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Features of Memory Consolidation and Reconsolidation Processes in Patients With Cerebrovascular Disorders

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Abstract: **Introduction**. Given the high prevalence of cerebral circulatory disorders (both acute and chronic), which are accompanied by a decrease in cognitive functions, for the most part, the effectiveness of rehabilitation and rehabilitation measures depends, among other things, on mnestic processes. The authors describe the characteristics of the memory consolidation and reconsolidation processes in patients with chronic (chronic cerebral ischemia) and acute (ischemic stroke in the circulation of the middle cerebral artery of hemispherical localization) disorders of the cerebral circulation. The study aimed to investigate the processes of consolidation and reconsolidation of memory in patients with impaired cerebral circulation (with acute and chronic cerebral ischemia). **Methods**. The research methods were methods of "10 words" and "Visual memory" by A. R. Luria, the experiment according to F. Bartlett's scheme, methods of descriptive and comparative statistics. The total size of the research sample is 57 people aged 65.2 ± 2.78 years. The first group included patients with chronic cerebral ischemia – 21 people; the second group included the patients with left-sided localization of the ischemic stroke focus – 17 people; the third group also included patients who had suffered an ischemic stroke, 19 people – with the localization of the dextrocerebral affected area. **Results**. In patients with cerebral circulatory disorders, a decrease in short-term audio-verbal and visual-picturesque memory volume was revealed, regardless of the type of cerebral circulatory disorder (acute or chronic cerebral ischemia). In an ischemic stroke of hemispheric localization, a change in the qualitative and quantitative characteristics of the memory consolidation and reconsolidation processes has been experimentally proven. This change is a consequence of a decrease in the volume of short-term audio-verbal and visual-picturesque memory. **Discussion**. The decrease in volume leads to instability of the memory traces, which distorts the consolidated information. In the process of reconsolidation, there is a reduction (in case of chronic cerebral ischemia) and distortion (in case of ischemic stroke of hemispheric localization) of the reproduced information.

Keywords: visual-picturesque memory, semantic memory, memory consolidation, memory reconsolidation, cerebrovascular disorders, ischemic stroke, chronic cerebral ischemia, short-term memory, long-term memory, memory traces (engrams)

Highlights:

- Memory as a process is carried out through memorization, which goes through short-term and long-term phases.
- Consolidation of memory leads to the transformation of the stored content.
- Each time the memory is retrieved, the old memory trace is replaced with new content (the change may be partial or complete).
- A decrease in volume leads to instability of memory traces and distortion of consolidated information, regardless of its quality (audio-verbal and visual-picturesque).

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Introduction

According to statistics, in 2017 in Russia, the number of patients diagnosed with the ICD group "Other cerebrovascular diseases" per 100.000 adult population was 5.560. Several works indicate the early development of cognitive disorders, including mnestic, in chronic cerebral ischemia (Zakharov et al., 2020; Kulesh et al., 2021).

Currently, a lot of attention is paid to the research of mnestic functions: in sensory disorders (visual and hearing disorders) Rosemann & Thiel (2020), Loughrey et al. (2021), Moorman et al. (2020), Griffiths et al. (2020), Zakharova et al. (2022); in Parkinson's disease and other neurodegenerative diseases, memory processes are studied by Barone et al. (2009), Berganzo et al. (2016), Brefel-Courbon et al. (2013), Hou & Lai (2007), Pourzinal et al. (2021), Siciliano et al. (2021), Nikishina et al. (2022), Nikishina et al. (2021). In mental illness, the role of memory was considered by Alekseev et al. (2021). Tikhomirova et al. (2020) present the results of a study of the dynamics of changes in visuospatial working memory in primary school, adolescence and youth, indicating the importance of several years of study in the development of visuospatial working memory during the training period. Many studies are devoted to the study of the possibilities of using memory reconsolidation processes for psychological interventions aimed at modifying memories (Yang et al., 2019; Bellfy & Kwapis, 2020; Pan et al., 2021; Milton, 2022). Nikitin et al. (2020) in their research question the effectiveness of the memory reconsolidation procedure to suppress negative pathological memory, pointing out that a violation of reconsolidation of at least some forms of memory can lead not only to temporary suppression or erasure of memory but also to the formation of stable irreversible anterograde amnesia.

Mnestic functions are studied concerning processes and types in which it is implemented and functions, have a significant compensatory resource for several disorders, regardless of age. In terms of the effectiveness of rehabilitation measures for patients with cerebral circulatory disorders (both acute and chronic), mnestic functions play an essential role.

