

Novel therapeutic techniques for post stroke aphasia: A narrative review

Fazaila Ehsaan¹, Nazia Mumtaz², Ghulam Saqulain³

Abstract

Aphasia, an acquired language disorder, commonly results from a stroke affecting network of cortical and subcortical structures. Aphasia lacks effective standardised treatment. Neuroimaging and behavioural research indicate that some interventions promote neuroplasticity changes in aphasia. Research has suggested that non-invasive brain stimulation may be effective, causing functional reorganisation of language areas between the two hemispheres. This reorganisation evolves from different researches exploring novel procedures, including transcranial magnetic stimulation and intracranial direct current stimulation, which may modulate cortical activity in aphasia. The current narrative review was planned to assess these techniques while examining the casual role of specific regions of brain and the understanding of the underlying mechanism for treatment effects of brain stimulation. Literature was explored on search engines and databases, like Medline, Web of Science and bibliography of published studies. The key words used for the search were 'non-invasive brain stimulation', 'post-stroke aphasia', 'transcranial magnetic stimulation' and 'transcranial direct current stimulation'. Of the 175 publications downloaded, 40(23%) full-text English publications were reviewed.

Keywords: Stroke, Aphasia, Neurological rehabilitation, Transcranial magnetic stimulation, Transcranial direct current stimulation.

DOI: <https://doi.org/10.47391/JPMA.2277>

Introduction

Language is the key to communication. The fundamental role of all linguistic interactions in daily living involves interpersonal communication for health-associated quality of life (QOL). In the late 19th century, the study of aphasia and the aetiology of its lesion were discussed that led to insights about the neural organisation of many language functions.¹

Aphasia is an acquired language disorder that commonly results from brain insult, mainly stroke, that usually involves injury to an extended network of cortical and subcortical

structures supplied by the middle cerebral artery (MCA) in the left hemisphere.² Impairment is mostly seen in the four primary areas, language comprehension, spoken language expression, writing, and reading, thus leaving a person with the loss of ability to use language as a tool for participation in life, depending on a person's unique set of symptoms. Usually, the intact non-linguistic cognitive skills, like memory and executive functioning, are intact and seen in the aphasic individuals, but these may also be affected with aphasia.³

A large European audit involving inpatient stroke cases revealed 64% prevalence of communicational impairments in post-stroke survivors, of whom 28% suffered both aphasia and dysarthria, while 24% had aphasia alone.⁴ In an Indian study, aphasia was diagnosed in 27.9% cases of stroke, being Global in majority (33.33%), followed by Broca's aphasia (28.3%), motor transcortical aphasia (13.33%), sensory trans-cortical aphasia (10%), Werneke's aphasia (8.33%), Anomic aphasia (5%) and Conduction aphasia (1.67%).⁵ Aphasia is usually seen in older adults compared to younger ones.⁶ The most common cause of aphasia is stroke, which can be caused by ischaemia, infection, traumatic or surgical brain injury, or progressive neurological diseases, like dementia. Ischaemic strokes, being the commonest, result from blockage of blood supply to the brain areas, or it can be haemorrhagic, which includes rupture of blood vessels that damage the surrounding regions of brain tissues.

To address the specific area of need that are identified during assessment, the goals of aphasia management are specific for the patient as well as for caregivers or family members, and treatment should be individualised. Keeping in mind the World Health Organisation's (WHO) International Classification of Functioning (ICF) framework guidelines 2001, the ultimate goals are to intervene with the intent to facilitate the individual in achieving the highest level of independent functioning for participation in daily living activities.⁷ The management of aphasia must be related to underlying structures and their functions that impede the communication of patients across different settings and partners. They must capitalise on the strengths and weaknesses of each individual. By teaching new skills and compensatory strategies to aphasic individuals as well as their partners enhance the participation and activity level. With the incorporation of Augmentative Alternate

^{1,2}Department of Speech Language Pathology, Riphah International University, Lahore, Pakistan; ³Department of Otolaryngology, Capital Hospital PGMI, Islamabad, Pakistan.

