Brain Mechanisms in Face-Name Memory: Evidence From Event-Related Potentials and Spatial Localization of Brain Activity

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Abstract

Face-name memory is a special type of memory comprising visual and semantic memory components. Existing research suggests that name retrieval occurs at the final stage of face recognition, but the precise timing has not been thoroughly investigated. This study utilized ERPs in conjunction with a method for spatially localizing brain activity to investigate the neural mechanisms underlying face-name memory. Participants performed four tasks: perceiving unfamiliar faces, learning face-name pairs, recalling names from faces, and recognizing familiar faces without name retrieval. We found that recently learned face-name pairs activated the same brain regions as long-term familiar faces, but long-term familiar faces exhibited larger amplitudes for the P100 component in the ventral occipital cortex and the N400 component in the thalamus and Gpi. Faces that could be recognized by name elicited stronger N400 component responses, particularly in the left-hemisphere-dominant thalamus, Gpi, hippocampus, and putamen, compared to faces that were merely familiar but not name-associated. These results suggest that the N400 component may reflect the retrieval of name-related semantic information and the depth of retrieval for face-name pairs.

Full Text

Preamble

Brain Mechanisms in Face-Name Memory: Evidence From Event-Related Potentials and Spatial Localization of Brain Activity

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Abstract

Face-name memory represents a specialized form of memory that integrates visual and semantic processing. While existing research suggests that name retrieval occurs during the final stage of face recognition, the precise temporal dynamics remain incompletely understood. This study employed event-related potentials (ERPs) and a spatial localization method for brain activity to investigate the neural mechanisms underlying face-name memory. Participants completed four tasks: perceiving unfamiliar faces, learning face-name pairs, recalling names from faces, and recognizing familiar faces without names. We found that recently learned face-name pairs activated the same brain regions as long-term familiar faces, though long-term familiar faces exhibited larger amplitudes for the P100 component in the ventral occipital cortex and the N400 component in the thalamus and internal globus pallidus (Gpi). Faces that could be recognized by name elicited stronger N400 responses, particularly in left-hemisphere-dominant thalamus, Gpi, hippocampus, and putamen, compared to faces that were merely familiar but not nameable. These results suggest that the N400 component may reflect both the retrieval of name-related semantic information and the depth of face-name pair retrieval.

Keywords: face-name memory, face recognition, event-related potentials, N400, localization of brain activity

1 Introduction

Face recognition likely represents the most sophisticated cognitive function of the human brain, and understanding this function constitutes a primary scientific objective in psychophysiology and cognitive neuroscience (Rossion et al., 2023). Face-name memory holds considerable importance in face recognition research and in studies of Alzheimer’ s disease. It constitutes a form of associative memory lacking inherent conceptual connections (Kormas et al., 2020) and involves multiple interacting cognitive processes, including visual and semantic memory (Kozlovskiy et al., 2018), as well as attention, speech, and decision-making (Kozlovskiy et al., 2017; Robinson-Long et al., 2009). However, the spatiotemporal mechanisms underlying the recognition and name retrieval of faces remain incompletely investigated.

Researchers have proposed numerous cognitive models of face recognition (Bruce

& Young, 1986; Haxby et al., 2000; Schweinberger & Burton, 2003; Schweinberger & Neumann, 2016). Schweinberger and Neumann (2016) suggested that name retrieval may occur during the final stage of face recognition and depends on semantic access, as we sometimes cannot recall names of familiar individuals. Event-related potential studies indicate that the N400 component, which reaches maximum amplitude in the central parietal lobe, may be associated with activation of identity-specific representations of familiar faces (Ambrus et al., 2021; Eimer, 2000; Popova & Wiese, 2022; Pyasik & Vartanov, 2015; Schweinberger & Neumann, 2016; Wiese et al., 2019; Wiese, Anderson, et al., 2022; Wiese, Hobden, et al., 2022; Wuttke & Schweinberger, 2019) and with aspects of semantic face processing (Schweinberger & Neumann, 2016).

Research suggests that face-name recognition involves an extensive cortico-subcortical network (Robinson-Long et al., 2009), including the left prefrontal cortex, parieto-occipito-temporal junction, and hippocampus. Face processing occurs primarily in posterior occipito-temporal cortical areas of the right hemisphere, while name processing occurs mainly in anterior temporal areas of the left hemisphere, with the left parieto-subcortical region often considered a multimodal convergence zone (Joassin et al., 2007).

