vital role in improving the well-being of local residents, but also function as important urban attributes to attract visitors (*Deng et al., 2017*). To some extent, the real visitors to urban forest parks in a city are usually not its residents but outsiders (*Law, 2002*). In addition, residents may expect different benefit by the experience in an urban forest from that of visitors. For example, taking Washington D.C. as the study area Deng et al. (*2017*) found that residents tended to focus on recreational aspects of urban forests as opposed to visitors who are more likely to value the visual and aesthetic aspects. For recruited visitors to a given urban forest, studies usually employed the face-to-face

questionnaires for self-reporting measures on mood state (*Park et al., 2011; McNair and Heuchert, 2013; Lee et al., 2014; Ochiai et al., 2015; Song et al., 2015; Li et al., 2016; Stigsdotter et al., 2017*). The profile mood state (POMS) questionnaire is a common approach to evaluate the perceived emotion. This method was mostly used with 10-20 participants (*Ochiai et al., 2015; Song et al., 2015; Li et al., 2016*). Studies using the POMS method to evaluate the emotional state have to lengthen the investigating period up to several days because to finish the questionnaires required some time course (*Park et al., 2011; Lee et al., 2014*). *Stigsdotter et al.* (*2017*) spent two years long to investigate 51 female university students for their self-evaluation on emotional responses to urban forest bathing. Therefore, when the number of visitors to urban forests was enlarged to some extent, the POMS method appeared to be improper due to the considerable spending of time and manual force.

Social networking services (SNS) have been an important channel for communication nowadays. Instead of traditional communicative approach, users post their portraits and facial images on the SNS platform to share their emotional perceptions (*Hsu et al., 2012; Sanadhya and Singh, 2015*). This resulted in an enormous number of facial-expression images hanging on the on internet through the SNS pathway, which may expose the users' privacy if images are published without declared permission by strangers (*Nakashima et al., 2015; d'Ambrosio et al., 2017*). Given the increasing use of mobile devices and fast development of mobile applications in SNS, the on-line facial-expression images have generated a big data pool with real-time personal details about not only the emotional state but also the location fixation. This hints a framework to reveal how the visitors are feeling in a given urban forest and where the forest they favor locates at. This can be achieved by extracting information about emotional perception from facial expressions in photos by visitors when they were stepping in an urban forest that inspired their interest to take a photo and uploaded to the SNS. Therefore, the large-scale evaluation of visitors'

emotions among different urban forests at the same time can be enabled by a crossover study (*Stigsdotter et al., 2017*). To our knowledge, no information is aware from the evaluation of emotional perception of visitors in the urban forests through analyzing their real-time facial expressions.

FaceReader™ is a tool to combine visual recording of visitors with a software algorithm that interprets emotional responses from their facial images. It has been reported a high accuracy (about 89%) of the emotional responses by FaceReader™ according to the self-reported emotional evaluation (*Kerrihard et al., 2017*). In this study, FaceReader™ technique was used to analyze the emotional expressions of visitors on-line images by visitors in urban forest parks in Northeast China. In China, the largest SNS in the mobile terminals was the WeChat (or Weixin) software (Tencent Co., Shenzhen, Guangdong, China) which reached more than 938 million monthly active user accounts as of the first quarter of 2017 (*Tencent. 2017*). However, images in the self-controlled-users' photo frames engaged a highly private policy in WeChat, which can only be browsed by authorized friends. Instead, we chose to use the Sina Micro-Blog software (or Weibo) (Sina Co., Beijing, China) as the data source to collect facial images. Up to 7 November 2017, Sina Micro-Blog has reached averaged 0.376 billion active monthly user counts and over averaged 0.165 billion active daily user counts (*Caijing, 2017*). The Sina Micro-Blog platform has been used as a modern approach to study human behaviors in the urbanized area due to its recording function for check-in activities with geographic information data online which can be utilized by both mobile devices and personal computer (PC) (*Gu et al., 2016; Dai et al., 2017*). The objective of this study was to evaluate the public emotional response to urban forests locating at regions with different urbanization intensities. Our study would be useful to be referred to for evaluating the effect of urban forests at different locations on the psychological state of visitors therein. Our results can be valuable for urban planning to motivate the positive potential of urban greening space on well-being perception.

METHODOLOGY

Study area

The Northeast China was chosen as the general study area of our study. In Northeast China, capital cities of Changchun, Harbin, and Shenyang were chosen as the objective cities in Jilin, Heilongjiang, and Liaoning Provinces, respectively. Changchun city (43°46'-43°58' N, 125°09'-125°48' E) locates in the hinterland of the Northeast Plain with a total population of 3.6 million (2010 data) inhabited in an urban area of 285 km^2 (*Ren et al., 2017*). Changchun is famous in its feature of "the Forest City" due to the forest vegetation coverage of 45%. In Changchun, urbanization started at 1979 and, since then, the urban forest patch density and tree density have increased by 162% and 37%, respectively (*Zhang et al., 2017*). Harbin (44°04'-46°40' N, 125°42'-130°10' E) was founded in 1896 and has been regarded as a "Garden City". Urbanization of Harbin started at 1978 and the gross domestic product (GDP) totaled RMB 501 billion in 2013. Urbanization in Harbin had induced increases of nine families and 17 genera of forest woody species (*Xiao et al., 2016*). Shenyang (41°48'-43°22' N, 123°25'-130°07' E) has an area of 129.48 thousands km^2 with the total population of 8.29 million in 2015. Shenyang belongs to the North China flora area but locates in the interactive zones between Changbai and Mongolia florae (*Xu et al., 2014*). The locations of the three cities are shown in Fig. 1.

