Neurorehabilitation of Visual Neglect: A Narrative Review of Approaches from A.R. Luria to Modern Clinical Protocols

Нейрореабилитация пациентов со зрительным неглектом: нарративный обзор эволюции идей от А.Р. Лурии до современных клинических протоколов

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Review

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ABSTRACT

BACKGROUND: Various methods of rehabilitation for patients with neglect syndrome have been developed in cognitive neuropsychology. In contrast, this issue has not been a central focus in Luria's neuropsychological rehabilitation.

AIM: The aim of this study is to provide a comparative analysis of A.R. Luria's methods for restoring higher mental functions (HMF) and existing approaches within the cognitive paradigm for rehabilitating patients with left-sided spatial neglect. These approaches will be evaluated based on concepts of "bottom-up" and "top-down" attention processes.

METHODS: The search for studies was conducted in the electronic databases PubMed, Scopus, Web of Science, and eLIBRARY.RU for the period from 1984 to 2024. Sources were included in the review if they contained information on techniques for overcoming left-sided visual neglect and assessing their effectiveness. The review considered publications across all study designs.

RESULTS: Based on an analysis of 56 publications, this study presents the first comparison between modern rehabilitation methods for left-sided neglect and A.R. Luria's methods for restoring HMF. This synthesis has enabled a refinement of the existing taxonomy of methods for restoring HMF, leading to the proposal of a novel methodology, which focuses on "expanding/correcting the capabilities of the leading afferentation of the functional system (directed correction)".

CONCLUSION: It is evident that the extant methodologies for addressing left-sided visual neglect are deficient in terms of efficacy. The most efficacious methods are those aimed at restructuring the functional system and based on arbitrariness and mediation, which largely correlates with "top-down" attention processes.

АННОТАЦИЯ

ВВЕДЕНИЕ: В когнитивной нейропсихологии разработаны различные методы реабилитации пациентов с синдромом неглекта. Вместе с тем в луриевской нейропсихологической реабилитации этот вопрос не находился в центре внимания.

ЦЕЛЬ: Сопоставить пути восстановления высших психических функций, предложенные А.Р. Лурией, с современными подходами когнитивной реабилитации пациентов с левосторонним пространственным игнорированием, в основе которых лежат представления о восходящих (bottom-up) и нисходящих (top-down) процессах внимания.

МЕТОДЫ: Поиск работ проводили в электронных базах данных PubMed, Scopus, Web of Science, eLIBRARY.RU за период с 1984 по 2024 г. Источники включали в обзор, если в них присутствовали сведения о техниках преодоления левостороннего зрительного неглекта и оценке их эффективности. При отборе публикаций тип исследования не учитывали.

РЕЗУЛЬТАТЫ: На основе анализа 56 исследований, включенных в обзор, впервые сопоставили методы реабилитации левостороннего неглекта и путей восстановления высших психических функций в концепции Лурии. Результатом стала ревизия систематики восстановительных подходов с выделением нового направления, ориентированного на расширение/коррекцию возможностей ведущей афферентации функциональной системы (направленная коррекция).

ЗАКЛЮЧЕНИЕ: Ни один из существующих методов преодоления левостороннего зрительного неглекта не является лидирующим по своей эффективности. Наилучшие результаты показывают методы, направленные на перестройку функциональной системы и опирающиеся на произвольность и опосредованность, что во многом соотносится с нисходящими процессами внимания (top-down).

Keywords: *left-sided visual neglect; ignoring; neuropsychological rehabilitation; psychophysiological rehabilitation; ways to restore impaired cognitive functions; A.R. Luria*

Ключевые слова: *левосторонний зрительный неглект; игнорирование; нейропсихологическая реабилитация; психофизиологическая реабилитация; пути восстановления нарушенных высших психических функций; А.Р. Лурия*

INTRODUCTION

Neglect syndrome (NS) is a psychoneurological disorder characterized by the inability to respond to stimuli presented on the opposite side of the affected hemisphere [1]. NS may result from cerebrovascular accidents (stroke), traumatic brain injury, and brain damage of other etiologies [2]. It is a relatively common and disabling consequence of stroke and is more pronounced in patients with right hemisphere damage [3]. Right-sided neglect is significantly less common (24%) than left neglect (33–85%) [2].