Presenting the results of modern research in a review article by Jardine et al. (2022), the authors concluded that after consolidation, long-term memories exist in a stable form. During reactivation, memory can become labile or unstable, depending on whether the reactivation conditions involve destabilization mechanisms. It is possible that memory reactivation does not cause memory destabilization if there are certain boundary conditions that prevent modification, in which case the memory will remain in a stable form. When memory destabilization occurs, the memory becomes susceptible to change. A destabilized memory is labile for a limited period before it reconsolidates and returns to a stable and potentially enhanced or otherwise updated state. Violation of reconsolidation by pharmacological or behavioral interventions will prevent the return of memories to a stable form (erasure) or lead to the restoration of a weakened version of the original memory. The process of reconsolidation "opens a window" of opportunities for updating consolidated memories with new information. Numerous studies presented in the authors' review paper have shown that reactivated memory traces can be weakened, strengthened, or otherwise "updated" during the post-reactivation window. Incorporating new information into existing memory networks is another type of memory update that probably happens regularly in the real world. The phenomenon of recovery-extinction is the most widely studied form of memory renewal outside the models of memory weakening or strengthening. Extraction-extinction paradigms demonstrate that targeting and remodelling of established memory during the window after reactivation can more efficiently update memory performance compared to typical extinction procedures.

Bazyan (2013), considering the molecular-neurochemical and neurophysiological mechanisms of brain plasticity in the process of consolidation, storage, and reproduction of memory, found that the basis for the implementation of behavior and learning is the modification of the efficiency of synaptic transmission, which is consolidated and maintained for a long time. From the point of view of molecular and cellular mechanisms of neuronal functioning, it does not matter how the efficiency of synaptic transmission is modified: by training an entire animal, by combined activation of two neuron inputs, by high-frequency stimulation or by pharmacological action. The NMDA receptor plays a key part in the plasticity of glutamatergic synapses. The reminder starts the recycling and updates the neural network and working memory from the storage stage. The prolonged absence of a reminder leads to the degradation of a specific cluster in the endosome, forgetting and erasing memory. Actualization of the neural network and working memory is possible because the reproduction of the specific activity of the GABA receptor reproduces the specific activity of the glutamatergic receptors of this neuron associated with it through the intracellular integration based on a transduction signal.

Molecular mechanisms of memory modification were also considered by Balaban (2017). The author proceeds from the assumption that when reactivating long-term memory, a process of local labilization/destabilization/erasure of existing memory occurs in the synapses of the neural network underlying this type of memory, with the participation of nitric oxide. In this case, the mechanism of synthesis of the same proteins is triggered, violations of which manifest themselves in the form of memory disappearance during subsequent testing. On the basis of the results of numerous studies conducted by Balaban, the mechanism of maintaining long-term memory can be mediated by the protein kinase M-zeta, and memory modification can be associated with the destruction of this protein with the participation of nitric oxide.

Mastrorilli et al. (2022), evaluating the role of memory in the process of restorative learning, found that distributed learning leads to more reliable memory formation compared to short-interval learning. Although this phenomenon, called the distributed practice effect, is ubiquitous for a variety of tasks and organisms and has long been known to psychologists, its neurobiological basis is still poorly understood. Using the striatum here as a model system, we tested the hypothesis that the ability of distributed learning to optimize memory may depend on the

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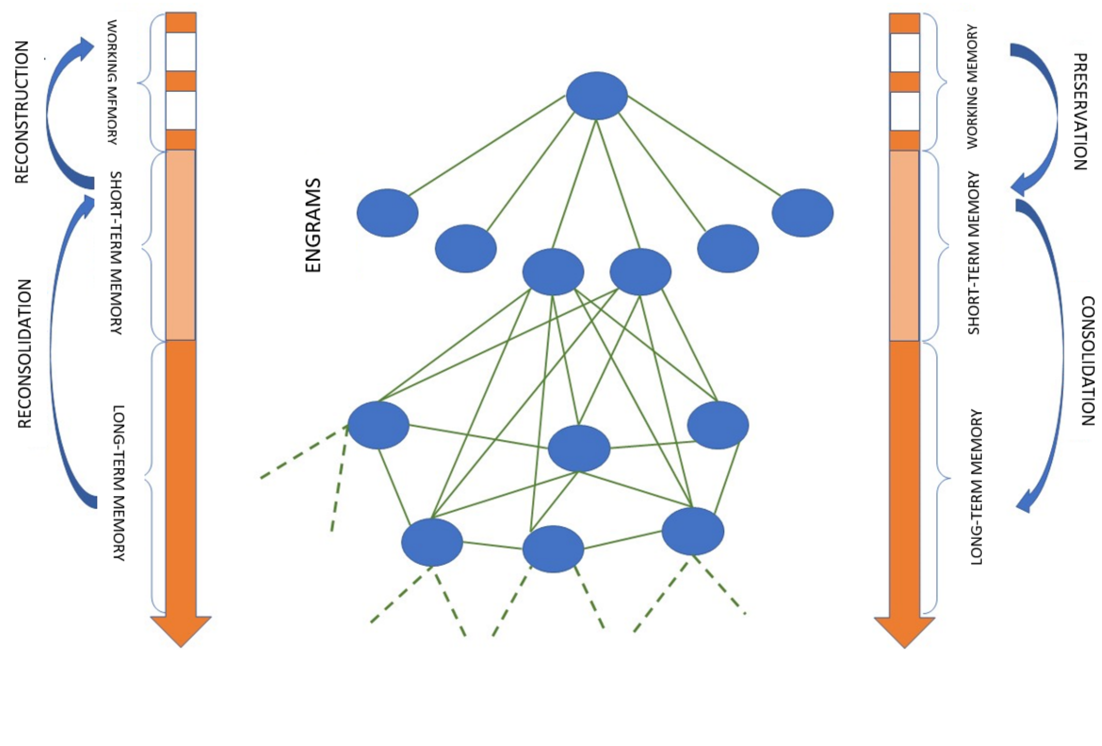
recruitment of various neural substrates compared to those involved in massive training. First, by comparing the medial and lateral domains of the dorsal striatum after massive and distributed training, we demonstrated that the neural activity assessed using c-Fos expression depends differently on the training protocol in the two subregions of the striatum. Then, by blocking AMPA receptors before recollection, we provide evidence confirming the selective role of the medial and lateral striatum in storing information obtained as a result of massive and distributed training, respectively. Finally, we found that optogenetic stimulation of the dorsolateral striatum during massive learning allows the formation of long-term memory similar to that observed in distributed training. Hegazy et al. (2022) in their study of the relationship between memory deficit and motor dysfunction of the upper extremities in stroke patients proved the presence of a significant correlation between memory deficiency and motor dysfunction in stroke and hemiplegia patients, leading to a decrease in the efficiency of the process of restoring motor functions (because restoring motor functions requires stored memory).