Correspondence: Ghulam Saqulain. e-mail: ghulam_saqulain@yahoo.com

Communication (AAC) strategies, by modifying the environmental factors, and taking into account the modern focus on evidence-based practice (EBP), aphasia management can improve.⁸ Most notably, spontaneous recovery is usually seen during the first 2-3 months following stroke, while many of them are left with some chronic defects in which the recent rehabilitation treatment is only marginally effective. However, long-term intense therapies can have positive outcome in post-stroke aphasia.⁹

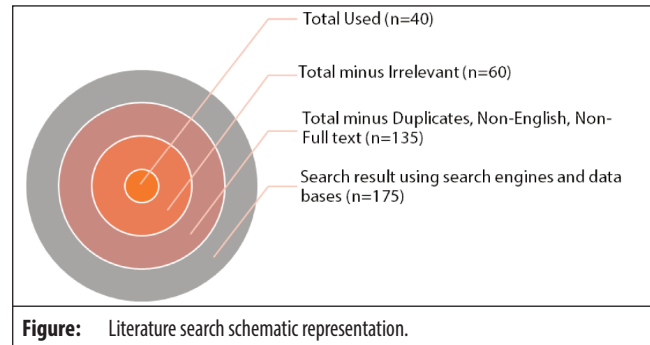
Recent clinical practices state that therapy must be person-centred or person-focussed and evidence-based. EBP is basically the approach that incorporates the most recent high-quality research evidence with the integration of or practitioner expertise and client values and preferences, while the evidence is evaluated on the basis of generalisability. When the treatment decisions are taken, the important things that should be kept in mind include individual's preferences, life circumstances, medical records, coping strategies, behavioural, sensory and psychological issues.¹⁰ Person-centred practice includes valuing the patients' rights and their individual needs, thoroughly understanding their illness, healthcare experiences and accepting them within effective relationships. This will eventually enable a patient to participate in clinical reasoning.¹¹

Mostly, speech therapists are the persons who evaluate, diagnose and manage the patients with post-stroke language impairment on the basis of individual needs, and then use integrations or combinations of strategies according to the individual's impairment profile. Currently, no gold standard procedure or universally-accepted methods are available for the management of aphasia against which more experimental intervention can be linked. Hence, the current narrative review was planned to review the use of non-invasive brain stimulation techniques while examining the casual role of specific regions of brain during the recovery process and the understanding of the underlying mechanism for treatment effects of brain stimulation.

Methods and Results

The current narrative review comprised literature search in major search engines, like Google and Google Scholar, databases Medline and Web of Science, and bibliography of published studies. The key words used were 'non-invasive brain stimulation', 'post-stroke aphasia' and 'aphasia'. There was no time-period limitation related to the literature searched.

Articles that were duplicate and in languages other than English were excluded.



Of the 175 articles downloaded, 135(77%) full-text English-language publications were further skimmed for relevancy. Finally, 40(52%) were used for comprehensive literature review (Figure).

Discussion

The comprehensive understanding of language-related functional neuroanatomy and relationships of brain behaviours has been made possible by current advancements in neuroimaging. Early in the 1980s, the understanding of underlying functional neuroanatomy was extended by positron emission tomography (PET), functional magnetic resonance imaging (fMRI) and magneto-encephalography. These techniques were considered safe and non-invasive. These imaging technologies discovered that language areas in the brain extend far beyond Broca's area and Wernicke's area. Many researches have concluded that there are some regions in the brain which show activation mostly while performing language tasks. However, in majority of neurologically healthy individuals, the left hemisphere depicts more activation. Moreover, some distant regions in the cortex, like inferior cortex, anterior temporal cortex, cerebellum, basal ganglia and thalamus, also show activation during language-related tasks.¹²

The complexity and richness of language comprehension and expression is also enhanced because of contemporary models of functional neuroanatomy of language. Increasingly, the interruption in the cognitive processes that underlies language are usually seen in aphasia. It has been known as the person-centred and EBP approaches to the rehabilitation of aphasia patients. With the advancement of understanding in neurobiology of recovery, the treatment of aphasia is now more informed. The early and intense therapy is supported by the fundamentals and principles of neuroplasticity. The functional importance of the concept 'use it or lose it' is revealed by plasticity studies which also indicate that neural changes and some beneficial behaviours are effected through repetitive and intensive practice.¹³

