



Cortical neurodynamics of the human brain during the perception of Ukrainian and Japanese visual artworks

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Article info

Received 21.12.2024

Received in revised form

14.01.2025

Accepted 10.02.2025

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Prokopenko, V., Chernykh, M., Kovalchuk, O., & Zyma, I. (2025). Cortical neurodynamics of the human brain during the perception of Ukrainian and Japanese visual artworks. *Regulatory Mechanisms in Biosystems*, 16(1), e25011. doi:10.15421/0225011

Neuroaesthetics is currently seen as a promising branch of cognitive science, which can reveal the brain mechanisms of aesthetic experience processing and provide important tools for novel neurorehabilitation techniques. Such findings have become immensely important nowadays, as they can be seen as prospective powerful tools in developing novel therapeutic approaches. The study is dedicated to revealing the cortical neurodynamics during the perception of visual artworks originating from countries with completely different cultural traditions in the fine arts, namely Ukraine and Japan. In order to reach the aim, EEG data were recorded during the presentation of Ukrainian and Japanese paintings to a Ukrainian audience, with further analysis performed using power spectrum density (PSD) and phase transfer entropy (PTE). The analysis showed activation related to the default perception of visual stimuli during perception of Ukrainian paintings. The study focused primarily on alpha and beta oscillatory bands, showing different activation patterns related to attention, cognitive activity, and self-focused attention. As a result, the perception of Japanese art was linked to more cortical generalized connectivity, which was particularly apparent in high-frequency activity ranges and may be related to enhanced associative search and cognitive control. Memory mechanisms, visual reactions, and response reactions to salient/familiar targets in the TPJ (temporal-parietal junction) and TPO (temporal-parietal-occipital region) zones were observed to be activated by Ukrainian paintings. Overall, the pieces of Japanese art enhanced coherent connectivity in the cortex, suggesting increased cognitive control, while viewing Ukrainian art induced mainly memory-related and visual system responses. These findings could be valuable for designing rehabilitation programs tailored to individual cognitive needs. This study not only highlights the specific mechanisms underlying the aesthetic experience but also demonstrates the culture-dependent differences in visual stimuli processing.

Keywords: art; electroencephalography (EEG); power spectrum density (PSD); phase transfer entropy (PTE); neuroaesthetic; temporal-parietal junction (TPJ); temporal-parietal-occipital region (TPO).

Introduction

Given the need to provide a roadmap to improve and deepen art therapies with a deeper grasp of neuroscience, research into the potential relationship between neuroaesthetic and art-based protocols for rehabilitation is crucial (King et al., 2019). The full-scale Russian invasion of Ukraine and its devastating impact on the mental health of combat veterans and civilians underscores the urgent need for more clinical research to develop novel management and rehabilitation paradigms to overcome the aftermath of chronic stress, post-traumatic stress disorder, prolonged grief, etc.

Neuroaesthetics, a rapidly growing subfield in neuroscience, holds immense promise in unraveling the brain's intricate mechanisms during aesthetic experiences. The primary goal of this field is to decode the neural underpinnings of our inherent aesthetic inclinations and to what extent these judgments are subjective, offering a hopeful path for future research and application (Zeki, 2020).

Several studies have been conducted in recent years to determine the neural correlates of human aesthetic experience. In these studies, the approach was to allocate the neural correlates of the level of beauty, that is, the areas of the brain that distinguish between beautiful and ugly stimuli presented to participants.

The most interesting issue in this type of research is checking and verifying cortical areas where beauty is assessed. Studies investigating the effects of beauty on different brain regions include the occipital and premotor cortex in the case of performing arts such as dance (Jacobs, 2012), the fusiform gyrus (Vartanian, 2004), the ventral tegmentum, the amygdala, and the nucleus accumbens (Ahron, 2001), as well as the orbitofrontal and motor cortex (Kawabata, 2004). The orbitofrontal cortex, rostral anterior cingulate cortex and amygdala have been reported to be involved in the tactile domain experience (where pleasantness rather than beauty was assessed) (Rolls, 2003).

Notably, there is a dearth of studies that have utilized neuroimaging material to explore the aesthetic preferences of paintings. The few that exist can be categorized into those examining brain areas involved in processing images with varying emotional coloring and those involved in processing images with differing emotional valence. These studies have revealed that the processing of pleasant pictures differs from that of neutral pictures, as evidenced by the activation of the cingulate gyrus, left superior parietal lobe, right and left insula, right inferior frontal gyrus, visual cortex, and left caudate nucleus (Vartanian, 2004). The study utilized a diverse range of stimuli, including works by Van Gogh (First Steps), Kandinsky (Sin, 1924), Gauguin (Swineherd, Brittany), and O'Keefe (Black Door with Red) – this variety of stimuli allowed a comprehensive exploration of aesthetic experiences. It shows the dependence of the picture pleasantness assessment on the time spent viewing them. The average response delay was 2351.4 ± 1033.4 ms. Thus, as preferences for a picture increased, respondents looked at it longer before rating it. Repeated measurements showed that representational pictures (1.73 ± 1.32) were better than abstract pictures (1.13 ± 1.14); $F(1, 11) = 6.65$, $P < 0.05$). The results also showed that original (1.84 ± 1.30) and modified (1.72 ± 1.26) pictures were preferred over filtered (0.74 ± 0.95) pictures ($F(2, 22) = 64.12$, $P < 0.001$). Finally, there was a significant interaction between type and format ($F(2, 22) = 36.54$, $P < 0.001$), indicating that the drop in preference between original and altered pictures compared to filtered pictures was more pronounced for representational than for abstract paintings (Vartanian, 2004).

