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Insights into Landscape Perception and Appreciation through Eye Movement Tracking

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Исследование восприятия и оценки пейзажа посредством отслеживания движений глаз

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Abstract. The variety of Russian natural scenery provides its natives with unique perceptive experience. Previous studies of this issue show cross-cultural differences among Russians and other cultures in their descriptions and emotional evaluation of landscapes. Our research aims to broaden the results of previous literature by exploring the connection between subjective judgements of landscapes by Russians and visual-spatial attention. Participants (n = 187; 136 females) were shown 102 pictures of native and foreign natural scenes and were asked to assess them by affective and location qualities using the semantic differential. During the picture presentation, eye movements were recorded with the usage of Tobii and Gazepoint eye-trackers. Our results suggest a link between individuals' cognitive evaluation of landscapes and visual behavior. Duration of fixation correlated significantly with exotism and familiarity marks (p < .01) for the landscapes, indicating the novel visual information which is gained from an exotic scenery demands additional attention resources. The correlation was also found among average saccade duration, emotional and aesthetic assessments (p < .01). Therefore, the elongation of eye movement shifts might be a signifier of interest in the landscape. In the current study, we demonstrate the connection between visual attention and subjective judgment of a landscape image, which have not been shown previously for the Russian sample.

Keywords*: emotional perception; visual attention; Russians; landscape; eye-tracking; cross-cultural studies*

Аннотация. Разнообразие природных ландшафтов России обусловливает уникальность их восприятия ее жителями. Ранее проводимые исследования показали межкультурные различия между россиянами и представителями других стран в их описаниях и эмоциональной оценке ландшафтов. Данное исследование направлено на то, чтобы расширить предыдущие результаты, изучив связь между субъективными оценками пейзажей россиянами и визуально-пространственным вниманием. Участникам (n = 187; 136 женщин) демонстрировали 102 фотографии местных и зарубежных пейзажей природы, которые следовало оценить по эмоциональному отклику и субъективному восприятию местоположения, используя семантический дифференциал. Во время презентации фотографий движения глаз фиксировались с помощью айтрекеров Tobii и Gazepoint. Полученные результаты указывают на связь между когнитивной оценкой ландшафтов и зрительным поведением. Продолжительность зрительной фиксации значимо коррелирует с показателями экзотичности и узнаваемости пейзажей (p < .01) и указывает на то, что новая визуальная информация, получаемая из экзотического пейзажа, требует дополнительных ресурсов внимания. Также была обнаружена корреляция между средней продолжительностью саккады, эмоциональными и эстетическими оценками (p < .01). Таким образом, увеличение продолжительности движения глаз может свидетельствовать об интересе к пейзажу. В настоящем исследовании демонстрируется связь между зрительно-пространственным вниманием и субъективной оценкой пейзажного изображения, которая ранее не изучалась на российской выборке.

Ключевые слова**:** *эмоциональное восприятие; зрительное внимание; россияне; пейзаж; айтрекинг; кросс-культурные исследования*

Introduction

Human preferences for natural landscapes have been a long-standing subject of study in the field of psychology. There is a significant amount of research whose authors have set the task to understand the reasons why people prefer certain types of natural landscapes to others, and how these preferences affect their behavior (Howard, Thompson, Waterton, & Atha, 2018; Matijosaitiene, Ucan, & Minasyan, 2014).

One of the key theories underlying these studies is the Attention Restoration Theory, proposed by American psychologists S. Kaplan and R. Kaplan (Kaplan, 1995). The main provisions of this theory state that the most preferred natural landscapes for humans and causing positive emotions contribute to the restoration of cognitive resources after mental exhaustion caused by factors of everyday life. From the point of view of the authors, elements of nature, such as trees, clouds, reservoirs, create a feeling of "expanded space," contributing to the restoration of attention.