It was emphasised in the finding of some investigational studies that intensive treatment for short duration is far better than the number of therapy sessions over a longer time period. Recently, the intensity of therapy, not the therapeutic approach used, are reported because they exhibit similar outcomes regardless of whether stroke survivors received conventional therapy or constraint-induced movement therapy (CIMT).¹⁴ In the case of chronic stroke, CIMT is more likely to enhance cortical reorganisation through encouraging the verbal versus nonverbal communication.¹⁵

The recovery from aphasia following a stroke is a dynamic approach which includes variations of plasticity changes in both hemispheres. It is supposed that the hierarchical combinations of changes occur in the patients facing language difficulties post-stroke. Current literature on the temporal dynamics of post-stroke language recovery has invoked differential involvement of both hemispheres with the passage of time.¹⁶ There are various factors that seem to have an impact on the recovery from aphasia, which includes size and site of lesions, and history of prior strokes.¹⁷ In individuals with extensive damage to the left hemisphere, the reallocation of language functions in the right hemispheres occur right after the stroke. Gradually this phenomenon diminishes following a reorganisation of the language processing function back to the left hemisphere. However, this processes is considered to occur mainly in individuals with smaller lesions.¹⁸

Non-invasive techniques, like transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), are techniques that are being explored to provide an important adjunctive approach to behavioural techniques¹⁹ due to their ability to modulate cortical excitability and to induce plasticity.²⁰ It has been hypothesised that neuroplasticity is facilitated by these non-invasive techniques by reactivating neuronal networks and enlisting compensatory and perilesional areas.²¹

TMS is a non-invasive technique that creates variations in brain activity pattern by generating varying magnetic fields by employing the principles of electromagnetic induction. For electromagnetic induction, the coil is held close to the head of the patient and the magnetic field is applied and allowed to penetrate the skull and the scalp. This results in the induction of minor currents to the plane of the coil in the brain. It generates the action potentials that are sufficient to depolarise neuronal membranes. Different combinations of intensities, pulse frequencies and stimulation locations are employed in TMS paradigms. The presentation of a series of pulses at a fixed or predetermined frequency is known as repetitive TMS (rTMS). It can generate the effects that outlast the

application of stimulation and is thought to induce plasticity in the brain, though the mechanism of this is not clear.²² Literature suggests that cortical excitability decreases when rTMS is delivered at low frequencies, while it increases when generated at high frequencies.²³ To examine the role of specific cortical regions for the execution of particular linguistic functions, usually rTMS is employed.²⁴ Low-frequency rTMS, when applied over inferior frontal gyrus, improves language recovery,²⁵ while, high-frequency rTMS on the damaged hemisphere also improves language function.²⁶

Further, tDCS is the application of small electric currents via a pair of surface electrodes to the scalp. In this procedure, the current flows through the cortex from the anode and moves out via cathode. To modulate the resting membrane potential of neurons, weak electric currents are used in tDCS in contrast to TMS which involves sufficient magnitude of current for the stimulation of action potentials.²⁷ The effectiveness of tDCS is totally dependent on which electrode is applied to the scalp area. Because of the hyperpolarisation of cortical neurons, less cortical excitability is associated with the stimulation of cathode. On the contrary, increased cortical excitability is linked with stimulation of anode which is due to depolarisation. On the basis of polarity, intensity and duration of stimulation, the effects of these procedures last from minutes to hours. A study found that reduction of excitability in the unaffected hemisphere by cathodal tDCS and increasing stimulation of the affected hemisphere by anodal tDCS could improve motor performance in patients.²⁸

A study argued that TMS and tDCS can enhance language recovery.²⁹ Also, another study reported that after daily therapy with anodic tDCS for 5 days, in which 1 mA anodic tDCS was given over 20 minutes in each session as along with sham stimulation on Wernicke's area, long-term effect on the recovery of anomic disturbance was detected.³⁰

In contrast, other studies,^{31,32} following application of 15 consecutive 24-hour treatments of anodal tDCS with 1 mA strength for 10 min, did not find any significant positive improvement in language abilities.