Subjects' ratings were analyzed using a mixed parametric analysis of fMRI data. The results showed that activity in the right caudate nucleus extending to the cortex decreased with decreasing liking for a picture. In contrast, activity in the left cingulate sulcus, occipital gyri, bilateral fusiform gyri, right fusiform gyrus, and cerebellum increased with an enhanced preference for pictures.

Materials and methods

The subjects of the study were 32 students of ESC "Institute of Biology and Medicine", Taras Shevchenko National University of Kyiv (nfem = 16) aged 18 to 24 years who participated in the examination voluntarily. Participants were informed about the content of the stimulation program; written informed consent was obtained from each subject in accordance with the World Medical Association (WMA) Declaration of Helsinki – Ethical Principles of Medical Research Involving Humans (Helsinki, Finland, June 1964), Declaration of Principles of Tolerance (28th Session of the General Conference of

UNESCO, Paris, November 16, 1995), Conventions for the Protection of Human Rights and Human Dignity in the Use of Biology and Medicine: Convention on Human Rights and Biomedicine (Oviedo, April 4, 1997).

A routine EEG was recorded using the Neurocom hardware and software complex (KhAI Medica, Kharkiv, Ukraine). The electrodes were placed according to the international electrode placement system "10–20." This EEG recording measured the brain's electrical activity in response to the stimulus material, providing valuable insights into the neural processes underlying aesthetic experiences in the context of art therapy for rehabilitation.

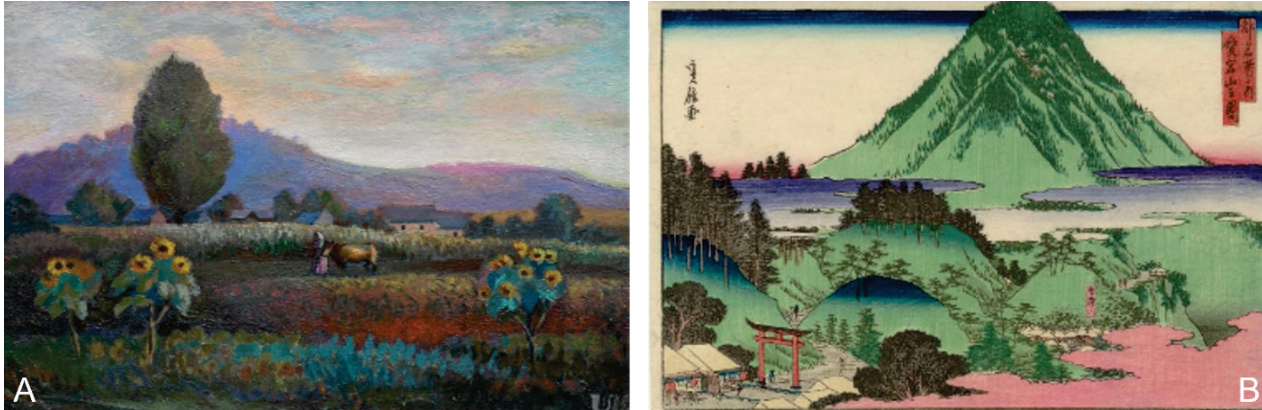


Fig. 1. Examples of the stimulus materials employed in the presentation of Ukrainian (A – Roman Selsky's "Return from the Pasture") and Japanese (B – Kano Shugen Sadanobu's "Metropolis of Sights") artworks

The examination was carried out in 6 stages of EEG recording. The first stage was the resting state EEG recording (1.5 min) with closed eyes. Thus, the person calmed down and adapted to the conditions in which the recording was made, and a recording was obtained of the state of rest of the person before the presentation of the stimulus material. The second stage of recording the subject with his eyes open was also conducted for 1.5 min, during which the subject was asked to look at the center of the screen, where a cross was displayed. The third stage is the presentation of the first set of stimulus material, Ukrainian landscapes (Fig. 1). The subject was shown 20 pictures of the same nature and narrative, which were standardized in size and presentation time (1000 ms). This stage lasted 3 minutes, during which the subject was asked to look at the pictures. The fourth stage was recording the aftermath (resting state with closed eyes, 1.5 min). The fifth stage contained the second set of stimulus material, Japanese landscapes (Fig. 2). The presentation was identical to the first set of images. The sixth, final stage of recording also aimed at recording the aftermath of the viewing. The time chosen for the exposure of the pictures, 1000 ms, allowed a person to understand and consider the object shown on the screen. The obtained data were processed on a computer using the EEGLAB software package (Delorme, 2004) based on the MATLAB software environment.