The presented research was methodologically based on the provisions of K. V. Anokhin's concept of memory (Anokhin, 2009) and the provisions of B. B. Velichkovskii's working memory concept. Memory as a process is carried out through memorization, which goes through two stages (phases). The short-term phase is characterized by the fixation of the stored information fully (without loss and distortion of the content) for a short period. It is a labile phase of memory, which corresponds to the retention of an information trace in the form of reverberation of nerve impulses. The long-term phase of memorization is characterized by a reduction in the amount of information during its subsequent long-term storage without making changes (Fig. 1).

Figure 1

Conceptual and experimental modelling of the study of memory consolidation and reconsolidation



Working memory characterizes the system of cognitive processes that ensure the processing and operational storage of information. It is a multi-component system, the functional organization of which ensures the implementation of the storing and processing information functions. By its purpose, working memory is not species-specific. Its content is determined by the type of memory. According to the functional result, memory is divided into figurative (visual-picturesque, figurative-symbolic, audio-verbal) and semantic.

At the stage of saving information, its simplification ("compression") occurs. While cognitive processing, information in working memory is transformed into a primary mnestic image or primary semantic content, forming traces of memory (engrams). Accordingly, the storage of information in working memory is driven by mechanisms of both short-term and long-term storage. Short-term storage mechanisms are meant to be used for the operational storage of information, which is especially significant for solving the current cognitive task (Velichkovskii, 2015).

When new information is consolidated, providing a transition from short-term to long-term memory, neural circuits are organized by changing synaptic activity between neurons included in this circuit. An access system is being formed to extract the information needed at a given time and to reconsolidate memory traces after "using" them (reproducing stored information). During consolidation, there is a further transformation of the stored information (regardless of the modality) by the available experience. The newly saved information is compared with the information already available in the long-term system. With the reactivation of memory, which provides information retrieval, its active reconstruction occurs, which, in turn, is accompanied by recategorization. Each recategorization is followed by the process of re-preservation of information (reconsolidation) (Grigor'yan, Markevich, 2014). Thus, each memory extraction is accompanied by the replacement of the old memory trace with new content (it may fully or partially change).

According to the results of Velichkovskii's long-term research (2014, 2015), violations of working memory, regardless of their cause, lead to a reduction in a person's ability to process information, make suboptimal decisions and, in general, to a decrease in adaptive potential (Velichkovskii, 2014, 2015).

The paper aimed to study the processes of consolidation and reconsolidation of memory in patients with cerebral circulatory disorders (ischemic stroke in the middle cerebral artery circulation of sinistrocerebral and dextrocerebral localization; chronic cerebral ischemia due to occlusion and arctation of cerebral arteries).

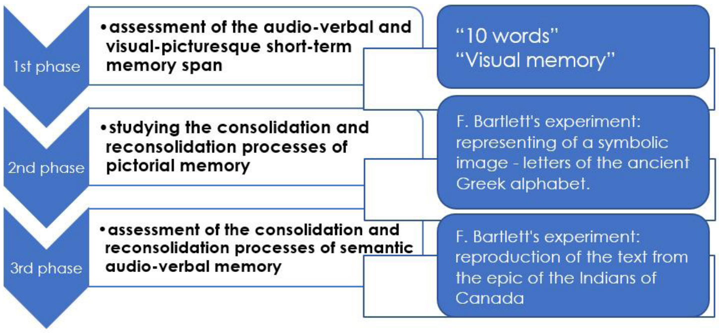
Methods

The total volume of the research sample was 57 people aged 65.2 ± 2.78 years. The first group included patients with a diagnosis of I66 – "Occlusion and arctation of the cerebral arteries that do not provoke a cerebral infarction" (according to ICD-10) – 21 people; the second group consisted of patients with a diagnosis of I63 – "Cerebral infarction" (according to ICD-10) – 17 people with the sinistrocerebral lesion; in the third group also included patients with a diagnosis of "Cerebral infarction" in the number of 19 people – with the dextrocerebral lesion. The research groups were equalized by gender. The criterion for inclusion of patients in the study program was the absence of pronounced cognitive impairment (at least 23 points on the MMSE scale in quantitative terms). The study was carried out individually with the informed consent of the patients.