While discussing the utility of these techniques, it is important to keep in mind that they heavily rely on the thorough understanding of anatomy and physiology of neuronal networks that underlie the language areas, other variables which have an impact on potential timing, and structure's functional reorganisation.¹⁹ A review article highlighted the hierarchical model in connection with aphasia recovery,²⁹ stressing that in cases related to recovering the language function post-stroke, a hierarchical group of changes occur. When there is a very

small lesion on the left hemisphere, almost full recovery is achieved by restoring the normal activation pattern in language network of the left hemisphere, but when the lesion involves important centres, area around the lesion in same hemisphere is associated with good recovery. But in case of a severely affected left hemisphere network, the right hemisphere assumes some language functions facilitated by the release of left hemispheric inter-hemispheric inhibition.²⁹ Hence, post-stroke aphasia recovery may occur by integration of left as well as right hemisphere areas to a varying degree over time.³³ For aphasia recovery enhancement, some evidence favours non-invasive cortical stimulation along with language or other therapeutic options.³⁴

TMS and tDCS techniques are non-invasive and safe as enhance or induce neuroplasticity changes in the activities of the brain. Recent evidence suggests that these non-invasive brain stimulation techniques tend to have positive impact in aphasia treatment post-stroke. For the selection of target area in non-invasive brain stimulation, it is necessary for the resource person to have a thorough and deep knowledge and understanding of all the underlying mechanisms that favour spontaneous recovery post-stroke. Recovery differs from person to person as there are some other linked factors, like lesion size and site, severity of syndrome, affected hemisphere and dominance of hemispheres among all individuals. Likewise, the preferred site for stimulation, adequate dosage of TMS and tDCS, pharmacological treatments and behavioural experiences also need detailed clarification.³⁵

Though non-invasive brain stimulation techniques have a very important role in aphasia recovery, they also shed light on the right and left hemispheres' role in the recovery of aphasia by giving a wide range of experimental manipulations. The integration of non-invasive brain stimulation techniques with behavioural techniques helps in facilitating the right hemisphere involvement in language-related activities. By applying TMS to different areas of the right hemisphere enhances specific linguistic processes. They may further explicate the structure function relationship in the reorganisation of language-related networks. The recovery of language function is also taken into account by stimulating the left and right hemispheres at different time points that are related to the onset of stroke.³⁶

As has been discussed in the current narrative review, TMS and tDCS are very promising techniques for advancement in language functional recovery in individuals with aphasia. It is also important to identify the effective method for the treatment of aphasia post-stroke that also helps in further treatment intervention and subsequent clinical decision-

making. However, it must be emphasised for patient safety purposes that, like other therapeutic techniques, rTMS and tDCS are not without adverse effects. Though rare, mild symptoms can result post-rTMS, like temporary hearing impairment, syncope, acute episode of psychiatric event, ache and pain, paraesthesia or cognitive changes as well as seizures.³⁷ On its part, tDCS is often associated with itching and tingling sensations.³⁸

The current review has a limitation as data regarding brain stimulation techniques only focussed on individuals with frontal lobe lesions and non-fluent aphasia. There is a need to explore brain stimulation procedure effects across all types of aphasia and among a variety of lesion locations.

Conclusion

Advancements in neuroimaging techniques, recent theories regarding language functions, and modifications in clinical practices must be integrated to approach aphasia management. This also necessitates the understanding of language functional neuroanatomy, the underlying cognitive process for language-related tasks, and the recovery mechanism post-stroke. It is also important to provide optimum care, standard rehabilitation and counselling to patients' families and caregivers to maximise the recovery. Treatment methods must incorporate evidence-based and person-focused approaches for standard care. Additionally, combination of non-invasive brain stimulation procedures with other behavioural techniques can prove to be promising interventions to facilitate the recovery of the language function in aphasia cases post-stroke.

Disclaimer: None.

Conflict of interest: None.