The power spectrum density distribution was determined based on the Fourier transformation to compare the method of phase transfer entropy with a conventional method of human brain activity assessment during cognitive activation. This characteristic is a de facto standard measure of the strength of oscillatory activity, which has been widely studied in trained emotional activation. Power spectral density was calculated for each EEG channel in each frequency band for each task. The spectral power density was calculated using the Welch period method (Bressler & Kelso, 2001). The obtained values in the corresponding frequency range were normalized relative to the maximum value for the emotional load and the background, after which the map of the topographic distribution of the corresponding values was drawn on the surface of the head.

Transfer entropy (TE) is an information-theoretic measure derived from information exchange theory to estimate conditional transition probabilities between two pairwise processes evolving over time. Consider two simultaneously measured time series generated by random processes X and Y. We will assume that a stationary Markov

process of finite order d can approximate each. Thus, it is possible to reconstruct the state space of process X using an embedded delay vector of dimension d with past values. Representing two time series as $X = x_t$ and $Y = y_t$, the embedded delay vector is defined as $x_{t,d} = (x_t, x_{t-\tau}, x_{t-2\tau}, \dots, x_{t-(d-1)\tau})$; a similar presentation is also true for $y_{t,d}$. The size of the embedding space is d, and the delay is τ . Under the assumption that the system X can be approximated by a stationary Markov process of order d, the transition probabilities describing the system are given as follows:

$$p(x_{t+\tau}|x_t^d). \quad (1)$$

The entropy level of a system X is the average number of bits needed to represent an additional state if all previous states are known. Thus, the entropy rate can be calculated as follows

$$h(x_{t+\tau}|x_t^d) = -p(x_{t+\tau}, x_t^d) \log p(x_{t+\tau}|x_t^d), \quad (2)$$

where $p(x_{t+\tau}|x_t^d) = p(x_{t+\tau}, x_t^d) / p(x_t^d)$, u – prediction time, p^* – probability.

If two processes are independent, information transfer will not occur, and $p(x_{t+\tau}|x_t^d) = p(x_{t+\tau}|x_t^d, y_t^m)$. A measure of deviation from this generalized Markov property can be calculated using Kullback divergence or shared information, which is a directional measure of information transfer from process Y to process X, denoted TE ($Y \rightarrow X$), is calculated as

$$E(Y \rightarrow X) = \sum p(x_{t+\tau}, y_t^m) \log \frac{p(x_{t+\tau}, y_t^m)}{p(x_{t+\tau})} \quad (3)$$

when $y_t^m = \{y_t, y_{t-\tau}, \dots, y_{t-(m-1)\tau}\}$, as process X depends on m states of Y.

Equation (3) can be written in terms of differential entropy as follows:

$$TE(Y \rightarrow X) = H(x_{t+\tau}^d, y_t^m) - H(x_{t+\tau}^d, y_t^m) + H(x_{t+\tau}^d) - H(x_t^d). \quad (4)$$

Note that TE is inherently asymmetric, i.e. $TE(Y \rightarrow X) \neq TE(X \rightarrow Y)$. In addition, when the processes are mutually independent, then $TE(Y \rightarrow X) = TE(X \rightarrow Y) = 0$.

TE values were estimated using the k-nearest neighbor approach, with $k = 4$, as suggested by Kraskov et al. (2011). The embedding delay (τ) was determined based on Cao's criterion (Restrepo et al., 2023), and the dimension (d and m) was obtained using an efficient search algorithm.

The dPTE coefficient for two cortical areas was calculated as the sum of the PTE coefficient values in both directions

$$dPTE = \frac{PTE_{xy}}{PTE_{xy} + PTE_{yx}} \quad (5).$$

The values of the dPTE criterion vary within $[-0.5; 0.5]$. The criterion was implemented based on the Brainstorm software package.

Results

The results of the study showed differences in the functioning of the human brain when viewing pictures and during the resting state. Further analysis was performed using the power spectrum density distribution and phase transfer entropy algorithm.