The organization of the study included three stages (Fig. 2).

Figure 2

Stages of research and methodological support



In the first stage, the volume of short-term audio-verbal and visual-picturesque memory was estimated using techniques developed by A. R. Lariya (Bizyuk, 2005). To estimate the volume of short-term audio-verbal memory, we let the patients read a list of 10 unambiguous one- or two-syllable words, semantically unrelated, having a specific meaning. After presenting a complete list of words, the patient had to reproduce the presented stimulus words. The procedure was repeated five times. In this stage following indicators were fixed: the number of correctly reproduced stimulus words, the number of repeatedly repeated words in each presentation, and the number of introduced words. The volume of short-term visual-picturesque memory was evaluated using the "Visual memory" technique. As stimulus material, patients were presented with a table consisting of 16 cells. Each cell contained one contour image of a separate object (geometric shapes and schematic images of objects). The one-time table presentation time was 2 minutes. After each presentation, the patient had to name all the objects depicted in the table cells that he remembered. This procedure was also repeated five times. The following indicators were recorded: the number of correctly reproduced visual-picturesque stimuli, the number of repeated images in each presentation and the number of words introduced.

To determine the features of the processes of consolidation-reconsolidation of memory in patients with cerebral circulatory disorders, a comparison group with the normative ageing process (52 people) was included in the study – correlated by age (67.2 ± 3.26 years), but with no history of cerebral circulatory disorders and the absence of severe somatic pathology. This group of subjects was formed based on the results of the planned medical examination procedure.

The study of the processes of consolidation and reconsolidation of visual-picturesque and semantic audio-verbal memory was carried out according to the experimental scheme proposed by F. Bartlett for the reconstruction of memory during its active extraction.

In the second stage, to study the processes of consolidation and reconsolidation of visual-image memory as a stimulus material (the selection criterion was the absence of this image in the previous experience), patients were offered an emblematic figure – a letter of the ancient Greek alphabet resembling an owl (Fig. 5). This symbol included four parts ("head", "trunk with leg", "wing", "leg"), in each of which elements were highlighted (for example, the "head" part contains two components – the head itself and the inner part in the form of a "tick"). Initially, patients had to copy the image. Then, at some intervals (after 40 minutes, 4 hours, and 36 hours), the patients had to reproduce the figure from memory. The evaluation of visual-picturesque memory was carried out according to such criteria as the integrity of the image, the number of losses, the number of distortions, and the number of stored elements.

The assessment of the processes of consolidation and reconsolidation of semantic audio-verbal memory was carried out in the third stage of the study. The text from the epic of the Indians of Canada, presented in Russian, acted as stimulus material. The text consisted of 79 semantic units (33 sentences, 1427 simbols, 295 words). A semantic unit was understood as a grammatical form characterized by semantic content and realized in various combinations of nouns as the leading linguistic form with other ones (adjectives, verbs, pronouns). When the text was read to the patients, they had to retell it accurate as possible. After the time intervals (40 minutes, 4 hours, 36 hours), the patients had to reproduce the text from memory. The evaluation of semantic audio-verbal memory was carried out according to such criteria as the number of preserved sentences, the number of preserved semantic units, the number of distorted sentences, the number of distorted semantic units, the number of violations of the sequence of the sentences, the number of violations of the sequence of semantic units.

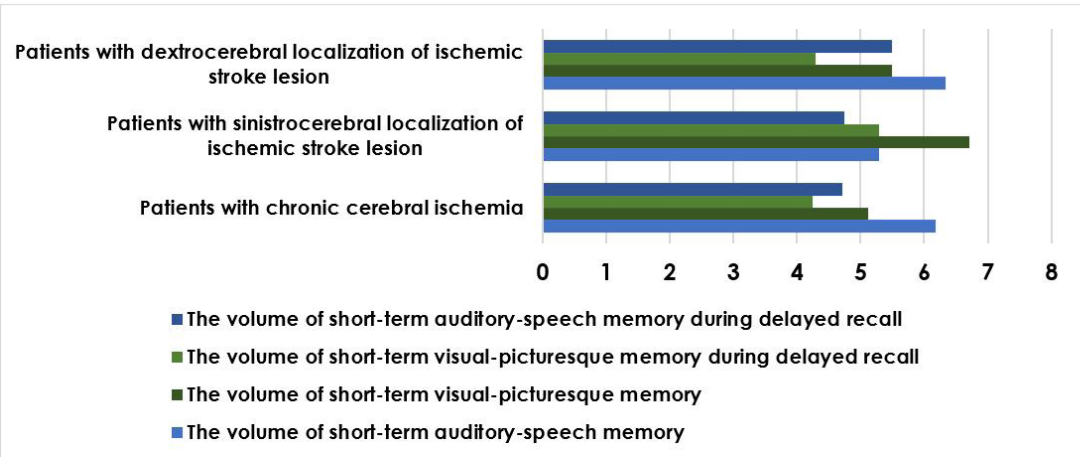
Statistical analysis of the obtained data was carried out using descriptive and comparative methods (Mann–Whitney U test, $p < 0.05$) statistics. A comparison of research groups by quantitative indicators was carried out in pairs.