Source of Funding: None.

References

1. Tippet DC, Niparko JK, Hillis AE. Aphasia: current concepts in theory and practice. *J Neurol Transl Neurosci.* 2014; 2:1042.
2. McNeil MR, Pratt SR. Defining aphasia: Some theoretical and clinical implications of operating from a formal definition. *Aphasiology.* 2001; 15:901-11.
3. Murray L. Focusing attention on executive functioning in Aphasia. *Aphasiology.* 2017; 31:721-4.
4. Mitchell C, Gittins M, Tyson S, Vail A, Conroy P, Paley L, et al. Prevalence of aphasia and dysarthria among inpatient stroke survivors: describing the population, therapy provision and outcomes on discharge, *Aphasiology.* 2020; 35:1-11.
5. Bohra V, Khwaja GA, Jain S, Duggal A, Ghuge VV, Srivastava A. Clinicoanatomical correlation in stroke related aphasia. *Ann Indian Acad Neurol.* 2015; 18:424-9.
6. Ellis C, Urban S. Age and aphasia: a review of presence, type, recovery and clinical outcomes. *Top Stroke Rehabil.* 2016; 23:430-9.
7. World Health Organization. How to use the ICF: A practical manual

- for using the International. Classification of Functioning, Disability and Health (ICF). Exposure draft for comment. 2013. Geneva: WHO. [Online] [Cited 2020 November 24]. Available from: URL: <https://www.who.int/classifications/drafticfpracticalmanual.pdf>
8. Koul RK, Corwin M. Augmentative and Alternative Communication Intervention for Persons with Chronic Severe Aphasia: Bringing Research to Practice. EBP Briefs. 2011; 6:1-8.
 9. Bhogal SK, Teasell R, Speechley M. Intensity of aphasia therapy, impact on recovery. Stroke. 2003; 34:987-93.
 10. Spencer K. Evidence-based practice: Treatment of individuals with dysarthria. Perspect Neurophysiol Neurogenic Speech Lang Disord. 2006; 16:13-9.
 11. Leach E, Cornwell P, Fleming J, Haines T. Patient centered goal-setting in a subacute rehabilitation setting. Disabil. Rehabil. 2010; 32:159-72.
 12. Stoodley CJ, Valera EM, Schmahmann JD. Functional topography of the cerebellum for motor and cognitive tasks: an fMRI study. Neuroimage. 2012; 59:1560-70.
 13. Kleim JA, Hogg TM, VandenBerg PM, Cooper NR, Bruneau R, Remple M. Cortical synaptogenesis and motor map reorganization occur during late, but not early, phase of motor skill learning. J Neurosci. 2004; 24:628-33.
 14. Woldag H, Voigt N, Bley M, Hummelsheim H. Constraint-Induced aphasia therapy in the acute stage: what is the key factor for efficacy? A randomized controlled study. Neurorehabil Neural Repair. 2017; 31:72-80.
 15. Szaflarski JP, Ball AL, Vannest J, Dietz AR, Allendorfer JB, Martin AN, et al. Constraint-Induced Aphasia Therapy for Treatment of Chronic Post-Stroke Aphasia: A Randomized, Blinded, Controlled Pilot Trial. Med Sci Monit. 2015; 21:2861-9.
 16. Hillis AE. Aphasia: progress in the last quarter of a century. Neurology. 2007; 69:200-13.
 17. Lazar RM, Speizer AE, Festa JR, Krakauer JW, Marshall RS. Variability in language recovery after first-time stroke. J. Neurol. Neurosurg. Psychiatry. 2008; 79:530-4.
 18. Saur D, Lange R, Baumgaertner A, Schraknepper V, Willmes K, Rijntjes M, et al. Dynamics of language reorganization after stroke. Brain. 2006; 129:1371-84.
 19. Tippet DC, Hillis AE. Where are aphasia theory and management "headed"? F1000 Res. 2017; 6:1038.