Yet another equally influential idea is the savanna hypothesis, put forward by American biologist Gordon H. Orians in the early 1990s and his colleagues (Orians & Heerwagen, 1992). The authors of this theory argue that preferences in natural landscapes are innate, since humans are evolutionarily predisposed to prefer open landscapes with rare groups of trees and water resources that demonstrate the most favorable conditions for survival.

Another theory that has had a significant impact on the study of preferences in natural landscapes is the theory of schemes developed by A. Purcell (1987). The main argument of this theory lies in the presence of schemas, or prototypical representations, reflecting the patterns of experience of interaction with the environment and stored in memory. Accordingly, affective reactions occur when the properties of a particular landscape do not coincide with the corresponding cognitive scheme. If the difference between the cognitive schema and the real image is relatively small, then the person experiences positive emotions; if the image largely does not correspond to its prototype, then the person tends to experience negative emotional reactions.

These theories influenced the further course of research in the preferences of natural landscapes. However, studies of landscape perception using the eye-tracking method have had no less impact on progress in this area. The main advantage of the training is the ability to obtain objective data about a person's visual attention, which is not available through surveys and self-reports (e. g., Duchowski et al., 2018). In studies of preferences in natural landscapes, eye-tracking is used to identify the most attractive elements of the landscape, determine the sequence of perception of objects, as well as to compare visual preferences in different groups of subjects (e. g., Dupont, Antrop, & Van Eetvelde, 2013, 2015; Ueda et al., 2012; Wang P., Yang, Wang D., & He, 2021).

One of the earliest such studies was conducted in 1996 by Spanish psychologists (De Lucio, Mohammadian, Ruiz, Banayas, & Bernaldez, 1996), during which the main strategies or patterns of visual scanning of the landscape were identified. The overall strategy is to take a global, uniform and thorough look at the entire scene, as opposed to

focusing on any specific areas. The second scanning strategy was to inspect specific sites and, accordingly, can be described through interest in them. The third viewing strategy is to focus visual attention on the central area of the landscape, or on contrasting elements.

Over the past quarter century, the eye-tracking method has undergone a significant transformation, mainly consisting in improving the accuracy of fixing eye movements, the emergence of new methods of visualization and data analysis, the emergence of machine learning methods and their use in data processing. Some modern studies devoted to the study of visual perception of landscapes of the natural environment using eye-tracking are focused on predicting preferences in landscapes based on the analysis of data on areas with the highest concentration of attention displayed in the form of so-called hitmaps or "hot spots" (Schirpke, Tasser, & Lavdas, 2022). However, it remains unclear from their results whether the psychophysiological correlates of emotional perception of landscapes are due to cultural specificity or whether they are universal for all people.

The geographical location of Russia with its diverse climatic conditions provides a wide range of natural landscapes available for observation, which allows us to make an assumption about the rich visual experience of Russians in relation to the natural species surrounding them, therefore, the question of the cultural specificity of visual perception of landscapes in the Russian sample is of particular interest. Thus, in the current study, we focused on studying how the process of viewing landscapes among Russian residents proceeds and whether it is related to the subjective attitude of the sample to this type of image.

Materials and Methods

This study involved 187 people (136 females, 29.4 ± 10.6 years old, and 51 males, 30.9 ± 11.2 years old) from Moscow and the Moscow region, each of whom left data on age, places of birth and residence, education, subjective preferences in landscapes and tourism experience. We collected psychophysiological data on eye movements, GSR and heart rate using the Gazepoint GP3 eye-tracker with a biometric kit, with a sampling rate of 60 Hz, and using the Tobii Pro Nano eye-tracker with a sampling rate of 60 Hz.

The respondents viewed 102 photographs of Russian and foreign landscapes. Each image was presented for 10 seconds, after which it automatically switched to the image assessment questionnaire. The participants started the main task (viewing and evaluating images) after completing a 9-point calibration, recalibration and familiarization with the instructions. In addition, we provided for the neutralization of the light reflex by demonstrating a gray screen between each stimulus and a focus point to calibrate the gaze (Skaramagkas et al., 2021).