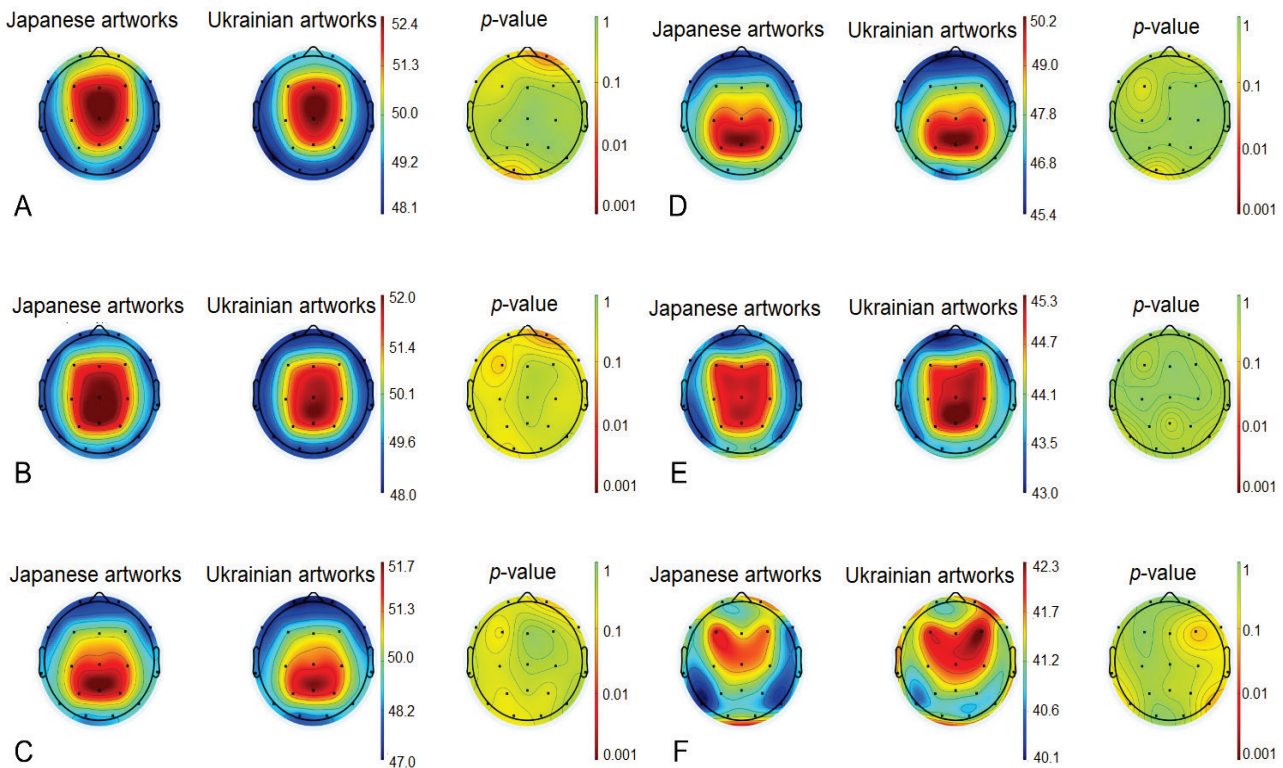


Fig. 2. The results of the PSD analysis of the EEG data for the Ukrainian and Japanese image series are presented for the following frequency bands: θ (A), $\alpha 1$ (B), $\alpha 2$ (C), $\alpha 3$ (D), $\beta 1$ (E), $\beta 2$ (F); $n = 32$; permutation statistics were applied considering $P < 0.05$ as statistically significant

The obtained material was divided into the following ranges for further analysis, namely: θ (4.0–7.4 Hz), $\alpha 1$ (7.5–9.5 Hz), $\alpha 2$ (9.5–10.5 Hz), $\alpha 3$ (10.6–13.5 Hz), $\beta 1$ (13.5–20.0 Hz), $\beta 2$ (20.1–30.0 Hz).

Sample θ when viewing Japanese and Ukrainian paintings. An increased power density is noted in the right frontal region for the Japanese sample ($51.3 \mu V^2/Hz$), and it is also noticeable that there are differences in the distribution density in the left occipital region ($51.1 \mu V^2/Hz$).

The results of the $\alpha 1$ spectrum show significant density differences ($48.3 \mu V^2/Hz$) in the right prefrontal cortex for the sample corresponding to exposure to Japanese images. For the $\alpha 2$ subband, a partial increase in density was found in the parietal regions in both Ukrainian and Japanese groups. However, the difference in density is also noted, namely in the frontal-frontal right part of the cortex. Lastly, differences in the density distribution in the $\alpha 3$ subrange are pointed out in the right prefrontal, left frontal, and left occipital. So, for the Japanese sample, the values in these areas will be (46.3, 47.1, and $46.9 \mu V^2/Hz$). In contrast to the Ukrainian ones, the values in the same areas were 1–2 $\mu V^2/Hz$ lower.

Activation in the $\beta 1$ band is seen throughout the cortex, spanning the parietal, central, and frontal cortices. In the parietal region, we observe the highest power density of the spectrum ($45.3 \mu V^2/Hz$). We also see slightly increased activation in the occipital lobe cortex for sample A. At the same time, in the $\beta 2$ subrange, there is a difference from the $\beta 1$ indicators. Thus, significant differences are observed in the right frontal and occipital-temporal zones (42 and $40 \mu V^2/Hz$, respectively). In the left hemisphere, note the occipital temporal zone with density ($40.8 \mu V^2/Hz$).

The results of the EEG analysis performed using the Phase Transfer Entropy (PTE) method are presented below (Fig. 3, 4). The energy-information connections in the cerebral cortex during the observa-

tion of Ukrainian paintings in the $\alpha 1$ subband indicated that the information flow originating from the left parietal cortex (P3) was directed to the left frontal, left central, parietal, and right central, and temporal areas (F7, C3, Cz, C4, T4, and Pz). Additionally, there was a projection from Fp2 to C4 and O2 to Cz.