In this study, we employed a novel brain activity localization method called the "virtually implanted electrode" (Vartanov, 2022; Vartanov, 2023) and focused on the N400 component to compare ERPs from brain regions of interest during retrieval of recently learned versus long-term familiar face-name pairs, as well as ERPs for familiar faces with names versus merely familiar faces without names. Our aims were to elucidate the ERP mechanisms of name memory for faces and the temporal and spatial dynamics of interactions among brain regions. We also examined components N50, P100, N170, P200, N250, and P300.

2 Method

Participants

The experiment involved 66 participants (mean age = 21.83 years, SD = 3.57), including 33 females (17 Chinese and 16 Russian) and 33 males (18 Chinese and 15 Russian). All participants were right-handed, highly educated, and proficient in English. Before the experiment, Chinese participants were unfamiliar with the Russian celebrity names in the stimuli, and Russian participants were unfamiliar with the Chinese celebrity names. No participants had neurological disorders or head injuries, and none were taking antidepressants. The study was conducted in accordance with the Ethical Code of the Russian Psychological Society and the Department of Psychology at Lomonosov Moscow State University. All participants provided informed consent for personal data processing.

Stimuli

To control for effects of stimulus color and face gender, we used black-and-white photographs of male faces. All photos depicted full-face views against a white background, with neutral expressions and direct gaze. The individuals shown had no hats, tattoos, piercings, or other jewelry (earrings, necklaces, etc.).

Stimuli were presented on a computer screen (1080$×$1080 pixels) and, during the learning phase, printed on A4 paper. All experimental materials used English.

The following face photograph types were employed: (1) Faces unknown to participants: 20 photos of non-celebrity Chinese citizens and 20 photos of non-celebrity Russian citizens, all generated by artificial intelligence; (2) Faces known to only one participant group: 10 photos of Chinese celebrities (well-known in China but unknown in Russia) and 10 photos of Russian celebrities (well-known in Russia but unknown in China); (3) Faces known to all participants: 10 photos of European and American celebrities, selected as internationally recognized figures known in both Russia and China. Caucasian faces were used for this category.

Experimental Design and Procedure

Participants were positioned 70 cm from the center of the monitor screen.

Task 1 -Perception of Unfamiliar Faces (Figure 1 [Figure 1: see original paper], Figure 2 [Figure 2: see original paper]). Thirty unfamiliar faces were presented sequentially in random order: 10 Russian non-celebrity faces, 10 Chinese non-celebrity faces, and 10 actor faces (famous Russian actors for Chinese participants; famous Chinese actors for Russian participants). Each face appeared for 1000 ms, followed by a 500 ms interval with a central fixation point. Each face was presented 10 times, totaling 300 presentations. EEG was recorded, with markers placed at face onset for subsequent ERP averaging.

Task 2 -Learning Face-Name Pairs (Figure 3 [Figure 3: see original paper], Figure 4 [Figure 4: see original paper]). Participants memorized names for 10 unfamiliar actors from Task 1 (Russian celebrities with names for Chinese participants; Chinese celebrities with names for Russian participants). Faces and names were printed on paper, and participants studied them at their own pace until achieving error-free recall. Memorization success was verified, and participants restudied if errors occurred. Names were presented in English (black, Times New Roman font). EEG was not recorded during this task.

Task 3 -Recalling a Name by a Face (Figure 5 [Figure 5: see original paper]). Participants viewed face images (30 Chinese, Russian, and international celebrity faces familiar to participants, including 10 faces learned in Task 2) presented sequentially in random order. Each face was followed by a name (correct or incorrect) presented in black on a white background (Times New Roman font, centered). Faces and names each appeared for 1000 ms. Participants pressed the right arrow key if the name matched the face and the left arrow key if it did not. Each face was presented 10 times, totaling 300 presentations. EEG was recorded with markers at face onset for ERP averaging.

Task 4 -Recognition of Familiar Faces (Figure 6 [Figure 6: see original paper]). Participants viewed 40 face photos presented sequentially in random order: 20 faces from Task 1 that were not studied in Task 2 or presented in Task 3, and 20 previously unseen faces of unknown individuals (10 Chinese, 10 Russian). After each face, participants indicated whether they had seen it before. Faces and the familiarity question each appeared for 1000 ms. Participants pressed the right arrow key for previously seen faces and the left arrow key for new faces. Each face was presented 10 times, totaling 400 presentations. EEG was recorded with markers at face onset.