For the incentive set, we collected 75 photographs of Russian natural landscapes, representing 7 categories of landscapes in equal numbers: forests, treeless plains (including tundra, wetlands and steppes), mountains, river valleys, waterfalls, lakes, sea coasts. In the process of collecting them, we relied on the experience of Russian researchers E. G. Petrova and Yu. V. Mironov, described in the article *Comparing the Visual Perception and Aesthetic*

Evaluation of Natural Landscapes in Russia and Japan: Cultural and Environmental Factors (Petrova et al., 2015). All the photos we have collected are 500 × 400 cm images that were taken from open sources and have a Creative Commons license.

In addition, the stimulus set used in the study also contained 27 photographs of foreign landscapes, which we took from the Oasis dataset (Open Affective Standardized Image Set) (Kurdi, Lozano, & Banaji, 2017).

To subjectively evaluate images, we used a semantic differential scale (Bradley & Lang, 1994), which allows respondents to evaluate images by a number of polar adjectives on a scale from 1 to 7 points. It contained 7 scales that can be divided into two groups: location scales, which contain questions related to the subjective assessment of the location of the landscape (exotic — familiar, located in Russia — located in another country, familiar — unfamiliar), and affect scales, which were aimed at assessing the subjective preferences of respondents (aesthetically attractive — aesthetically unattractive, causes positive emotions — causes negative emotions, delights me — causes sleep, apathy, causes stress — causes relaxation, open — closed) (*Figure*). In developing the survey scales, we also relied on research by E. G. Petrova and Yu. V. Mironov mentioned above, as well as other relevant works listed in the references.

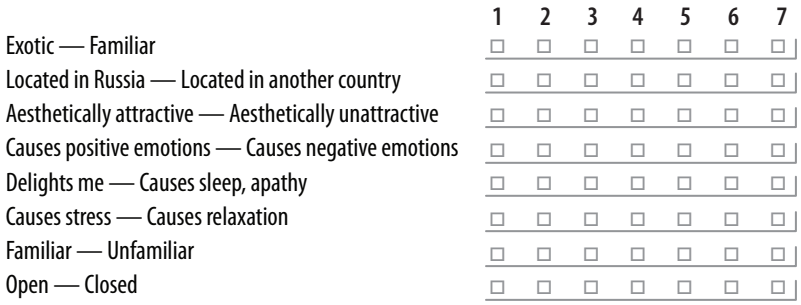

Figure. Example of a response scale that contains a description of images with clear polar characteristics

Results

After analyzing the data obtained, we found the following results. We have recorded correlations using the Spearman method with the Bonferroni-Holm correction between subjective estimates of location and parameters of eye movements. The first such correlation is the correlation between subjective location estimates and eye movement parameters. Thus, we found that the average duration of fixations positively correlated with the perceived exoticism of landscapes ($r = .265$, $p = .01$): the less familiar and more exotic the landscape appears, the longer fixations can be observed. A negative correlation was also found between the average fixation duration and recognizability ($r = –.229$, $p = .05$): the longer the average duration of fixation on any of the landscapes, the less recognizable it is (*Table*).

Table

Correlation between subjective evaluation of location estimates, affective estimates and parameters of eye movements

Variable	*r*
Average duration of fixations & perceived exoticism of landscapes	.265**
Average duration of fixations & recognizability	–.229*
Average duration of saccades & the valence of emotions	.277**
Average saccade duration & aesthetic appeal	.241*

Note. *$p < .05$, **$p < .01$

We also found two significant correlations between subjective affective assessments and the parameters of the subjects' eye movements. One of these correlations is a positive correlation between the average duration of saccades and the valence of emotions ($r = .277$, $p = .01$): the higher the duration of saccades, the more positive emotions a person experiences in the process of viewing the landscape. The second correlation found is a positive correlation between the average saccade duration and aesthetic appeal ($r = .241$, $p = .05$): the longer the saccades are, the more aesthetically attractive the observed landscape is.