Urban forest park selection

In this study we aimed to select three urban forest parks locating at regions of different urbanizing-levels. People in China prefer to inhabit the most urbanized area near downtown resulting in the typical urbanization pattern of a nearly circle with the center of downtown and increasing boundaries of ring-roads (*Xiao et al., 2016; Zhang et al., 2017*). The downtown area was determined for each of the three cities according to the standards adapted from *Stigsdotter et al.* (*2017*): not only representing the typical

architectonical style of the city but also obtaining the high historical qualities compared to the surrounding regions. All forest parks within each ring-road circle were labeled as the candidates and only those meeting the purpose of largest number of facial image data acquirement were selected as the objective sites. By screening for the check-in data from Sina Micro-Blog software, three parks with largest visiting population at different regions with various urbanizing levels were selected for one city. Totally, there were nine urban forest parks selected in this study. Name, area and distance of urban forest from downtown for each selected forest parks are presented in Table 1, and their distributions are shown in Fig. 1.

Facial image data

Facial images were firstly on-line checked from the time 00:00 of 24 September to the time 24:00 of 7 October 2017 and then downloaded for expression analysis for those over the screening standard. This time course was chosen because it overlapped a short holiday to celebrate the National Day, which belongs to one kind of hot-social-event when the active users increased drastically in Sina Micro-Blog (*Guan et al., 2014*). This time course was also chosen by to study check-in data of urban residents in Sina Micro-Blog (*Dai et al., 2017*). Only images containing the frontal view of an intact face were screened to pass the choosing standard because this kind of image can best facilitate the computer recognition by the software (*Kang et al., 2017*). Thus, some head poses of respondents in our collected images resulted in non-frontal faces but some of them were still screened to be the candidate for expression analysis as long as all the sense organs were shown clearly at the nearly symmetry. An example of non-frontal head-pose image is shown in Fig. 2 which can be analyzed by the on-line FaceReader™ software. Although facial images about a range of head poses can be analyzed for emotional expression, the non-frontal-face images need to be pre-processed to reduce unfavorable characteristics (*Muhammad et al., 2017; Ngo et al., 2017*).

Therefore, this kind of images was excluded from our first screening. The respondents wearing sunglasses or light-reflecting glasses were excluded because their image cannot be analyzed for expressions around eyes. We found that nearly 100% of the images were selfies hence non-selfies were excluded. The faces with heavy makeup or modification (less than 2%) failed to pass the screening because they may impact the precision of expression analysis. As a result 1139 facial images passed the first-round screening and 935 of them were downloaded for further analysis. The gender proportion and geographical distribution of these images are shown in Table 1.

Analytical method

FaceReader™ can recognize eight basic emotional expressions: neutral, happy, sad, angry, surprised, scared, disgusted, and contempt (*Haj et al., 2016; Kerrihard et al., 2017*). In our study, these basic expressions were also given by the FaceReader™ software (Fig. 2). Results were given as the percentage degree for each expression. Our data were analyzed by a split-block design with the different cities as main block (Changchun, Harbin, and Shenyang) and urbanizing levels (fully urbanized, sub-urban, and remote-rural) as the sub-block. SAS ver. 9.2 (SAS Institute, Cary, NC, USA) software was used for data analysis. The distributions of all expressions failed to pass the normality test according to the result of UNIVARIATE program. Therefore, data were compared in couple by the Wilcoxon rank-sum test at different factorial combinations (*Statistical Consultant System, 2017*). The general significance degree was regarded as $P<0.05$ but the specific significance was adjusted by the Bonfferoni correction depending on the number of coupled comparisons. In detail, the significance degree was adjusted to be $P<0.0167$ for three comparisons among cities or among urbanizing levels (degree of freedom=2); while that was adjusted to be $P<0.0014$ for comparisons 36 comparisons among combined cities and urbanizing levels (degree of freedom=8).

Subsequently, data were analyzed by both Pearson and Spearman correlations to detect linear and non-linear relationships, respectively, with the CORR program in SAS. A gross correlation was analyzed between expression degree and any of the factors of gender, distance of urban forest from downtown and park area. As long as the significance was detectable a second regression was conducted for each city to detect the fitted regressing model. A third regression was conducted among expressions using both the gross data and the separated data at each urbanizing level. The regression among expressions specifically in each city was not conducted because this part had little business with the topic of this study.

Results

In our study, data about the negative expressions of "sad" and "scared" failed to respond to any of the factors. They also had no relationship with any other expressions. Therefore, data of these two expressions were excluded from the result analysis.

Demographical analysis

Generally there were more women than men in urban forest parks to take selfies (Table 1). The number of female visitors was 202, 200 and 290in Changchun, Harbin and Shenyang, respectively while that of male visitors was 74, 63 and 106, respectively. The total number of images of men accounted for about 35% of that from female visitors. More images were collected from visitors to the forest park in the remote-rural area in Harbin and Shenyang, but in Changchun very few images can be collected in the sub-urban area.