Results

The volume of short-term auditory-speech and visual-picturesque memory was assessed in patients with cerebrovascular diseases. As a result, the persistent decrease in the volume of short-term auditory-speech and visual-picturesque memory was found in all groups of subjects in comparison with the group of subjects with normative aging (Fig. 3).

Figure 3

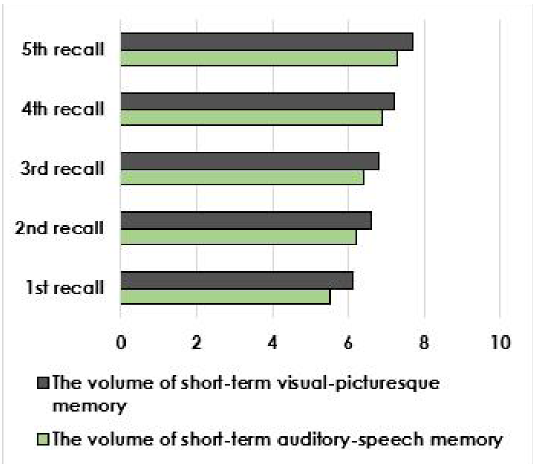
Histogram of average values of indicators of the volume of short-term auditory-speech memory during direct and delayed (40 minutes) recall



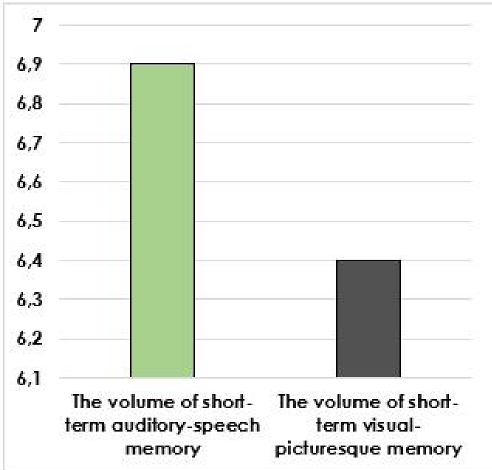
Considering that one has normative aging, the volume of short-term auditory-speech and visual-figurative memory corresponds to the lower limit of normal. The memory curve has the following form: visual-picturesque memory – 6, 7, 7, 7, 8; auditory-speech memory – 6, 6, 6, 7, 7 (Fig. 4).

Figure 4

Histogram of the average values of short-term auditory-speech memory during direct and delayed (40 minutes) recall during normal aging



Memory volume by series



Delayed recall

Qualitative analysis of the recalled material allows one to identify the specialized features of stored information. In chronic cerebral ischemia, the loss of incoming information with perseverative repetition of recalled stimulus words should be indicated as a general trend. In ischemic stroke, perseverative repetition of recalled stimulus words was not found. However, depending on the hemispheric localization of the lesion of ischemic stroke, recall errors have their own specifics. With sinistrocerebral localization of ischemic stroke lesion, patients almost flawlessly recalled the stimulus words presented last (2–3 words) and presented first in the list (2–3 words). When recalling visual-picturesque information, the patients primarily reproduced the visual images shown on the left side in the table. Rare perseverative repetitions of words consonant with stimulus word are noted. In case of dextrocerebral localization of ischemic stroke lesion, patients carried out the replacement of stimulus words with a synonymous concept. When recalling visual-picturesque information, patients reproduced a certain generalized image, including images of individual elements from different cells of the table with stimulus images.