Discussion

Interpreting these results, we can draw several conclusions. Firstly, as can be seen, the exoticism of the natural landscape is a factor of visual interest in it. This fact can be explained by appealing to the scheme theory mentioned above (Purcell, 1987), according to which, if there is a difference between the prototype of the landscape and its image, in reality, the subject observing it tends to experience positive emotions. This provision of the theory of schemes can explain the results we obtained: we can assume that exotic landscapes were evaluated more positively because the corresponding cognitive schemes, or prototypes, did not fully correspond to the images observed in reality.

Secondly, our results demonstrate the relationship between the attractiveness of landscapes and viewing strategies. Strategies for viewing the most attractive landscapes, characterized by a high duration of saccades and, accordingly, the most active visual behavior, are associated with the fact that a person needs to consider all the interesting elements that this landscape contains.

Conclusions

The results obtained by us can have practical application in a number of areas.

Firstly, data on the peculiarities of visual perception and subjective assessment of different landscapes by Russians can be useful in marketing and advertising. They would

make it possible to create more effective visual materials that take into account the cultural characteristics and preferences of the audience.

Secondly, the data obtained can also be used in the design of landscape design (e. g., Liu Q. et al., 2021). Getting to know them can help landscape designers and architects better understand which elements of the landscape are most attractive to Russians. This will allow you to create more aesthetically attractive and emotional spaces, parks, urban areas and recreation areas. Also, these results can be useful in designing tourist routes. Understanding which elements of the landscape attract the attention of tourists allows you to create more attractive locations (e. g., Liu Y., Hu, & Zhao, 2019).

In addition, the results of this study can be used in modeling the prediction of preferences in landscapes. It is worth recalling the study that we mentioned at the beginning (Schirpke et al., 2022), the authors of which are also engaged in the implementation of preference prediction based on the features of landscape perception obtained in eye tracking studies.

During our research, we encountered a number of limitations. The first of them is a limited number of camera angles in the photo and the photos themselves. However, this limitation can be removed by the fact that when collecting incentive materials, we were guided by the methodology of research conducted earlier. Another limitation is to limit the unevenness of the sample by gender. Also, one of the limitations is the absence of a comparison group (a foreign sample). However, it is worth emphasizing that this study is aimed at studying the peculiarities of perception of the Russian sample.

In our future research, we plan to minimize these limitations by achieving a balanced sample by gender and age. We are also going to expand our set of psychophysiological data by adding new categories of culturally specific stimuli to it and use it to improve the machine learning algorithm for emotion recognition, which was developed in our laboratory and presented earlier (Ivanina, Tokmovtseva, & Akelieva, 2023).

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References

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry, 25*(1), 49–59. https://doi.org/10.1016/0005–7916(94)90063–9

De Lucio, J. V., Mohamadian, M., Ruiz, J. P., Banayas, J., & Bernaldez, F. G. (1996). Visual landscape exploration as revealed by eye movement tracking. *Landscape and Urban Planning, 34*(2), 135–142. https://doi.org/10.1016/0169–2046(95)00208–1

Duchowski, A. T., Krejtz, K., Krejtz, I., Biele, C., Niedzielska, A., Kiefer, P., & Giannopoulos, I. (2018). The index of pupillary activity. *Proceedings conference on human factors in computing systems "CHI 2018"* (282, pp. 1–13). New York, NY: Association for Computing Machinery. https://doi.org/10.1145/3173574.3173856

Dupont, L., Antrop, M., & Van Eetvelde, V. (2013). Eye-tracking analysis in landscape perception research: Influence of photograph properties and landscape characteristics. *Landscape Research, 39*(4), 417–432. https://doi.org/10.1080/01426397.2013.773966