Emotional expression at different urbanizing-leveled regions in three cities

None of the facial expressions responded to regions at different urbanizing levels in different cities, but the neutral degree was higher in Shenyang (49.76±28.50 %) than in Changchun (41.26±27.90 %) and both were not statistically different from that in Harbin (43.19±27.77 %) (Table 2). The happy degree tended to be highest in Changchun (49.21±28.83 %), followed by Harbin (48.73±28.05 %), and lowest in Shenyang

(45.76±28.25 %); while the angry degree showed contrasting range among the three cities (Changhcun, 1.42±2.50 %; Harbin, 1.64±5.32 %; Shenyang, 1.68±4.72 %). Degrees of surprised and disgust expressions had a tiny difference among cities, and they both changed by less than 6%. The location of urban forest parks had no effect on emotional expressions (Table 2). The neutral degree tended to increase by urbanization, while happy degree tended to decline. The angry degree tended to be highest in the sub-urban area, where the surprised degree tended to be lowest.

Regression analysis on the gross expression data

Gender of the visitors had a significant correlation with nearly all the expressions except for the contempt degree (Table 3). With the precondition that male visitors were represented by the number "1" and females by "0", their gender was found to have a positive relationship with the neutral, angry and disgusted degrees and a negative relationship with the happy and surprised.

Distance of urban forest from downtown had a positive relationship with the neutral degree (Table 3). This positive relationship can be fitted by a linear regression using both the gross data (Fig. 3a) and the averaged data with higher slope using (Fig. 3b). Although the relationship between distance of urban forest from downtown and the disgusted degree can be described by the Spearman correlation (Table 3), the negative correlation occurred only when the distance of urban forest from downtown was longer than 8.9 km (Fig. 3c). The correlation between distance of urban forest from downtown and the disgusted degree can be fitted by a quadratic curve with the highest degree to be 2.59% (Fig. 3c). However, when values of the disgusted degree were averaged by each park no regression can be found further (Fig. 3d).

Regression between distance and expression in each city

The parameter of distance of urban forest from downtown had a negative relationship with the happy degree in Shenyang (Fig. 4c), but no relationship was found in Changhcun and Harbin. However, with the

252 distance of urban forest from downtown increased the angry, surprised and disgusted degrees all showed
253 decreased trend in Changchun (Fig. 4d, g, j). The relationship between distance of urban forest from
254 downtown and disgusted degree was also found to be negative in Shenyang (Fig. 4l).

255 **Regression among expressions**

256 In general, there existed a significant relationship (either by Pearson or by Spearman correlations) between
257 any of the two expressions using the gross data across all cities and all regions of different urbanizing
258 levels (data not shown). Therefore, data were separated into three groups by urbanizing levels to detect the
259 specific relationship among expressions in each group (Fig. 5). In forest parks at city center and remote-
260 rural areas, the neutral degree was positively correlated with the angry, surprised and contempt degrees,
261 but negatively correlated with the happy and disgusted degrees (Fig. 5a, c). However, in forest parks at the
262 sub-urban area the correlations of the neutral degree with the surprised and disgusted degrees both
263 disappeared (Fig. 5b). The happy degree was negatively correlated with the angry, surprised, disgusted,
264 and contempt degrees in the forest parks at the city center (Fig. 5a), but the correlation between the happy
265 and the disgusted degrees did not exist in the forest parks at the sub-urban and remote-rural areas (Fig. 5b,
266 c). In the forest parks at all areas, the angry degree was positively correlated with the disgusted and the
267 contempt degrees and negatively correlated with the surprised degree, while the surprised degree was
268 always negatively correlated with the disgusted degree. In the forest parks at the remote-rural area, the
269 disgusted degree was negatively correlated with the contempt degree (Fig. 5c).

270 ## DISCUSSION

271 **The irrelevant expressions on sad and scared faces**

272 Due to the complicated emotional performance of human being in response to environmental changes, not
273 all expression-data given by FaceReader™ are necessary to be used in the analysis (*Haj et al., 2016;*

Kerrihard et al., 2017). The sad and scared expressions represent extremely negative emotions, neither of which responded to any exogenous factors. It seemed that the kind of extremely negative emotions tended to be obvious in forest professionals whose properties are related to urban forest trees. For example, urban forest planners and strategists in eastern Australian cities regarded urban trees as green infrastructure and they perceived scared of the effects from trees' risks on property and themselves (*Kirkpatrick et al., 2013*). In Canada, forest managers perceived sad in trees suffering from emerald ash borer (EAB) when they did not get enough information about how to cope with EAB from the researchers (*MacQuarrie et al., 2015*). In our study, most of the images were generated by common visitors who did not perceive the extreme negative emotions in urban forests probably because trees had very little relation with their own benefit and properties.

The gender effect on facial expression

Due to the popularization of mobile devices and the enhancing photographing function in cell phones, visitors would more likely take selfies than photos for others. This was one of the corollaries of social media platform development (*Shah and Tewari, 2016*). Our study indicated that much more facial images were originated from selfies by female visitors than by male visitors. This was attributed to the nature of attitude and motive being different between male and female respondents (*Shah and Tewari, 2016*). In addition, the correlation between the gender of visitors and emotional expressions suggested that male visitors showed more negative emotion in urban forests probably because they had higher neutral, angry and disgusted expression degrees. In contrast female visitors showed more positive emotions through the happy and surprised expressions. Two explanations can be responsible for these contrasts. Firstly, female visitors may tend to pose to show a happy face on purpose, e.g. by pouting, while male visitors tended to show the natural feeling on their face and may be perplexed to pose (*Shah and Tewari, 2016*). Male

visitors may perceive more stress than female visitors, which were supported by determining results of oxygenated hemoglobin (*Lee, 2017*). In addition, *Jiang et al.* (*2014*) found that men can perceive stress in response to tree density while women cannot perceive stress facing tree cover. The Sina Micro-Blog permits users to keep their personal details as highly classified privacy which cannot be browsed by strangers; hence in our study we were unable to obtain more data to study the effect of gender on facial expression. Future work is suggested to be conducted as off-line face-to-face experiment wherein the details of every participant can be aware.