Equipment and Data Analysis

Stimuli were presented using Presentation software (version 20.2, Neurobehavioral Systems, Inc., USA). Brain activity was recorded monopolarly with a 19-channel EEG system ("Neuro-KM," Statokin, Russia). Two reference electrodes were placed on the mastoids, with electrode placement following the international 10-20 system. The BrainSys program (BrainWin, Russia) was used for artifact rejection.

We subsequently employed a novel brain activity localization technique called the "virtually implanted electrode" (Vartanov, 2022), which has demonstrated notable benefits for spatial localization (Vartanov, 2023). Activity was investigated at 53 sites selected from the MNI152 atlas, located at the centers of the following structures: Hypothalamus, Brainstem, Mesencephalon, Medulla Oblongata, Caudate Nucleus (left and right), Medial Globus Pallidus (left and right), Putamen (left and right), Thalamus (left and right), Hippocampus (left and right), Amygdala (left and right), Medial Cingulate Gyrus, Anterior Cingulate (BA32), Insula (left and right, BA13), Ventral Striatum (BA25), Dorsomedial Prefrontal Cortex (left and right, BA9), Supramarginal Gyrus (left and right, BA40), Parietal Cortex (left and right, BA7), Primary Visual Cortex V1 (left and right, BA17), Broca' s Area (left, BA44), Wernicke' s Area (left, BA22), BA44 (right), BA22 (right), Cerebellum (left and right), Angular Gyrus (left and right, BA39), Middle Frontal Gyrus (left and right, BA10), Orbital Frontal Cortex (left and right, BA47), V4 (left and right), V3v (left and right), VO1 (left and right), VO2 (left and right), PHC1 (OFA, left and right), and PHC2 (FFA, left and right).

Based on EEG activity localization, ERPs were averaged across all participants with 95% confidence interval estimation. For each structure, an integral index of average signal amplitude (standard deviation) was calculated across the entire EEG recording period for each condition, and correlation coefficients between all structure pairs were computed as functional connectivity indices. Additionally, "effective" (causal) connections were examined by analyzing ERP latency shifts between structures, allowing determination of causal linkage direction based on which structure showed activity changes first. This yielded comparative connectivity graphs among analyzed structures.

3 Results

3.1 Behavioral Results

3.1.1 Task 3 -Recalling a Name by a Face The average percentage of correct responses (hits) for the name recall task was 84.44%, significantly above chance (50%).

3.1.2 Task 4 -Recognition of Familiar Faces The average percentage of correct responses (hits) for the face familiarity recognition task was 76.6%, significantly above chance (50%).

3.2 ERP and Connectivity Results

3.2.1 Recently Learned vs. Long-Term Familiar Face-Name Pairs In Task 3 (name recall by face), participants retrieved names for two face types: recently learned and long-term familiar faces. ERPs from all participants (Russian and Chinese) were averaged to obtain:

- **LRN**: Recently learned faces (Russian celebrities for Chinese participants; Chinese celebrities for Russian participants)
- **OLD**: Long-term familiar faces (Russian and European/American celebrities for Russian participants; Chinese and European/American celebrities for Chinese participants)

The comparative oriented connectivity graph (Figure 7 [Figure 7: see original paper]) revealed that VO1 R, VO1 L, and VO2 L were strongly activated in both conditions, with P100–200 amplitudes of 10–12 μV. Regions important for face recognition and name retrieval were also activated, including the cerebellum, FFA R, hippocampus, putamen, thalamus, and internal globus pallidus (Gpi).

Examination of ERP waveforms (Figure 8 [Figure 8: see original paper]) showed that in initially activated areas (VO1 L, VO1 R, VO2 L, OFA R), left and right hemisphere ERPs appeared similar, with significant P100 amplitude differences showing larger amplitudes for long-term familiar faces. In subsequently activated areas, the N170 component was pronounced in the cerebellum and FFA R, but without significant amplitude differences across components. ERPs in the hippocampus, cerebellum, thalamus, and Gpi appeared similar, with no significant amplitude differences in the hippocampus and cerebellum. While early component amplitudes did not differ significantly in the thalamus and Gpi, the N400 component showed significant differences, with larger amplitudes for long-term familiar faces.