At the same time, the $\alpha 1$ subband EEG data (Fig. 3D) corresponding to the perceptions of the Japanese paintings comprised the following information flows: from P3 to T3 and T5; from Fp1 and Cz to C3; F4 flows to F7, C3, and T4; Fz, in turn, flew to C3 and T4; P4 and T6 flew to O2; and from Pz to T4 and O2.

The EEG data in the $\alpha 2$ subband (Fig. 3B) indicated four connection hubs of information flow originating within F8, P3, Pz, and O2. The electrode in the right frontal region (F8) is associated with information flow to Cz, Fz, and F3. The pathways of information flow from the central parietal electrode (Pz) are identical, as information from this electrode is directed to all three sites. The occipital region, namely its right area, is connected to temporal areas bilaterally (T6 and T3). The largest network of connections originated from P3 and proceeded to T3, F7, Cz, and Fz.

A distinct difference in the number of interrelationships is evident for the $\alpha 2$ subband when perceiving Japanese paintings (Fig. 3E) compared to Ukrainian paintings. The direction of the information flow can be summarised as follows: the right parietal area (P4) is the starting point for connections with frontal areas (Fz and F4) (information is also transmitted to this region from T6); from C4, a connection is established with Fp2.

The results obtained for the $\alpha 3$ subband during the perception of the Ukrainian painting (Fig. 3C) demonstrated substantial connections directed toward the right occipital area (O2). Notably, the connections from C3, C4, and T4 do not diverge to other cortical regions besides O2. Additionally, the transfer of information to F4 and O2 was initia-

ted from the right temporal region (T6). The inputs from the central parietal cortical area, Pz, were conveyed to the left anterior frontal (F3) and right occipital (O2). Furthermore, information diverges from the left parietal zone (P3) to the central frontal (Fz) and right temporal (T4) regions.

When the same subband is examined for Japanese painting demonstration (Fig. 3F), it becomes evident that the information is transferred from the central, parietal, and temporal regions and subsequently reaches the visual cortex. This can be observed in the following sequence: C3 and P4 to O1; C4, T4, and T6 to O2.