When assessing the significance of the differences, we found that in patients with dextrocerebral localization of ischemic stroke lesion, the volume of short-term visual-picturesque memory is significantly lower than in patients with sinistrocerebral localization of the stroke lesion (both with direct recall – $p = 0.027$, and with delayed recall – $p = 0.022$), and also lower than in patients

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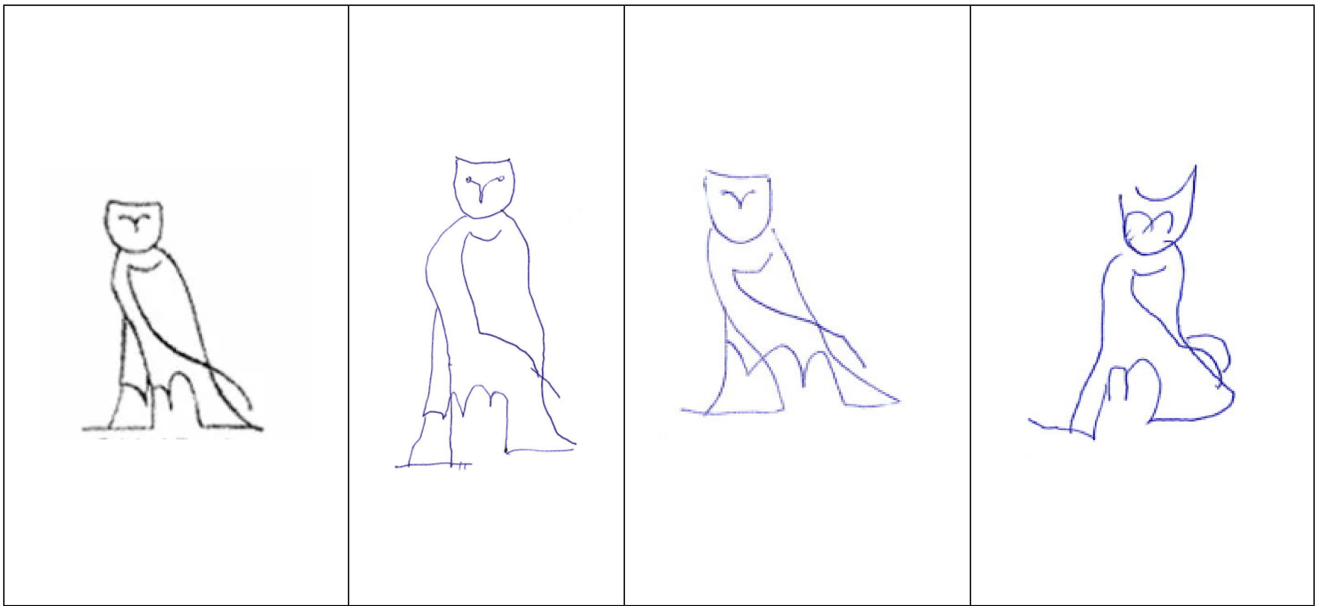
with chronic cerebral ischemia (with direct recall – p = 0.025, and with delayed recall – p = 0.020). The maximum decrease in the volume of short-term auditory-speech memory is reliably captured in the sinistrocerebral localization of the lesion: both during direct recall (compared with patients with dextrocerebral localization of the lesion, p = 0.020; compared with patients with chronic ischemia, p = 0.044), and with indirect recall (compared with patients with dextrocerebral localization of the lesion, p = 0.024; compared with patients with chronic ischemia, p = 0.048).

As a result of the study of the processes of consolidation and reconsolidation of visual-picturesque memory, the following features were revealed. At the stage of copying in all groups of patients, the preservation of the image of all elements of the symbol is clearly observed (Fig. 5).

Figure 5

Stimulus image for copying and example images at the copying stage divided by patient groups



Stimulus image	Chronic cerebral ischemia	Sinistrocerebral localization of the lesion	Dextrocerebral localization of the lesion

In this case, we can state the preservation of the symbolic image at the stage of copying. In the volume of working memory, the original stimulus is preserved without losing elements and bringing it to a specific image. The process of storing visual-picturesque information in short-term memory with subsequent consolidation ensures the fixation of a symbolic image with almost no distortion. Inaccuracies in the connection of image lines were detected only in patients with dextrocerebral localization of ischemic stroke lesion.

With delayed recall after 40 minutes, as well as when recalling a stimulus symbolic image after 4 hours and 36 hours, regardless of the nature of cerebrovascular accident, recall of distorted symbolic content is observed (Fig. 6).

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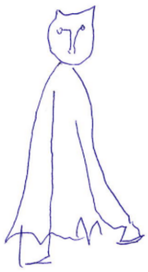
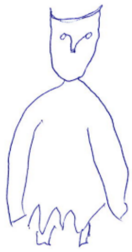
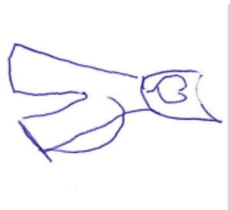
Figure 6

Examples of images of patients with cerebrovascular disease when recalled after 40 minutes, 4 hours, 36 hours

I. Recalled after 40 minutes		
		
Chronic cerebral ischemia	Sinistrocerebral localization of the lesion	Dextrocerebral localization of the lesion
II. Recalled after 4 hours		
		
Chronic cerebral ischemia	Sinistrocerebral localization of the lesion	Dextrocerebral localization of the lesion

III. Recalled after 36 hours		
		
Chronic cerebral ischemia	Sinistrocerebral localization of the lesion	Dextrocerebral localization of the lesion

Minimal distortions of the symbolic image were found in the group of patients with chronic cerebral ischemia. When reproducing the symbol from memory, after 4 hours and 36 hours, the image details are brought to a symmetrical shape – the second leg is drawn in frontal view.