The neutral expression in response to the distance from the downtown

The correlation analysis indicated that the neutral degree in the facial expression increased with the distance of urban forest from downtown. This was generated by urbanization and forests in less urbanized area made visitors to perceive neutral. This concurs with findings from the comparison between forest bathing and urban environment (*Park et al., 2011; Song et al., 2013, 2014, 2015; Lee et al., 2014*). Through the POMS questionnaire method, *Park et al.* (*2011*) found that the neutral perception was disturbed by urban environment due to higher air temperature. Other studies reported that after walking in the urban environment participants perceived artificial (*Song et al., 2013, 2014, 2015; Lee et al., 2014*), aroused (*Lee et al., 2014*) and awakening (*Song et al., 2013, 2014, 2015*) instead of the neutral feeling. Our study proved these outcomes by facial expression analysis, which was more precise and objective to describe the temporally emotional perception. The neutral feeling was taken as the result from restorative effect in response to the nature-based activities to counter negative feelings caused by nature-deficit disorder (*Palomino et al., 2016*). Therefore, in our study area urbanization may have negatively impacted the restorative effect of forests on the human health.

The difference of neutral expression between cities

318 Respondents in our study showed more obvious neutral expression in urban forest parks of Shenyang than
319 that of Changchun. However, the neutral expression did not show any responses along the distance-
320 gradient in neither of these two cities. Instead, other expressions of happy, angry, surprised, and disgusted
321 all had a negative relationship with the distance of urban forest from downtown. Regarding some
322 significant relationships existed among facial expressions; these results suggest that the difference of the
323 neutral expression between Shenyang and Changchun was generated by the co-contributions of other
324 expressions rather than the neutral one itself. Both happy and disgusted expressions had negative
325 relationships with the distance from the downtown in the rural forest park in Shenyang. These two
326 expressions also negatively correlated with the neutral expression. These results suggest that the low
327 degrees of happy and disgusted expressions in the rural area of Shenyang resulted in the high degree of
328 neutral expression therein. Accordingly, the distance of urban forest from downtown to the rural forest
329 park in Shenyang (19 km) was the longest in all forest parks. By contrasting in Changchun, all of the
330 angry, surprised and disgusted expressions increased with the shortening of distance to downtown, around
331 which in the city center all these three expressions were negatively correlated with the neutral degree.
332 These results suggest that the high degrees of the angry, surprised and disgusted expressions in the forest
333 parks around downtown resulted in the low degree of the neutral expression of Changchun.

334 **The inter-relationship between neutral and other expressions**

335 The neutral expression was usually used as a baseline condition by most of the functional neuroimaging
336 studies on emotions (*Lee et al., 2008*). The percentage of neutral's appearance in the overall emotions was
337 highest in the recognition by FaceReader™ (*Terzis et al., 2013*). However, prototypical "neutral" faces
338 may be evaluated as negative emotion in some circumstances (*Lee et al., 2008*). For example, in many
339 circumstances FaceReader™ can recognize an angry face simultaneously with a neutral one because

people tend to have clouded brow when they are highly concentrated (*Terzis et al., 2013*). This can explain the positive correlations between the neutral expression and negative expressions of angry and contempt. In contrast, the correlation between neutral and happy was negative. In addition, a neutral face can also be evaluated as negative if the preceding expression was happy and vice versa (*Russell and Fehr, 1987*). Although the disgust expression is also of negative emotion, it did not positively correlate with the neutral expression. This was because the disgusted response has to occur when the emotion is under conscious appraisal and a face is hard to be in the neutral expression (*Hartigan and Richards, 2017*). Moreover, direct comparison of contempt vs. disgust yielded significantly contrasting neural correlates (*Sambataro et al., 2006*). Therefore, the neutral expression did not correlated with distance of urban forest from downtown in any cities probably because it was easily mismatched by the temporal emotion.

The limitation of this study

In our study, urban forests were selected depending distance from the downtown to study urbanization effect on facial expressions of visitors therein. Our study focused on the geographical variation of forest locations along the urbanization intensity gradient hence usually took the objects' response to the forest at the rural areas as the reference to quantify that at the fully urbanized area. This methodology has been common and employed several times in other studies of the relevant topic in Northeast China (*Lv et al., 2016; Zhai et al., 2017; Zhang et al., 2017*). However, in studies on emotion perception of the nature experience, the urban environment was usually taken as the reference (or the control) to quantify participants' performance in a forest (e.g. *Bratman et al., 2015; Chun et al., 2016; Stigsdotter et al., 2017*). Therefore, our results were insufficient to reveal the restorative effect of an urban forest compared to the urban environment. Maybe a couple comparison between impervious and forest surfaces in the same area at a given urbanizing level would better illustrate the response of well-being to urban forest than

362 former studies and our study. In addition, people tend to smile when taking a selfie, which appears to
363 impact our results' precision. We admit this existed as a case in our study and several images showed the
364 face of an apparently intentional smile. However, this "interruption" existed for all images generating an
365 even natural error in all forest parks. Difference from comparisons and regressions were mainly caused by
366 geographical and environmental variations with quite indeterminate influence of intensive smiles.