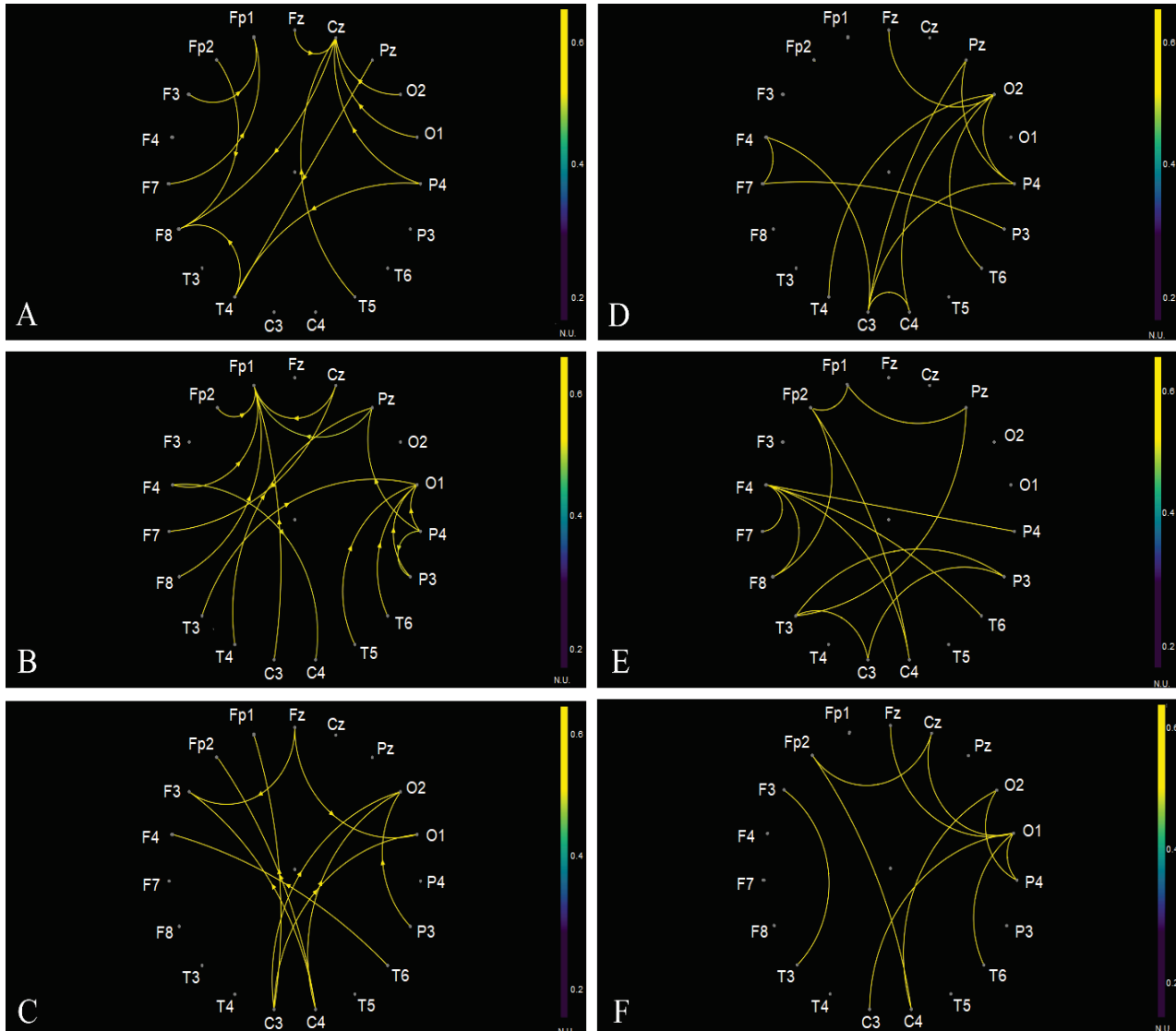


Fig. 3. The visualization of PTE results demonstrates the signal path through cortical areas in the α -band for Ukrainian (α_1 – A, α_2 – B, α_3 – C) and Japanese (α_1 – D, α_2 – E, α_3 – F) image series ($P < 0.05$, $n = 32$): names of the EEG leads, abbreviated according to the international “10–20%” system, are presented as a circle diagram; the color bar in the right corner represents the coherence levels; $n = 32$

When showing paintings of Ukrainian art, changes in the β_1 (Fig. 4A) subband are noticeable in the EEG data. The information flows are arranged as follows: from the central frontal area (Fz) to the right frontal (F4) and central (C4) regions simultaneously; from F4 to T4; from Cz to C4; T5 sent connections to both F3 and Fz; and from P3 to F3.

Concurrently, the activity in the β_1 subband during the perception of Japanese paintings (Fig. 4C) exhibited the following dynamics: the initial phase of information transmission from P3 diverged to F7, C3, Cz, and T6. Subsequently, the information was redirected from Pz to P4, C3, F3, Cz, Fz, C4, and T4.

The directed connections observed in the β_2 subband of the EEG data during the subjects' exposure to Ukrainian paintings (Fig. 4B) exhibited the following dynamics: from T5, the flow was directed to F7, C3, and Cz. Additionally, the connections from P3 to F7, C3, T3 and T5 were also observed, as well as from T6 to C4, F8, T4.

At the same time, different dynamics were reflected in the β_2 subband during the perception of the Japanese paintings (Fig. 4D). The information flow was directed from the posterior (T5) to the

anterior temporal area (T3) within the left hemisphere and simultaneously was directed to the central region (C3). Additionally, P3 was connected with C3, and the information from Pz was sent to the relatively distant Fp2. From T6, the information flow proceeded to F8 and T, in addition to the flow from T4 to F8.

Discussion

In the course of the study, results showed the differences in the functioning of the human brain when viewing pictures and during the resting state using the PSD distribution and PTE connections. It is worth noting that in the following figures, the density of one or another rhythm will be noticeable in the central areas of the cortex. The mathematical apparatus behind the calculation of EEG data explains this behavior of power spectra. The analysis apparatus is built on the old principles of calculation using decimal logarithms - this causes visible rounding of the power spectrum density distribution during group analysis. After examining and analyzing the obtained results on the distribution of the power spectrum density, it became clear that most

of the activation we see using this method is default-tuned to the perception of visual stimuli (Jacobs, 2012).

In Figure 2A, which shows the results for the θ band (4.0–7.4 Hz), the difference in the right frontal and left occipital areas was

observed. The displayed activation pattern indicated the activation of systems of passive information scanning and correspondence to the status of attention involvement (Buzsáki, 2002).