 20. Klomjai W, Lackmy-Vallée A, Roche N, Pradat-Diehl P, Marchand-Pauvert V, Katz R. Repetitive transcranial magnetic stimulation and transcranial direct current stimulation in motor rehabilitation after stroke: An update. Ann Phys Rehabil Med. 2015; 58:220-4.
 21. Cotelli M, Fertonani A, Miozzo A, Rosini S, Manenti R, Padovani A, et al.: Anomia training and brain stimulation in chronic aphasia. Neuropsychol Rehabil. 2011; 21:717-41.
 22. Klomjai W, Katz R, Lackmy-Vallée A. Basic principles of transcranial magnetic stimulation (TMS) and repetitive TMS (rTMS). Ann Phys Rehabil Med. 2015; 58:208-13.
 23. Miniussi C, Rossini PM. Tran cranial magnetic stimulation in cognitive rehabilitation, Neuropsychol Rehabil. 2011; 21:579-601.
 24. Devlin JT, Watkins KE. Stimulating language. insights from TMS. Brain. 2007; 130:610-22.
 25. Ren CL, Zhang GF, Xia N, Jin CH, Zhang XH, Hao JF, et al. Effect of low-frequency rTMS on aphasia in stroke patients: a meta-analysis of randomized controlled trials. PLoS One. 2014; 9:e102557.
 26. Dammekens E, Vanneste S, Ost J, De Ridder D. Neural correlates of high-frequency repetitive transcranial magnetic stimulation improvement in post-stroke non-fluent aphasia: a case study. Neurocase. 2014; 20:1-9.
 27. Nitsche MA, Paulus W. Sustained excitability elevations induced by transcranial DC motor cortex stimulation in humans. Neurology. 2001; 57:1899-901.
 28. Fregni F, Boggio PS, Mansur CG, Wagner T, Ferreira MJ, Lima MC, et al. Transcranial direct current stimulation of the unaffected hemisphere in stroke patients. Neuroreport. 2005; 16:1551-5.
 29. Hamilton RH, Chrysikou EG, Coslett B. Mechanisms of aphasia recovery after stroke and the role of noninvasive brain stimulation. Brain Lang. 2011; 118:40-50.
 30. Fiori V, Coccia M, Marinelli CV, Vecchi V, Bonifazi S, Ceravolo MG, et al. Transcranial direct current stimulation improves word retrieval in healthy and nonfluent aphasic subjects. J Cogn Neurosci. 2011; 23:2309-23.
 31. Elsner B, Kugler J, Pohl M, Mehrholz J. Transcranial direct current stimulation (tDCS) for improving aphasia in patients with aphasia after stroke. Cochrane Database Syst Rev. 2015; 5:CD009760.
 32. Polanowska KE, Leśniak M, Seniów JB, Członkowska A. No effects of anodal transcranial direct stimulation on language abilities in early rehabilitation of post-stroke aphasic patients. Neurol Neurochir Pol. 2013; 47:414-22.
 33. Hartwigsen G, Siebner HR. Novel methods to study aphasia recovery after stroke. Front Neurol Neurosci. 2013; 32:101-11.
 34. Mylius V, Zouari HG, Ayache SS, Farhat WH, Lefaucheur JP. Stroke rehabilitation using noninvasive cortical stimulation: aphasia. Expert Rev Neurother. 2012; 12:973-82.
 35. Lang N, Speck S, Harms J, Rothkegel H, Paulus W, Sommer M. Dopaminergic potentiation of rTMS-induced motor cortex inhibition. Biol Psychiatry. 2008; 63:231-3.
 36. Schlaug G, Marchina S, Norton A. Evidence for plasticity in white matter tracts of chronic aphasic patients undergoing intense intonation-based speech therapy. Ann N Y Acad Sci. 2009; 1169:385.
 37. Sobreira G, Aleixo MA, Moreira C, Oliveira J. Adverse effects in repetitive transcranial magnetic stimulation- Prevention and Management. Eur Psychiatry. 2016; 33:555-6.
 38. Brunoni AR, Amadera J, Berbel B, Volz MS, Rizziero BG, Fregni F. A systematic review on reporting and assessment of adverse effects associated with transcranial direct current stimulation. Int J Neuropsychopharmacol. 2011; 14:1133-45.