International studies on rehabilitation methods for patients with NS tend to analyze this disorder as an attention impairment consisting of bottom-up and top-down processes [4]. The proposed approaches to the rehabilitation of patients with NS are based on these processes [5, 6].

The top-down processes rely on the patients' conscious, voluntary involvement. They direct attention towards the space opposite the affected hemisphere [7]. Such methods based on top-down processes may be difficult to apply in cases of severe NS [8].

Bottom-up processes draw on remaining mechanisms of neural plasticity. They influence physiological functions through sensory stimulation, environmental changes, or motor adaptation, bypassing potential regulatory deficits [9].

Currently available methods for NS are based on top-down or bottom-up frameworks or combine elements of both [10]. By contrast, traditional Russian neuropsychological rehabilitation has mainly focused on overcoming aphasic speech disorders rather than NS. Therefore, comparing international NS rehabilitation with the Russian paradigm for restoring higher mental functions (HMF) is an important task.

This comparison is necessary because Russian and international neuropsychology differ in how they understand the mechanisms underlying mental function recovery. In addition, Russian neuropsychologists face difficulties in applying rehabilitation tools developed abroad for patients with left visual neglect.

The aim of this study is to provide a comparative analysis of A.R. Luria's approach for restoring HMF and existing approaches within the cognitive paradigm for rehabilitating patients with left-sided spatial neglect. These approaches will be evaluated based on concepts of "bottom-up" and "top-down" attention processes.

METHODS

Eligibility criteria

The review included peer-reviewed articles that met the following criteria:

- reported on an intervention for left-sided visual neglect and contained an objective assessment of the intervention's effectiveness;
- analyzed changes in NS over time following the use of specific rehabilitation interventions;
- published in English, Russian, German, and French;
- encompassed any study design, including clinical studies, meta-analyses, systematic reviews, and original research articles.

Studies were excluded from the review if they contained data involving patients with NS combined with psychotic symptoms, aphasia, or developmental disorders.

Information sources

The search was conducted in the PubMed, Scopus, Web of Science, and eLIBRARY.RU electronic databases. The search period ran from 1984 to 2024. The lower time threshold was chosen because rehabilitation practice at that time began to shift from isolated methods to a combined approach integrating functional (cognitive) and holistic (social) strategies [11].

Search strategy

The search query included the following keywords in Russian and English (as well as their combinations): "neglect syndrome", "rehabilitation of spatial neglect", "unilateral disregard", "prism adaptation", "visual search", "transcranial magnetic stimulation", "stroke", "hemineglect", "motor neglect", "neglect", "personal neglect", "representational neglect", "sensory neglect", "unilateral spatial neglect", "neurorehabilitation", "neuropsychological rehabilitation", "visuospatial neglect", and "treatment outcome".

The search query was formulated by G.K.S. and D.D.T. and approved by all co-authors.

Selection process

Primary screening was performed by reviewing article titles and abstracts and making a preliminary assessment of their eligibility. Articles that passed this stage underwent full-text analysis to determine whether they met the inclusion and exclusion criteria. Three authors (G.K.S., D.D.T., V.A.P.) independently screened the articles, with subsequent confirmation by two additional authors (A.M.B., E.V.V.). Disagreements were resolved by three authors (M.S.K., A.A.S., N.A.V.).

The database search found 139 articles. After screening titles and abstracts, 73 publications were considered potentially relevant. Following full-text review, 56 publications met the eligibility criteria and were included in the final analysis.

Data analysis

The authors used a descriptive approach, involving analysis and evaluation of publications that reported on the effectiveness of rehabilitation methods for patients with NS.

No risk-of-bias assessment was performed, as this was not required for the aims of our narrative review.

RESULTS

Luria's approaches for restoring HMF

Approaches to restoring cognitive functions have long been discussed in the scientific literature [12–14]. In his monographs, Luria [15–17] identified three main approaches: disinhibition of the suppressed functional system (FS), substitution (vicariation), and fundamental rearrangement of impaired activity. These pathways require a careful study of their mechanisms and interrelations in patient rehabilitation [15].