In summary, no qualitative differences emerged in strongly activated brain structures between recently learned and long-term familiar faces, suggesting they utilize the same cortico-subcortical network. Quantitative differences in amplitude likely reflect varying processing depths during short-term versus long-term memory retrieval. Joint activation of VO1 R, VO1 L, and VO2 L may correspond to ERP components P100-P200. In initially activated structures (VO1, etc.), early component differences were significant (P100) while late component differences were not. In immediately subsequent structures (FFA R, etc.), no component differences were significant. In the final activated structures (thalamus, Gpi), early component differences were non-significant while late component differences (N400) were significant. All differences indicated larger amplitudes for long-term familiar faces.

3.2.2 Unfamiliar Faces, Familiar Faces With Names, and Familiar Faces Without Names Tasks 1, 3, and 4 presented unfamiliar faces, familiar faces with known names, and familiar faces without known names, respectively. ERPs for each condition were averaged to obtain:

- **UNF**: Unfamiliar faces (all faces from Task 1)
- **F+N**: Familiar faces with names (all faces from Task 3)
- **F-N**: Familiar faces without names (faces from Task 4 that appeared in Task 1)

Notably, "F+N" and "F-N" differed in significantly activated brain structures (Figure 9 [Figure 9: see original paper]). The comparative oriented connectivity graph showed that VO1 R, VO1 L, and VO2 L were highly activated in both conditions, with P100 amplitudes reaching 10–12 µV. V4 R (P100 amplitude up to 9 µV) and right hemisphere Gpi (P300 amplitude up to 5 µV) showed strong activation during "F-N." Important regions included both thalamic hemispheres, both hippocampal hemispheres, and the right putamen.

Additionally, activation from the left hippocampus to the right putamen differed significantly between conditions: the correlation coefficient was 0.62 at 7 ms latency for "F+N" and 0.97 at 6 ms latency for "F-N," suggesting faster putamen activation for nameless faces. However, the dorsomedial prefrontal cortex inhibited the thalamus, Gpi, and putamen, with putamen inhibition differing between conditions.

ERP waveforms (Figure 10 [Figure 10: see original paper]) revealed that in initially activated areas (primary visual cortex, VO1 L, VO1 R, VO2 L, OFA R), both familiar face conditions showed similar patterns, with N50 components in both hemispheres and significant P100 amplitude differences in the right hemisphere (larger for faces with names). Two subsequent negative components between 100–200 ms (N140 and N170) showed larger amplitudes for faces without names. In later-activated areas (V4 L, V4 R, ventral striatum, both thalamic hemispheres, both Gpi hemispheres, both hippocampal hemispheres, both putamen hemispheres), ERPs began diverging in late components, with significant N400 differences in both hemispheres (larger for "F+N"). Additionally, the P100 component in V4 R showed larger amplitude for "F-N," while N170 differences were non-significant. The N250 component showed significant differences in the left thalamus and left hippocampus (larger for faces with names), and the P300 component showed significant differences in the ventral striatum, both thalamic hemispheres, both Gpi hemispheres, left hippocampus, and both putamen hemispheres (larger for "F-N").

For unfamiliar faces, the comparative oriented connectivity graph (Figure 11 [Figure 11: see original paper]) showed less extensive activation than for familiar faces, though VO1 R, VO1 L, and VO2 L remained strongly activated, with P200 amplitudes reaching 10–11 μV (Figure 10). Among important activated structures, the P100 component in both hemispheres differed significantly from familiar faces, with amplitudes ordered as "F+N" > "F-N" > "UNF." N170 amplitude differences were significant in V4 L, left thalamus, and both Gpi hemispheres, with larger amplitudes for unfamiliar faces. The P200 component in the left primary visual cortex and VO2 L differed significantly from familiar faces, with larger amplitudes for unfamiliar faces.

The N250 component, evoked in significantly activated right hemisphere regions, was not prominent for unfamiliar faces compared to familiar faces. In the N400 component, the left and right thalamus, Gpi, and left hippocampus showed clear separation across three conditions: faces with known names, unfamiliar faces, and familiar faces without known names, in descending amplitude order.