367 ## Conclusions

368 In this study, 935 facial images of visitors to urban forests in three cities of Northeast China were screened
369 and downloaded from the large SNS platform of Sina Micro-Blog for facial recognition by FaceReader™.
370 Eight emotional expressions were recognized, i.e. neutral, happy, sad, angry, surprised, scared, disgusted,
371 and contempt, but results of the sad and scared expressions were irrelevant with others. There was a
372 gender effect on the number of images and more images were from female visitors. Compared to images
373 in urban forests at Changchun, those at Shenyang were recognized to harbor higher degree of the neutral
374 expression, which showed a general positive relationship with the distance of urban forest from
375 downtown. According to the inter-relationship among expressions, this between-cities difference resulted
376 from meanwhile the low degrees of happy and disgusted expressions in the rural area of Shenyang (high
377 neutral degree) and the high degrees of the angry, surprised and disgusted expressions in the city center
378 area of Changchun (low neutral degree). Our results can be valuable for urban planning to motivate the
379 potential of urban forest to promote well-being perception.

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ADDITIONAL INFORMATION AND DECLARATIONS

Competing Interests

The authors declare there are no competing interests.

Author Contributions

- Haoming Guan took part in the data collection, and data analysis, thereafter wrote the initial edition of the paper.
- Hongxu Wei designed the experiment and took part in the data analysis; contributed mainly to the article revision.
- Xingyuan He suggested the subject of the whole study and gave advises on the layout of the experiment.
- Zhibin Ren was responsible for the facial image analysis for expressions.
- Xin Chen assisted to analyze facial expression, data analysis, and data collection.
- Peng Guo designed the experiment, assisted to the data collection, data analysis, revised the manuscript, and finished all figures and tables.

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Table 1(on next page)

Table 1

Details in urban forest parks and number of visitors in cities of Changchun, Harbin, and Shenyang in Northeast China.

Downtown	Forest park	Area (ha)	Distance from downtown (km)	Park location	Male number	Female number	Total number
			—Changchun—				
People's square	Nanhu	222	3.5	C	34	95	129
	Beihu	205	10.5	S	3	17	20
	Jingyuetan	2052	15.5	R	37	90	127
			—Harbin—				
Harbin Railway Station	Zhaolin	7	1.8	C	10	26	36
	Sun-isle	246	4.5	S	26	101	127
	Northeast Tigers Garden	105	7	R	27	73	100
			—Shenyang—				
The Youth Str. Subway Station	Nanhu	82	2.5	C	15	77	92
	Dongling	833	14	S	37	49	86
	Int. Hort. Exp.	369	19	R	54	164	218
			Total number		243	692	935

Table 2(on next page)

Table 2

Degrees of facial expressions of neutral, happy, angry, surprised, disgusted, and contempt in visitors to urban forests locating at city-center (C), sub-urban (S), and remote-rural (R) areas in cities of Changchun, Harbin, and Shenyang in Northeast China.

City	Location	*n*	Neutral		Happy		Angry	
			Mean (%)	SE	Mean (%)	SE	Mean (%)	SE
	C	129	40.48	27.9	45.22	29.05	1.67	2.68
Changchun	S	127	41.7	29.81	50.61	30.99	1.06	2.02
	R	20	43.55	35.09	66.1	28.51	2.05	5.08
	C	36	38.58	29.75	44.08	32.13	1.06	1.48
Harbin	S	100	42.11	29.64	51.7	29.92	2.83	8.85
	R	127	45.34	28.76	47.72	28.49	0.88	1.36
	C	92	43.45	29.52	55.23	30.31	1.67	5.22
Shenyang	S	218	51.19	29.8	44.5	28.34	1.39	2.94
	R	86	53.28	30.5	38.36	31.17	2.4	8.1
			Surprised		Disgusted		Contempt	
			Mean	SE	Mean	SE	Mean	SE
	C	129	8.47	12.73	2.8	3.22	8.71	11.05
Changchun	S	127	5.27	7.32	1.63	1.34	7.95	10.68
	R	20	2.95	2.15	1.25	0.88	14.95	18.41
	C	36	4.61	7.8	1.94	2.41	10.58	14.17
Harbin	S	100	5.7	6.29	2.81	5.32	7.82	10.56
	R	127	7.37	9.34	1.62	2.09	10.68	12.8
	C	92	5.58	9.9	2.2	3.57	9.68	14.13
Shenyang	S	218	7.16	11.1	1.46	1.59	8.16	9.87
	R	86	7.12	12.02	3.26	6.66	8.62	11.06

Table 3(on next page)

Table 3

Regression coefficient (R) and significance degree (P) from Spearman correlation between facial expressions and parameters of gender distance from downtown and park area.