We analyzed Luria's pathways for restoring HMF and modern rehabilitation tools to develop the following classification (Table 1).

Rearrangement of the FS structure and change in the level of its functioning can occur together [18, 19]. For example, the use of external cues involves the application of an additional afferent element, which at the same time serves as a sign, allowing a switch in the function of the FS from an involuntary level to a voluntary one.

Table 1. Classification of approaches for restoring higher mental functions

Recovery	Recovery type	Description
Physiological	Spontaneous	Disappearance of "systemic shock" or diaschisis without intervention by specialists; spontaneous vicariation.
	Targeted	Diaschisis disappears under medical or other targeted physiological influence.
Psychological	Spontaneous	Compensatory mechanisms unconsciously used by the patient.
	Targeted	Correction of the afferentation existing in the psychological FS. Rearrangement of the FS structure: an intra-system rearrangement, with the use of FS elements that have already been used in it, or an intersystem rearrangement (the missing element of the FS is replaced by a new one that has not been previously used in this FS). Change in the level (voluntary, involuntary) of the FS functioning.

Note: FS — functional system.

Rehabilitation methods for patients with NS based on international concepts of bottom-up and top-down attention can be theoretically and methodologically justified within the Russian paradigm.

Understanding these methods within Luria's framework will allow Russian neuropsychologists to understand better the mechanisms underlying NS intervention. This may contribute to a more appropriate application of these methods.

Rehabilitation methods aligned with Luria's disinhibition pathway

The pathway of FS disinhibition was first described by Monakov, who identified the mechanism of diaschisis [12].

Inhibited functions can be recovered through different approaches: pharmacological or physiological interventions that affect neurotransmitter metabolism and restore synaptic conduction, or by changing the mental attitudes of the individual [14].

The mechanism underlying FS disinhibition suggests that this pathway belongs to both targeted and spontaneous pathways of restoring HMF. In both cases, the FS has the same constituent elements [16].

Transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS) are commonly used non-invasive brain stimulation methods [20, 21].

TMS enables direct stimulation of cortical neurons. The physiological mechanism underlying the therapeutic efficacy of TMS involves long-term potentiation, which forms the basis of neuroplasticity [22]. However, there is no consensus on how long the exposure should last to induce plastic changes in the nervous system [9].

The efficacy of TMS and tDCS was assessed using a meta-analysis that analyzed 12 studies involving 168 subjects [23]. Most patients had their first right-hemisphere stroke with cortical lesions. All studies were conducted in the subacute phase (4 weeks to 6 months), except for one study conducted in the acute phase (less than 4 weeks) [23]. Three studies used tDCS, and nine employed repetitive transcranial magnetic stimulation (rTMS). These studies evaluated the severity of NS with different outcomes. The most used tests were the Line Bisection Test and the Behavioral Inattention Test (BIT) [24].

According to the study evidence, tDCS tended to reduce the severity of NS, although the results were inconsistent, while TMS had a positive effect on NS [21, 22]. One study also examined the combined use of tDCS and neck muscle vibration, which may help correct subjective vertical orientation in patients with NS [25, 26]. However, there is a need for further studies with larger samples to clarify the role of non-invasive brain stimulation in the management of NS.

Because these methods are purely physiological, distinguishing top-down and bottom-up processes within the psychological process of attention is not appropriate.

Thus, TMS can be compared with a targeted physiological disinhibition of the brain's FS. In clinical practice, this method is important for optimizing the functional state of neuronal networks involved in simultaneous attention.

Rehabilitation methods aligned with Luria's rearrangement pathway

Top-down processes

Top-down approaches used internationally in NS rehabilitation align well with the FS rearrangement pathway according to Luria [15–17]. These methods focus on the patient's conscious, voluntary acquisition of new ways to carry out actions. Currently, they are central to NS management, as physiological methods alone can create the basis for simultaneous attention but cannot restore the

psychological process itself. Each of the methods presented below has shown effectiveness, but none is optimal.