In groups of patients with ischemic stroke, with delayed recall – after 40 minutes, as well as after 4 hours and 36 hours, the reduction in image elements is observed up to a complete loss of the original content. In 50 % of cases, patients with ischemic stroke could not completely reproduce the stimulus symbolic image after 36 hours, regardless of the disease hemispheric localization. It indicates a complete loss of memory traces. As a specific feature, one should note that in patients with dextrocerebral localization of ischemic stroke lesion during delayed recall, the preservation of the largest elements of the symbolic image is observed, allowing it to be identified with the original one. At the same time, distortion during reproducing is quite significant. In patients with sinistrocerebral localization of ischemic stroke lesion, when recalled after 40 minutes, 4 hours and 36 hours, there is a complete loss of the original symbolic image. At the same time, we can state the preservation of individual elements in the form of continuous lines.

Therefore, when extracting visual-picturesque information in patients with cerebrovascular accident in the form of ischemic stroke of hemispheric localization, an image transformation is observed with a complete loss of symbolic meaning. In chronic cerebral ischemia, the original symbol is transformed in the direction of its concretization and reduction to a symmetrical image.

When studying the processes of consolidation and reconsolidation of auditory-speech memory in patients with cerebrovascular accident, a text evaluation scheme was built for each patient, reflecting the quality of reproduction of semantic units in relation to their distribution over text sentences (Fig. 7).

As a result of text recalling immediately after presentation, the maximum loss of semantic content was recorded in all groups of subjects. The most complete semantic content was recalled by patients with chronic cerebral ischemia. The loss of semantic content during direct recall was 61.7 %. In ischemic stroke, the loss of semantic content also ranges from 60 to 63 % (with the sinistrocerebral localization of ischemic stroke lesion 60.9 %; with the dextrocerebral localization of ischemic stroke lesion – 63.1 %). However, unlike patients with chronic cerebral ischemia, in ischemic stroke, semantic content distortions and semantic confabulations are observed.

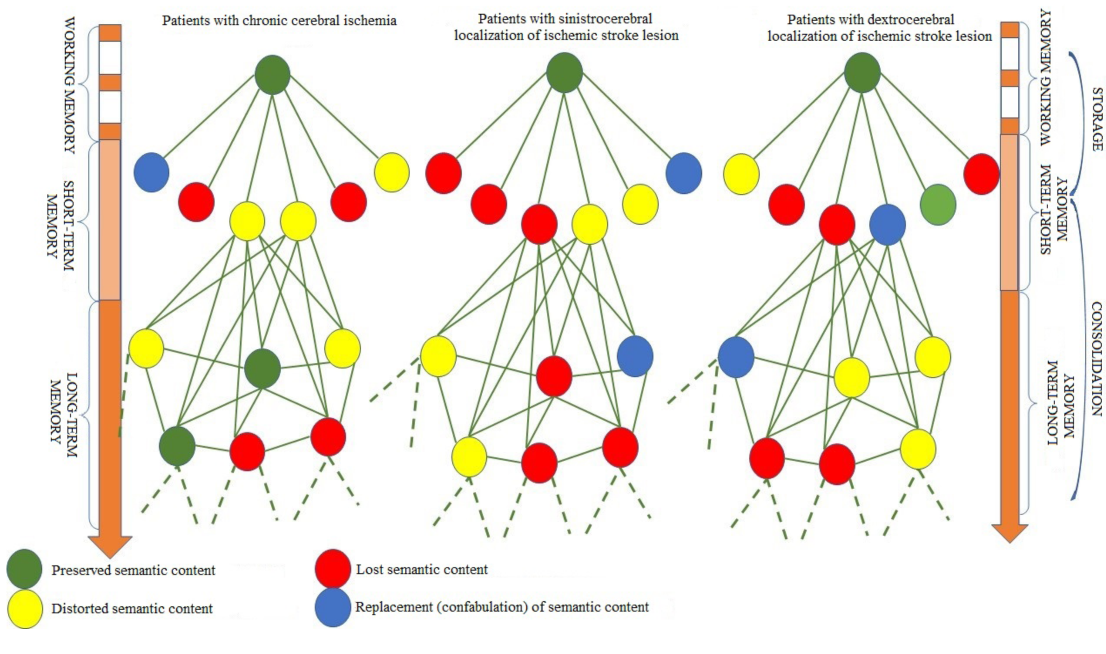
When analyzing the number and nature of errors made during the direct recalling of auditory-speech information, as well as at time intervals of 40 minutes, 4 hours and 36 hours, in all groups of subjects, a decrease in the number of correctly recalled semantic units was found with an increase in the number of distorted and confabulatory semantic units. In addition, one should note an increase in the number of incoherent sentences that do not have semantic content, with each subsequent reconsolidation – after 40 minutes, 4 hours, 36 hours.