Facial expression		Gender	Distance from downtown	Park area
		n=935	*n*=935	*n*=9
Neutral	*R*	**0.2564**	**0.0843**	0.1257
	P	**<0.0001**	**0.0100**	0.7473
Happy	*R*	**-0.2806**	-0.0437	-0.2833
	P	**<0.0001**	0.1820	0.4600
Angry	*R*	**0.0764**	0.0190	-0.0500
	P	**0.0195**	0.5625	0.8984
Surprised	*R*	**-0.0894**	-0.0064	0.3500
	P	**0.0062**	0.8459	0.3558
Disgusted	*R*	**0.1391**	**-0.0717**	-0.0833
	P	**<0.0001**	**0.0283**	0.8312
Contempt	*R*	-0.0084	0.0005	-0.3833
	P	0.7985	0.9869	0.3085

Figure 1(on next page)

Fig. 1

The distribution of urban forest parks locating at the city-center, sub-urban, and remote-rural areas of cities of Changchun, Harbin, and Shenyang in Northeast China.

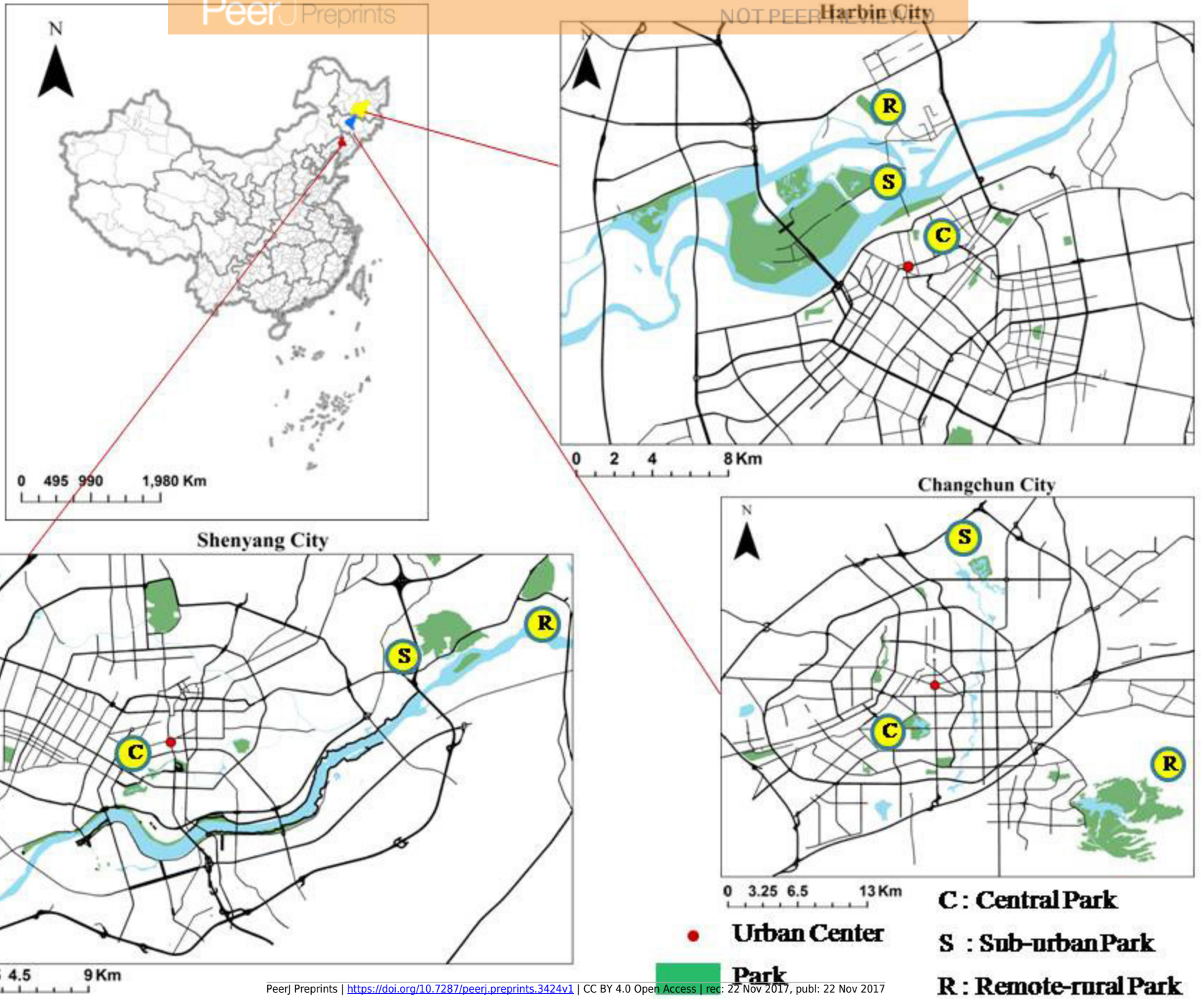

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Figure 2(on next page)

Fig. 2

A typical set of results about facial expressions degrees of neutral, happy, sad, angry, surprised, scared, disgusted, and contempt recognized by the FaceReader™ . The face image was screened and downloaded from the SNS platform of Sina Micro-Blog.