1. Visual scanning training.

Visual scanning training involves training the patient to turn the head and trunk toward the neglected side [27]. The method aims to improve spatial scanning by reorienting the egocentric reference system, which is most used by psychologists in rehabilitative care [28]. It requires precise instructions: the examiner asks the patient to find the left edge of the page marked with a wide red line before reading the next line [25]. A reference point is thus created, and the patient learns to navigate in space and scan the visual field from left to right during tasks such as reading and writing.

Despite its frequent use in clinical practice, several randomized controlled trials have evaluated its efficacy [27, 29–32]. The studies that showed improvements in visuospatial search parameters were limited to paper-and-pencil tests [30, 32]. Long-term outcomes were not recorded to confirm sustained improvements. Some studies showed limited transfer of training effects to patients' daily functioning [29, 32, 33].

2. The "spotlight" strategy.

Within the "spotlight" strategy, patients focus on specific stimuli (similar to using a light in a dark room) while neglecting others [34–36]. Here, attention is conceptualized as a spotlight that can switch from place to place just as a beam of light moves across a dark room [36].

3. The "lighthouse" strategy.

This method is a continuation of the previous strategy. It uses a visual metaphor in which patients imagine themselves as a lighthouse, with their eyes and head as a beam of light that must "illuminate" the space from right to left [37]. This mental representation helps to encourage patients to scan their surroundings systematically, thereby improving attention to the side of neglect [38]. This approach requires patients to have a certain capacity for abstraction and associative memory [37].

Training in visual scanning using the "lighthouse" and "spotlight" strategies illustrates intra-system rearrangements within Luria's framework.

Bottom-up processes

Methods based on bottom-up attention processes align with the FS rearrangement pathways in Luria's framework [14–16]. Such methods focus on activating involuntary levels of attention.

As with top-down attention, individual bottom-up methods are not central to the neuropsychological rehabilitation of patients with NS. However, they can be used as supplements to top-down approaches in clinical practice.

1. Vestibular stimulation.

Modern methods of vestibular stimulation include caloric and galvanic vestibular stimulation. Caloric vestibular stimulation usually involves the instillation of cold water into the ear opposite the affected hemisphere [39]. Galvanic vestibular stimulation applies a weak electric current on the mastoid processes of the temporal bone [40].

Vestibular stimulation is based on the relationship between neural structures involved in vestibular and spatial processing and an impaired spatial reference system, including the bodily reference system [39]. This is supported because the subjective orientation of the body is shifted to the right in patients with left NS. This involves additional afferentations (intra-system rearrangement in Luria's framework).

The efficacy of these methods was evaluated in a meta-analysis of 17 studies that included 180 patients with stroke-related NS [41]. Results showed no significant differences between the effects of galvanic vestibular stimulation and placebo conditions, whereas caloric vestibular stimulation showed significant improvements in NS symptoms compared with pre-stimulation findings [41].

2. Optokinetic stimulation.

Optokinetic stimulation represents intra-system rearrangement within Luria's rehabilitative framework. In this procedure, the patient follows stimuli moving from right to left across the screen with their eyes. Kerkhoff et al. [42] showed that this stimulation decreases the auditory manifestations of NS.

In this procedure, the eye movements are guided by instructions, which alters their psychological structure. The study by Leontiev and Zaporozhets [43] revealed the relationship between the characteristics of the movement and the way the task is set. Voluntary movements that are similar in their geometry and anatomy [43] will be performed differently if the subjects have different tasks. When such movements are incorporated into another meaningful voluntary task, they can become automated.

3. External cues.

Another method of rehabilitation is using external cues, which draw the patient's involuntary attention to the side of spatial neglect [44, 45]. External cues include visual, auditory, and cutaneous kinesthetic (limb activation method)

cues [46]. The examiner uses bright objects located on the left as visual cues [5]. Non-verbal auditory cues, such as sound signals, are initially presented on the right side of space to capture attention [42]. Gradually, the signal moves to the left side, causing the patient to direct their eyes to the left involuntarily. Pilot studies have shown that auditory cues can reduce NS symptoms [47].