In summary, among familiar faces, VO1 R, VO1 L, and VO2 L were co-activated in both named and unnamed conditions, likely corresponding to the P100 component. Faces without names additionally activated V4 R (corresponding to P100) and right Gpi (corresponding to P300), with faster activation. Regarding ERP amplitudes, in initially activated areas (VO1, etc.), early components N50 and P100 showed larger amplitudes for faces with names, while N140 and N170 showed larger amplitudes for faces without names. In later-activated structures (thalamus, etc.), N250 and N400 showed larger amplitudes for faces with names, while P300 showed larger amplitudes for faces without names; N170 differences were non-significant. Unfamiliar faces activated relatively fewer brain regions, with strongly activated VO1 R, VO1 L, and VO2 L likely corresponding to the P200 component. The P100 component showed larger amplitudes for familiar faces, while the N170 component in both hemispheres and the P200 component in the left hemisphere showed larger amplitudes for unfamiliar faces. The N250 component was not evident in unfamiliar face activation areas. The more pronounced N400 components in the left hemisphere thalamus, Gpi, and hippocampus showed the largest amplitude for familiar faces with known names, intermediate for unfamiliar faces, and smallest for familiar faces without known names.

4 Discussion

4.1 Recently Learned vs. Long-Term Familiar Face-Name Pairs

Our methodology focused on differences in highly activated brain areas, activation time delays, inhibitory activation patterns between regions, and ERP amplitude differences. A key question concerns whether memory retrieval differs between newly learned (short-term memory) and long-term familiar (long-term memory) face-name pairs.

During name recall from faces, the retrieval process generally proceeds through the cerebral cortex before converging on subcortical structures. No significant differences emerged in activated brain regions when recalling names for recently learned versus long-term familiar faces, suggesting they utilize the same cortico-subcortical structural network (no qualitative differences). Amplitude differences likely reflect quantitative variations in processing depth during long-term versus short-term memory retrieval. Early in memory retrieval, significant P100 differences in the ventral occipital lobe may indicate the onset of deep long-term memory retrieval for faces around 100 ms. These differences disappeared during the middle period, reflecting simultaneous spatial and depth-based information processing. Late N400 differences were significant in subcortical structures—the thalamus and Gpi—which are involved in cognitive processing (Navid et al., 2022) and possibly in retrieving names from long-term memory when processing depth again becomes more profound (Kutas & Federmeier, 2000).

4.2 Unfamiliar Faces, Familiar Faces With Names, and Familiar Faces Without Names

According to Schweinberger and Neumann's (2016) face recognition model, name retrieval occurs at the final stage of familiar face recognition. We therefore examined how recognizing faces with known names differs from the late stage of recognizing faces that are merely familiar but nameless.

Our results show that when recognizing faces with and without names, the dorsomedial prefrontal cortex exhibits inhibitory effects on the thalamus, Gpi, and putamen, likely reflecting high task complexity and cognitive conflict (Clairis & Lopez-Persem, 2023). The hippocampus and putamen have been shown to be important for memory (Driscoll et al., 2024; Packard, 1999; Sadeh et al., 2011) and may interact (Poldrack & Packard, 2003). In the absence of a name, the left hippocampus activated the right putamen faster, suggesting that processing and retrieval of nameless memories is faster, while name processing requires greater cognitive effort and resources. Human names have low frequency, allow infinite sound variations, lack inherent meaning, are arbitrarily linked to faces, cannot be mentally visualized, and have few connections to facial features (Kormas et al., 2020), consequently slowing activation rates.

Additionally, the additional strong V4 R activation at 100 ms for faces without names represents an intermediate processing step in the lateral visual pathway important for object recognition, perceptual decision-making, and higher-order behavior (Pasupathy et al., 2020). The globus pallidus has been linked to cognitive function and working memory (Barón-Quiroz et al., 2021), and the additional strong right Gpi activation at 300 ms may relate to working memory processes (Donchin, 1981; Linden, 2005; Polich et al., 2007). Activation of both areas may thus reflect activation of task-relevant information in participants' working memory.

Regarding activation time courses, the P100 component in initially activated areas was larger for faces with names, possibly reflecting deeper processing, while N170 was larger for faces without names, perhaps reflecting person recognition in relation to task demands. In subcortical structures, N250 and N400 were larger for faces with names, possibly reflecting name retrieval and deeper processing, with approximately 400 ms being optimal for distinguishing named from unnamed information.

Having discussed familiar face recognition, what differences emerge in ERPs when recognizing unfamiliar versus familiar faces? Early N50 activation and large P100 amplitudes for familiar faces may indicate that the brain has already sensed familiarity (Förster et al., 2020), although this contradicts some studies (Marzi & Viggiano, 2007; Abreu et al., 2023), possibly due to differences in stimulus materials and tasks.