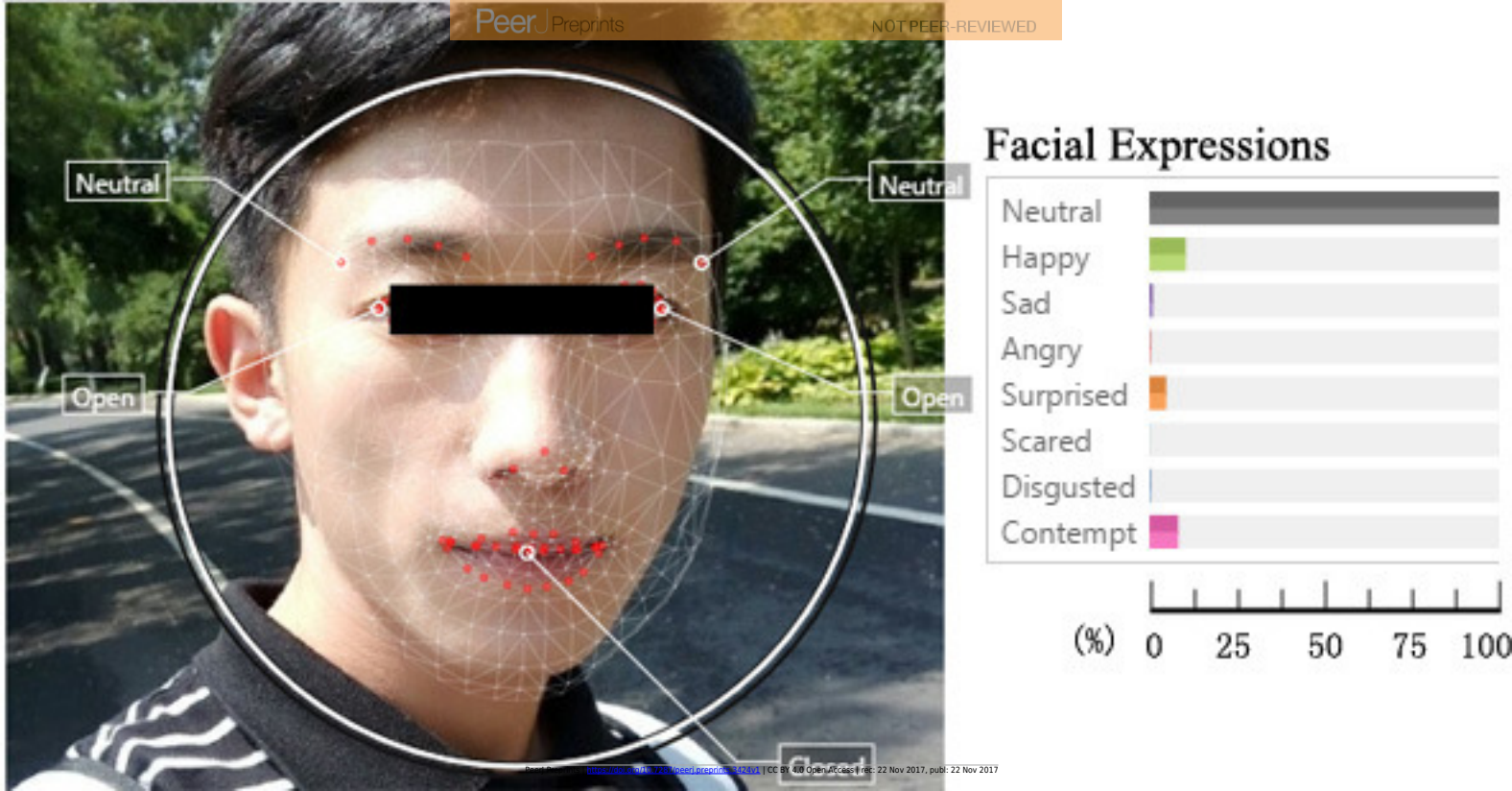

Figure 3(on next page)

Fig. 3

The regression between distance from downtown and facial expression degrees of neutral (up) and disgusted (bottom) using gross data across all cities and urban parks (left) or averaged data by each forest parks (right).