A similar auditory cue is used in the limb activation method [28, 33, 48]. A sound-producing device is attached to one of the left limbs. The device can operate in two modes: emitting sounds at fixed intervals regardless of limb movement [33, 48], or activating when the limb remains unused for an extended period. Rehabilitation with this method was associated with reduced NS symptoms across personal, peripersonal, and locomotor space [47–49]. Following treatment, improvements in peripersonal space and overall motor function of the left limbs continued for 18–24 months [48, 49].

External cues that add an afferent element and shift the FS to a more voluntary level can be interpreted, within Luria's rehabilitative framework, as part of the FS rearrangement pathway.

4. Use of biofeedback (neurofeedback).

Rehabilitation outcomes are more effective if neuropsychological and neurobiological methods are more integrated [50]. For example, the "neurofeedback" method is based on the finding that the function of the frontoparietal control network in the right hemisphere is impaired in NS [51]. This method activates the network during cognitive tasks using feedback from electroencephalography and real-time functional magnetic resonance imaging. Improved visuospatial search was demonstrated in patients undergoing this procedure [52].

Using neurofeedback is possible because of an intra-system rearrangement, as it increases the level of voluntariness.

Rehabilitation methods for expanding or adjusting the leading afferent input of the functional system

1. Prism adaptation.

Rossetti et al. [53] used wide-field prismatic lenses that shifted the patient's field of view by 10 degrees to the right. Patients wore the prismatic glasses and performed tasks involving pointing to visual targets on both sides of their body's midline. The position of the head was stabilized with a chin rest and controlled by the investigators to minimize movement. The duration of training with prismatic lenses varied from 2 to 5 minutes. Results were recorded before and after the training. Prism adaptation produced significant improvements in midline pointing tasks and in classical paper-and-pencil neuropsychological tests assessing NS. These improvements persisted for at least 2 hours after the lenses were removed [54].

A randomized controlled study [55] assessed the long-term sensorimotor and therapeutic effects of prism adaptation. Although patients showed significant sensorimotor changes after prism adaptation, these improvements did not result in sustained repetitions in functional independence in daily life. Prism adaptation effectively decreases the manifestations of NS in the short term. However, a more intensive and prolonged intervention is required for long-term therapeutic results.

Studies have also shown that NS symptoms are temporarily reduced after prism adaptation. However, the therapeutic effect often disappears after a few weeks [56]. One explanation for this short-lived effect is that prism adaptation promotes a spatial attention shift, increasing exploratory eye movements toward the neglected side. However, it does not produce lasting changes in visual perception on that side [57]. Prism adaptation can temporarily improve the patient's orientation on the side of neglect, but does not profoundly affect the cognitive perception of this area [58].

2. Eye patching.

The method involves placing a bandage over the intact half of the patient's visual field on their glasses or using half-occluded sunglasses [59–61]. These devices use a transparent or shaded lens to reduce visual stimuli from the intact field of view. The procedure is based on Franz's ideas, which propose that these conditions direct patients with left NS to attend to the left half of their visual field [62]. By occluding the right half of the visual field, information is prevented from reaching the intact left hemisphere. This promotes greater involvement of intact regions of the damaged right hemisphere in task performance [59, 61].

The results confirm the positive influence of the method regarding head turns and spontaneous eye movements to the left neglected side [25, 39].

3. Mirror therapy.

This method involves placing a mirror along the patient's midline, creating the illusion of movement of the paretic and/or neglected limb [59, 63–65]. The intact limb "performs"

Table 2. Comparison of pathways for restoring higher mental functions with neglect syndrome rehabilitation methods

A.R. Luria's pathways for restoring		Methods
Rehabilitation methods aligned with Luria's disinhibition pathway		Non-invasive brain stimulation: TMS and tDCS
Rehabilitation methods aligned with Luria's rearrangement pathway	Top-down processes	Visual scanning training The "spotlight" strategy The "lighthouse" strategy
	Bottom-up processes	Vestibular stimulation (CVS and GVS) Optokinetic stimulation External cues Use of biofeedback (neurofeedback)
Rehabilitation methods for expanding or adjusting the leading afferent input of the functional system		Prism adaptation Eye patching Mirror therapy

Note: CVS — caloric vestibular stimulation; FS — functional system; GVS — galvanic vestibular stimulation; tDCS — transcranial direct current stimulation; TMS — transcranial magnetic stimulation.

various tasks [64–66]. The illusion is thought to activate motor areas of the damaged right hemisphere, since illusions activate the same part of the brain as real movements [67]. Mirror therapy was originally used in the rehabilitation of patients with paresis but was later applied to those with motor NS [63, 65].