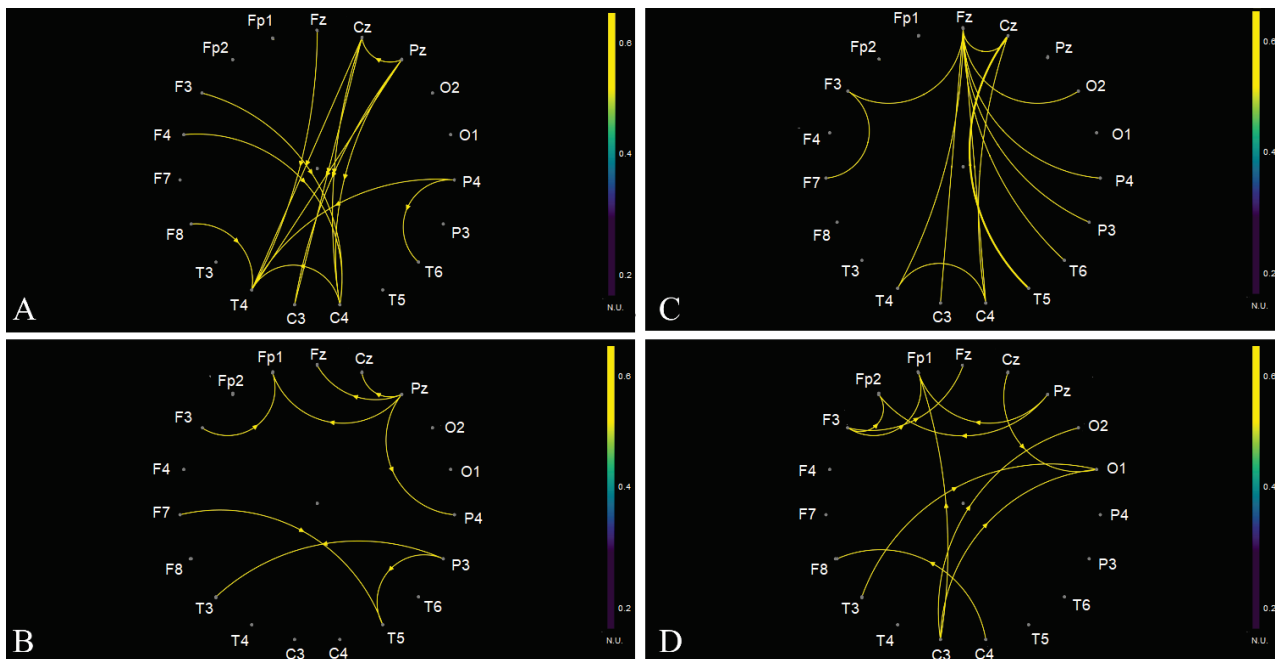


Fig. 4. The visualization of PTE results demonstrates the signal path through cortical areas in the α -band for Ukrainian (β_1 – A, β_2 – B) and Japanese (β_1 – C, β_2 – D) image series ($P < 0.05$, $n = 32$); names of the EEG leads, abbreviated according to the international “10–20%” system, are presented as a circle diagram; the color bar in the right corner represents the coherence levels; $n = 32$

In the α band, namely the α_1 subband (Fig. 2B), activation of the right prefrontal area was visible. Synchronization of α_1 in the prefrontal area may indicate a reaction of negative emotional perception (Trochidis & Bigand, 2014). It is worth noting that such activation is significantly enhanced by sensory stimulation due to the exposure of images that are not inherent to the eye of an average Ukrainian.

According to the literature, what is shown in (Fig. 2C), a steady synchronization within the α_2 subband (9.5–10.5 Hz) corresponded to the redistribution of resources and incoming information to different cortical areas. That is why we can see that the power density is heterogeneous over the entire scalp. Such a reaction in the α_2 is also associated with the normal functioning of the adult brain aimed to avoid the overloading of functional streams (Lozano-Soldevilla & VanRullen, 2019). Therefore, speaking of activation, it was uniform in both samples, and the differences are not statistically significant.

Moving on to considering high-frequency alpha (α_3 , Fig. 2, D), we note that according to modern data, α_3 is an important component during emotional engagement. Also, α_3 is responsible for complex constructive semantics regarding stimuli presented at the moment (Fellinger, 2012; Fink & Benedek, 2014). The α_3 PSD values in the somatosensory cortex (Pz) were slightly elevated for the Ukrainian series of images, which might correspond to searching for known intellectual constructions (visual images) (Ergenoglu et al., 2004).

Interpreting the results in the β_1 range is difficult because the clear differences in Fig. 2E are not visible. The nature of the distribution of activation is generalized, which is characteristic of the β -range, so activation is observed in the parietal, central, and frontal areas. According to literature and research data, such activation is associated with the concentration of externally directed attention (Wróbel, 2000). In our case, visual stimulation causes a need for concentration of attention because the stimulation material was unknown to the subjects.

In contrast to β_1 , the β_2 band (Fig. 2F) shows increased oscillatory power in the frontal region. It covers the parietal region, and a decreased power density distribution is seen in the occipital region. The functional significance of this activation pattern indicates the state of awareness, self-focused attention, and cognitive activity.

The study (Rassi et al., 2023) suggests that such activation may correlate with the activation of various cortical representations of the processed sensorics.

The results obtained thanks to the power spectrum density distribution method were less indicative than expected. Therefore, an analysis was performed using the phase transfer entropy method, and the effectiveness of the methods was compared. PTE, unlike PSD, is more informative because it can show correlational interactions of areas and the direction of information flow, which will mean the information path for us. In its turn, PSD only indicates the functional state of areas of the cerebral cortex.

Using phase transfer entropy to obtain resting state results with both eyes closed and eyes open yielded dPTE values approaching zero. Thus, the hypothesis that this method is effective for analyzing states related to cognitive activity was confirmed.

The phase transfer entropy method has features that must be considered when analyzing the results. In short, distant connections mostly reflect the electrical activity of closely located areas (electrodes), show the bioelectric property of matter, and show the actual property of the current to disperse to nearby areas – it is not appropriate to analyze such connections. Instead, long-distance connections reflect information (energy) flow to functionally connected areas within a specific neural network (Chernykh & Zyma, 2021).