As a general trend, we can state the schematization and concretization of the text. In cases of cerebrovascular accidents, with the general preservation of semantic units, the structure of the sentence is significantly reduced and simplified. The semantic content remains more unchanged in comparison with the specific wording of the sentence. At all of time intervals of recalling, the relative stability of the content of the text is characteristic in comparison with that which was saved by patients during direct recall.

For patients with chronic cerebral ischemia, it is typical to simplify the sentence with a distortion of its semantic content, as well as the use of sentences either short or, conversely, combined into one several sentences with a common semantic content. Patients with sinistrocerebral localization of ischemic stroke lesion are characterized by a violation of the sequence of semantic units, as well as their significant loss. At the same time, there are multiple additional details and their excessive use. Patients with dextrocerebral localization of ischemic stroke lesion, while maintaining the overall logical sequence of the presentation of the semantic content, miss a significant amount of detail. In turn, it leads to a distortion of the semantic content up to its complete loss.

Figure 7

Scheme of semantic transformation of auditory-speech information in the process of memory consolidation and reconsolidation in patients with cerebral circulatory disorders



Discussion

As a result of the study, a decrease in the volume of short-term auditory-speech and visual-picturesque memory was found in all groups of subjects with cerebral circulation disorders. Changes in the qualitative and quantitative characteristics of the processes of consolidation and reconsolidation of memory in ischemic stroke of hemispheric localization have been reliably established. This change is due to a decrease in the volume of auditory-speech and visual-picturesque short-term memory. In turn, it leads to the instability of memory traces, which ultimately distorts the consolidated information. At the stage of the short-term phase of the memory process, the stored information is fixed without loss and distortion of the content within a short period of time. It has been experimentally proven that memory traces (engrams) decrease even at the first reconsolidation – after 40 minutes. With each subsequent reconsolidation, the information distorted / partially lost during the previous reproduction is saved. In the process of reconsolidation, there is a reduction (in chronic cerebral ischemia) and distortion (in ischemic stroke of hemispheric localization) of the recalled information.

In chronic cerebral ischemia, the instability of memory traces leads to a reduction and partial loss of both visual-picturesque and semantic content. Moreover, in the process of reconsolidation of visual-picturesque information, it is concretized (with the loss of symbolic meaning, requiring more accurate preservation of memory traces) and simplification. The symbolic image is concretized and simplified (reduced to a detailed symmetrical image). Auditory-speech information is reduced and greatly simplified. Noteworthy that the sequence of information content is preserved. In patients with cerebrovascular accidents in the form of ischemic stroke of hemispheric localization, when extracting visual-picturesque information, a transformation of a symbolic image is observed with a complete loss of symbolic meaning. With sinistrocerebral localization of ischemic stroke lesion, a violation of the sequence of semantic units, a decrease in their number, multiple additional details and their excessive use are characteristic. These features are due to hemispheric violation of successiveness. The dextrocerebral localization of ischemic stroke lesion leads to the fact that while maintaining the overall logical sequence of the presentation of the semantic content, a significant amount of detail is lost. In turn, it leads to a distortion of the semantic content up to its complete loss. Such manifestations are due to a violation of the hemispheric factor of simultaneity, which ensures the integrity of perception and cognitive processing of incoming information.

Conclusion

A decrease in the volume of short-term auditory and visual-picturesque memory in patients with acute disorders of cerebral circulation (ischemic stroke) leads to a simplification and almost complete loss of the symbolic image at the stage of reconsolidation in the process of its reactivation and recategorization. Ultimately it leads to a complete loss in 50 % of cases. The instability of memory traces (engrams), which are neural chains that arise during the formation of memory and include neurons in the hippocampus, prefrontal cortex, and amygdala, is due to cerebrovascular disturbance. Cerebral ischemia (chronic or acute) leads, on the one hand, to a decrease in the number of corresponding neural connections in the process of consolidation, and, on the other hand, to their instability. With each subsequent reconsolidation, the number of neural connections that ensure the stability of memory traces decreases. This leads to a reduction in the volume of recalled information, regardless of its quality (both auditory-speech and visual-picturesque). Distortions and confabulations in the process of reconsolidation are due to the attempts to compensate for the missing neural connections by the formation of new ones, but without relying on the existing ones (formed at the stage of information storage).

Findings

Memory as a process is conducted through memorization and goes through short-term and long-term phases. The process of consolidation of memory traces, which characterizes the transfer of content from short-term memory to long-term memory, leads to the transformation of the stored content. Each retrieval of stored memory is accompanied by the replacement of the old memory trace with new content (it may be completely or partially changed).

A decrease in memory volume in case of cerebral circulation disorders leads to instability of memory traces and distortion of the consolidated information, regardless of its quality (auditory-speech and visual-picturesque). The transformation of the stored content with each extraction is manifested in the partial loss of the stored information content, as well as in the partial or complete change of the information content, regardless of its quality (both visual-picturesque and semantic).

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Conflict of Interest Information

The authors have no conflicts of interest to declare.