Systematization of NS rehabilitation methods and their comparison with Luria's pathways for restoring HMF

The methods described above and presented in integrative classification within Luria's framework for restoring HMF are shown in Table 2.

Most of the methods presented above can be used in a virtual environment. This is not a new rehabilitation tool, but a technology that can increase the diversity of stimuli [68], reach more patients per unit of the examiner's working time, and decrease the costs of rehabilitation personnel [69]. However, the evidence confirming the effectiveness of this tool does not suggest its practical value [70].

DISCUSSION

A meta-analysis comparing the efficacy of various rehabilitation methods in patients with NS included 37 randomized controlled studies [10]. It did not reveal the efficacy of any specific rehabilitation methods because of small sample sizes, lack of objectivity, assessments of the generalization of gained skills, and longitudinal studies [10]. However, combining methods for the rehabilitation of patients with NS was more effective than any of the methods alone [8, 10, 70–73].

Among rehabilitation methods conventionally used in NS, the publication by Cicerone et al. [74] is noteworthy. Based on 10 studies on NS rehabilitation, the authors conclude that visual scanning training (standard level) is the preferable option. Recommended methods include microcomputer exercises, limb activation techniques, and mirror therapy, which are used as complementary tools, increasing the effectiveness of visual scanning training. Using electronic technologies in visual scanning training is possible. According to the authors, the primary method of rehabilitation is the visual scanning strategy. Other methods can only supplement it and are not recommended as separate tools, which is explained because improved functioning is associated with compensation [74]. The authors conclude that the top-down pathway is the most effective one in the cognitive rehabilitation of patients with NS [74]. Compensation is a directed, conscious attempt to overcome the deficit, which is consistent with Luria's idea of FS rearrangement [16, 17].

The main limitation of our review is the 40-year span of publications analyzed. This limitation is because of changes in the perception of neurological rehabilitation in the late 1980s. The period is characterized by the gradual introduction of both methods consistent with the functional and holistic approaches to rehabilitation [11].

In addition, the studies included in the review were noticeably heterogeneous, as the diagnostic methods varied significantly. Participant samples differed in terms of rehabilitation phase (acute, subacute, etc.), tools employed, and duration of the rehabilitation process. Some investigators did not adhere to the principle of monotherapy: in several publications, rehabilitation was limited to a single method being evaluated, while in others, patients were simultaneously treated with other therapeutic interventions in a hospital setting.

These differences could affect the representativeness and homogeneity of results.

CONCLUSION

Current rehabilitation methods for NS are diverse and are commonly categorized into bottom-up and top-down approaches. Each has its advantages and limitations. A combined approach that can offset these limitations and provide a comprehensive approach to rehabilitation is preferable for rehabilitative training.

To better understand these rehabilitation methods, they were compared with Luria's pathways for restoring impaired HMF, and a classification of psychophysiological and neuropsychological methods was developed. However, despite a large number of studies, their efficacy and superiority are still a matter of debate. Future studies should be conducted with larger samples, under stricter control, with an assessment of skill generalization, and over longer follow-up periods. The choice of specific methods should be guided by the patient's condition, individual characteristics, and the rehabilitation goals set by specialists. Thus, integrating various methods of rehabilitation for patients with NS does not guarantee optimal recovery of social adaptation and functional independence. In conclusion, none of the discussed methods of rehabilitation in NS should be regarded as the most effective. This highlights the need to find the most effective strategy for combining the above methods and developing new ones, for example, specialized training programs including Luria's restorative training elements.

All NS rehabilitation methods reviewed here have practical significance, as integrating physiological and psychological approaches may improve research practice and speed up recovery during the early stages of rehabilitation. The highest efficacy was shown for the methods associated with the FS rearrangement involving voluntariness and mediation, which is largely related to top-down attention.

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