Dupont, L., Antrop, M., & Van Eetvelde, V. (2015). Does landscape related expertise influence the visual perception of landscape photographs? Implications for participatory landscape planning and management. *Landscape and Urban Planning, 141,* 68–77. https://doi.org/10.1016/j.landurbplan.2015.05.003

Howard, P., Thompson, I., Waterton, E., & Atha, M. (Eds.). (2018). *The Routledge Companion to Landscape Studies* (2nd ed.). London: Routledge. https://doi.org/10.4324/9781315195063

Ivanina, E. O., Tokmovtseva, A. D., & Akelieva, E. V. (2023). EmoEye: Eye-tracking and biometrics database for emotion recognition. *Lurian Journal, 4*(1), 8–20. https://doi.org/10.15826/Lurian.2023.4.1.1

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Kurdi, B., Lozano, S., & Banaji, M. R. (2017). Introducing the Open Affective Standardized Image Set (OASIS). *Behavior Research Methods, 49*, 457–470. https://doi.org/10.3758/s13428-016-0715-3

Liu, Y., Hu, M., & Zhao, B. (2019). Audio-visual interactive evaluation of the forest landscape based on eye-tracking experiments. *Urban Forestry & Urban Greening, 46,* 126476. http://dx.doi.org/10.1016/j.ufug.2019.126476

Liu, Q., Zhu, Z., Zeng, X., Zhuo, Z., Ye, B., Fang, L., … Lai, P. (2021). The impact of landscape complexity on preference ratings and eye fixation of various urban green space settings. *Urban Forestry & Urban Greening, 66,* 127411. https://doi.org/10.1016/j.ufug.2021.127411

Matijosaitiene, I., Ucan, O., & Minasyan, A. (2014). Cultural differences in landscape perception. *Journal of Sustainable Architecture and Civil Engineering, 8(3),* 16–25. https://doi.org/10.5755/j01.sace.8.3.7150

Orians, G., & Heerwagen, J. H. (1992). Evolved responses to landscapes. In J. H. Barkow, L. Cosmides, J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 555–580). New York, NY: University Press. https://doi.org/10.1093/oso/9780195060232.003.0016

Petrova, E. G., Mironov, Y. V., Aoki, Y., Matsushima, H., Ebine, S., Furuya, K., … Ueda, H. (2015). Comparing the visual perception and aesthetic evaluation of natural landscapes in Russia and Japan: Cultural and environmental factors. *Progress in Earth and Planetary Science, 2*(6), 1–12. https://doi.org/10.1186/s40645-015-0033-x

Purcell, A. T. (1987). Landscape perception, preference, and schema discrepancy. *Environment and Planning B: Planning and Design, 14*(1), 67–92. https://doi.org/10.1068/b140067

Schirpke, U., Tasser, E., & Lavdas, A. A. (2022). Potential of eye-tracking simulation software for analyzing landscape preferences. *PLoS ONE, 17*(10), e0273519. https://doi.org/10.1371/journal.pone.0273519

Skaramagkas, V., Giannakakis, G., Ktistakis, E., Manousos, D., Karatzanis, I., Tachos, N. S., … Tsiknakis, M. (2021). Review of eye tracking metrics involved in emotional and cognitive processes. *IEEE Reviews in Biomedical Engineering, 16,* 260–277. https://doi.org/10.1109/RBME.2021.3066072

Ueda, H., Nakajima, T., Takayama, N., Petrova, E., Matsushima, H., Furuya, K., & Aoki, Y. (2012). Landscape image sketches of forests in Japan and Russia. *Forest Policy and Economics, 19,* 20–30. https://doi.org/10.1016/j.forpol.2012.01.002

Wang, P., Yang, W., Wang, D., & He, Y. (2021). Insights into public visual behaviors through eye-tracking tests: A study based on National Park System pilot area landscapes. *Land, 10*(5), 497. https://doi.org/10.3390/land10050497

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