Significant P200 component activation (Latinus & Taylor, 2006; Schweinberger & Neumann, 2016) in ventral occipital regions VO1 R, VO1 L, and VO2 L during unfamiliar face recognition, along with significant N170 component activation (Cheng & Pai, 2010; Schweinberger & Neumann, 2016) primarily in subcortical structures, may imply processing of facial identity features, whereas familiar faces require less deep processing. The N250 component increases significantly for familiar faces (Wiese, Hobden, et al., 2022; Wiese et al., 2023). In the N400 component, the left hemisphere thalamus, Gpi, and hippocampus showed clear three-group separation (Salisbury & Taylor, 2012; Vigneau et al., 2011), with amplitudes from largest to smallest for: faces with known names, unfamiliar faces, and familiar faces without known names. Interestingly, if the N400 component reflected only familiarity (Ambrus et al., 2021; Wiese, Hobden, et al., 2022), unfamiliar faces should have shown the lowest amplitude, which was not the case. This suggests the component may reflect not only familiarity but also retrieval of name-related semantic information (Barrett & Rugg, 1989; Schweinberger & Neumann, 2016), consistent with our assumptions.

In summary, retrieval of face-name pairs from both long-term and short-term memory activates the same brain network. However, long-term memory retrieval involves more extensive processing, as indicated by P100 activation in the ventral occipital cortex and N400 activation in the thalamus and right hemisphere Gpi. Faces associated with names provide more detailed information than merely familiar but nameless faces. Recognizing familiar but nameless faces is slower and involves deeper processing. In left-hemisphere-dominant subcortical structures—particularly the thalamus, Gpi, hippocampus, and putamen—a late negative component (N400) may indicate retrieval of name-related semantic information. Perception of known faces is detected in the primary visual cortex and ventral occipital cortex from early processing stages (N50, P100, N250), whereas unfamiliar face perception requires additional feature processing (N170, P200).

5 Conclusion

Our work provides further evidence for face-name association retention. Successful face-name memory retrieval is strongly associated with N400 component activation, particularly in the thalamus, Gpi, hippocampus, and putamen. The N400 component may reflect retrieval of name-related semantic information and the depth of face-name pair retrieval.

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Figure 1 Examples of Faces Shown to Russian Participants in Task 1

1000ms 500ms

Note. From left to right: famous Chinese face, unfamiliar Chinese face, unfamiliar Russian face.

Figure 2 Examples of Faces Shown to Chinese Participants in Task 1

1000ms 500ms

Note. From left to right: famous Russian face, unfamiliar Chinese face, unfamiliar Russian face.

Figure 3 Examples of Faces of Famous Chinese Actors With Corresponding Names Learned by Russian Participants in Task 2

Figure 4 Examples of Faces of Famous Russian Actors With Corresponding Names Learned by Chinese Participants in Task 2

Figure 5 Examples of Faces and Names of Celebrities Shown to Participants in Task 3

1000ms 1000ms

Note. From left to right: famous Chinese face, name (correct); famous American face, name (incorrect); famous Russian face, name (correct).

Figure 6 Examples of Faces and Questions Shown to Participants in Task 4

1000ms 1000ms

Note. From left to right: familiar Chinese face, question (Yes); unfamiliar Chinese face, question (No); familiar Russian face, question (Yes); unfamiliar Russian face, question (No).

Figure 7 Comparative Oriented Connectivity Graph of the Studied Brain Structures for Recently Learned Face-Name Pairs (LRN) and Long-Term Familiar Face-Name Pairs (OLD)

Note. Here and below, black connecting lines indicate overall positive correlation, dashed lines indicate inhibition (negative correlation), and arrows indicate causation; circles represent cortical structures, squares represent subcortical or bilateral structures; yellow indicates all highly activated area groups, blue indicates the first group, and green indicates the second group.

Figure 8 ERPs for Recently Learned Face-Name Pairs (LRN) and Long-Term Familiar Face-Name Pairs (OLD)

Note. Here and below, small dotted lines represent 95% confidence intervals. The horizontal axis shows time in ms; the vertical axis shows amplitude in V.

Figure 9 Comparative Oriented Connectivity Graph of the Studied Brain Structures for Familiar Face with Name (F+N) and Familiar Face Without Name (F-N)

Figure 10 ERPs for Unfamiliar Face (UNF), Familiar Face With Name (F+N) and Familiar Face Without Name (F-N)

Figure 11 Comparative Oriented Connectivity Graph of the Studied Brain Structures for Unfamiliar Face (UNF)

Note: Figure translations are in progress. See original paper for figures.