This work focused primarily on the alpha and beta oscillatory bands, which showed a distant interaction, while the theta range was not indicative. Thus, Figure 4 presents the results for the alpha range, where the communication of cortical areas was compared when viewing images of Ukrainian and Japanese paintings.

The α_1 subband shows a pattern of a connection hub in the left parietal and central parietal leads (Fig. 3A), reflecting the active operation of attention processes and information retrieval in memory (Igelström et al., 2016). This can be explained by the fact that the subjects had the experience of viewing similar landscapes or even paintings during their lives since this correlates with the ethnicity of this group. However, the pattern shown for viewing Japanese images is the opposite. We see (Fig. 3D) the formation of central frontal and parietal hubs of connections. According to the literature, information

interaction of this type indicates a process of selecting relevant sensory inputs on which multisensory perception is built, contributing to cross-modal communication (Misselhorn et al., 2019). We also hypothesize that bilateral alpha effects in the frontal and right parietal cortex reflect top-down control, thereby regulating perceptual gain (Misselhorn et al., 2019). Such selective cortical routing consistently recognizes the unknown through sensations relevant to the stimulus.

Figure 3B shows us the association of connections in the above-mentioned temporoparietal junction (TPJ) in the $\alpha 2$ subband. Because the TPJ is a multimodal cortical region that receives input from thalamic, limbic, auditory, visual, and somatosensory areas, it may indicate self-determination processes in space and time about the stimulus (Laufs et al., 2003). This leads to the brain's reaction to evaluating what is already known and experienced (Carmody & Lewis, 2006). However, during the presentation of Japanese stimuli, we observed a right-lateralized nature of information transmission from the parietal and right central areas to the frontal part of the cortex. We see the formation of a triangular hub that modulates the beginning of information flows in the temporal-parietal-occipital area of the right hemisphere (Fig. 3E), the rTPJ functional area. It modulates the activity of the prefrontal and frontal regions, revealing the function of implementing loyalty and commitment behavior in visual stimulus comparison tasks (Schäfer et al., 2021).

The results obtained in the $\alpha 3$ subband for both Ukrainian images (Fig. 3C) and Japanese images (Fig. 3F) show the direction of the central parietal and occipital zones to the direction of information flows in the area of the occipital leads. Such a reaction is explained by reorientating cognitive processes of attention to stimuli (Vossel, 2013). This is the embodiment of the response of neural networks through the semantic constructs of the analysis of visual stimuli. In this case, we assume that $\alpha 3$ demonstrates the processing of spontaneous visual information through cognitive mechanisms (Vossel et al., 2013).

The differences revealed during the data analysis of the $\beta 1$ and $\beta 2$ subbands of bioelectric activity are the most pronounced. The topographic distribution in the $\beta 1$ subband of activity demonstrated the formation of powerful hubs of connections in the central and central-parietal areas, which reflects the active work of the fronto-parietal analytical neural network (Wang et al., 2022) during the perception of Ukrainian pictures (Fig. 4A). In contrast, the perception of Japanese art was accompanied by the formation of an extensive network of connections with centers in the temporal lobes of the right hemisphere, which emphasized the significant activation of analytical and integrative processes (Sadaghiani et al., 2018). It can also be noted that when processing Japanese images in the $\beta 2$ subband of electrical activity (Fig. 4D), it was possible to observe the formation of an extensive network of connections, in particular distant ones (for example, between the central and occipital regions of the cortex), which generally reflect an increase in controlled externally directed attention (De Benedictis et al., 2014).

Based on this, we state that the perception of works of Japanese art was accompanied by higher generalized connectivity in the cortex, especially noticeable in the high-frequency ranges of activity, which can be associated with the strengthening of cognitive control and the search for associative connections. In contrast, Ukrainian artwork evoked processes associated with memory, visual responses, and responses to salient/familiar targets in the TPJ and TPO areas. Such data may become useful for understanding and developing new rehabilitation methods and diagnosis of cognitive abilities. For instance, this evidence might be used to create stimulation programs based on patient needs and background.

Conclusions

According to the purpose of the study, data was obtained that shed light on the dynamics of changes in brain activity, showing the degree when comparing reactions to the perception of art objects (paintings) radically different in origin and ethnic narrative (Ukraine, Japan). Thus, the perception of works of Japanese art was accompanied by higher generalized connectivity in the cortex, especially noticeable

in high-frequency ranges of activity, which can be associated with increased cognitive control and search for associative connections. Ukrainian paintings activated memory mechanisms, visual reactions, and response reactions of the salient/familiar targets in the TPJ (temporal-parietal junction) and TPO (temporal-parietal-occipital area) zones. A comparison between neurophysiological mechanisms showed that when viewing Ukrainian images, there was greater activation of memory and visual reactions, while when viewing Japanese images, increased cognitive control and the search for associative connections were manifested.

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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