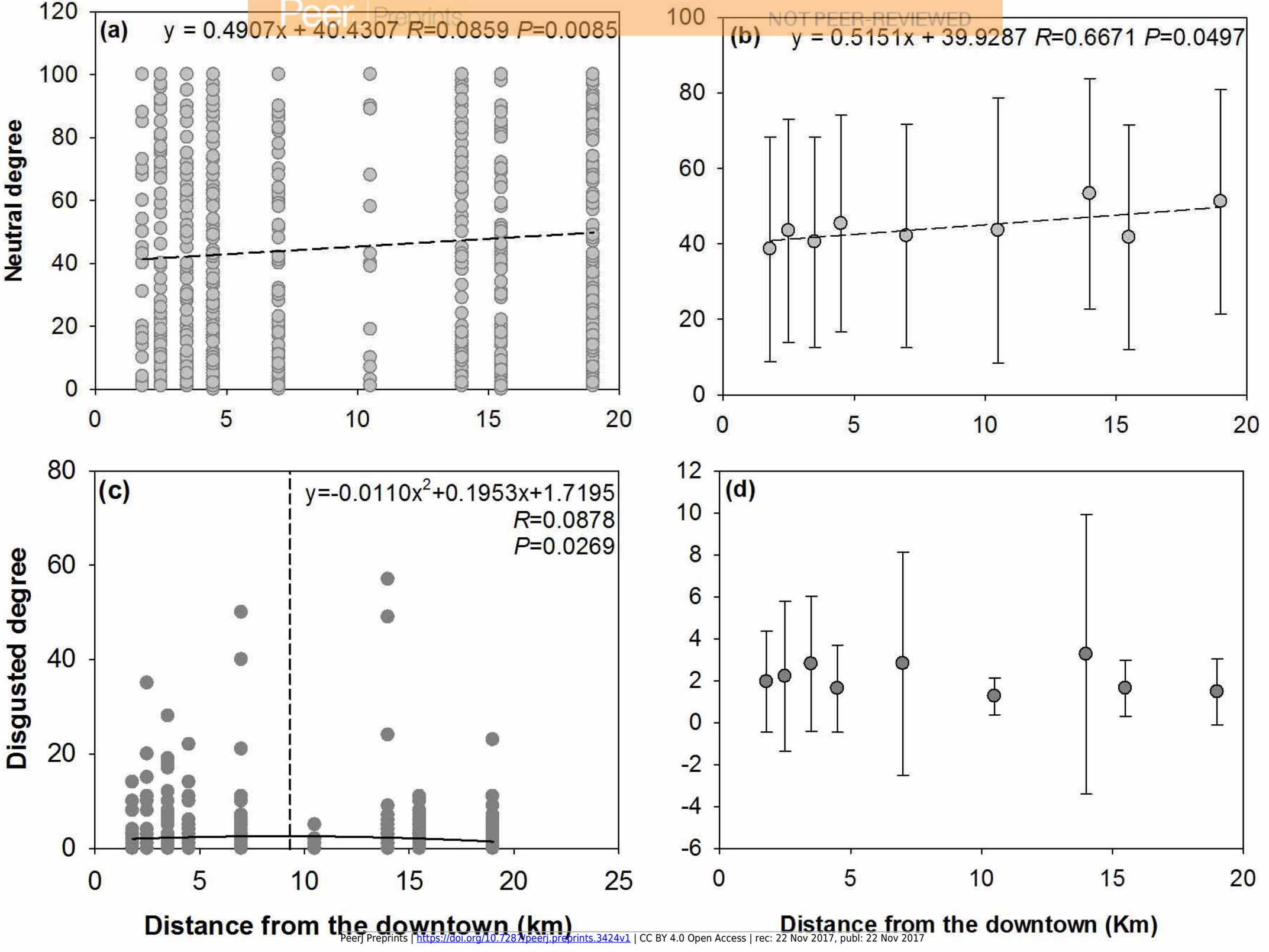

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Figure 4(on next page)

Fig. 4

The regression between facial expression degrees of happy, angry, surprised and disgusted and distance from downtown in cities of Changchun, Harbin, and Shenyang in Northeast China.

Changchun Harbin Shenyang

Happy degree

(a)

(b)

(c) y=-0.6474x+54.7825
R=0.1139
P=0.0233

Angry degree

(d) y=-28.6031/(13.3081+x)
R=0.1210
P=0.0466

(e)

(f)

Surprised degree

(g) y=-2748x+9.2162
R=0.1234
P=0.0405

(h)

(i)

Disgusted degree

(j) $y=3.2767e^{-0.0485x}$
R=0.1878
P=0.0017

(k)

(l) $y=3.7117e^{-0.0473x}$
R=0.1559
P=0.0018

Distance from the downtown (Km)

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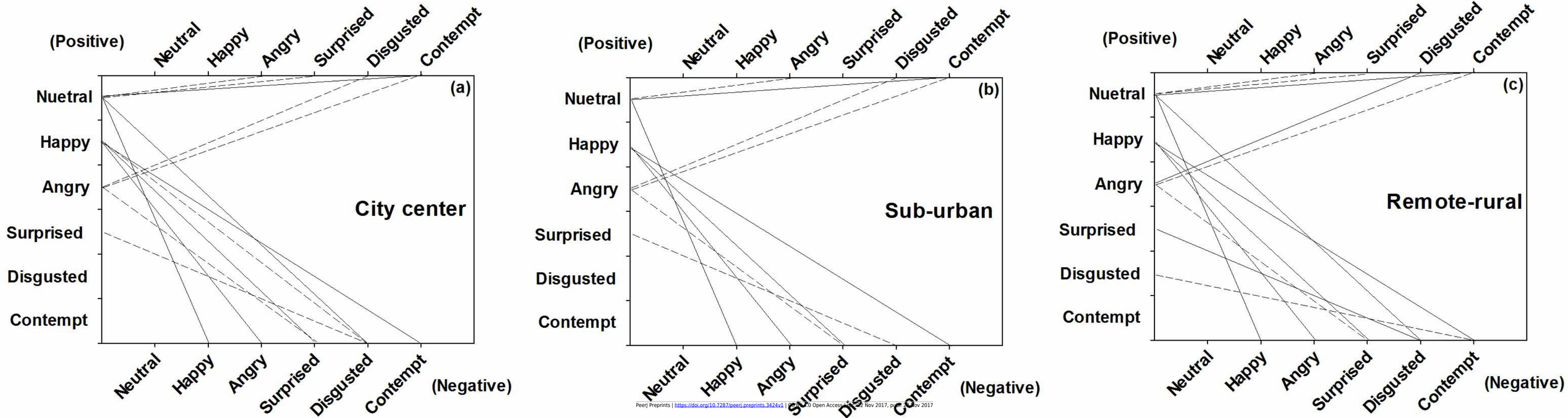
Figure 5(on next page)

Fig. 5

The correlation analysis among facial expressions of neutral, happy, angry, surprised, disgusted, and contempt in areas of city center, sub-urban and remote-rural by both Pearson (full lines) and Spearman (dashed lines) functions. Positive correlations were labeled by upward lines and negative correlations were labeled by downward lines.

Pearson correlation Spearman correlation



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