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HEART & STROKE FOUNDATION
Canadian Partnership
for Stroke Recovery

Chapter 14: Aphasia and Apraxia Rehabilitation

Abstract

The AHCPR Post-Stroke Rehabilitation Clinical Practice Guidelines defines aphasia as "the loss of ability to communicate orally, through signs, or in writing, or the inability to understand such communications; the loss of language usage ability." It has been reported that aphasia is one of the most common consequences of stroke in both the acute and chronic phases. Acutely, it is estimated that from 21 - 38% of stroke patients are aphasic. The presence of aphasia has been associated with decreased response to rehabilitation intervention and increased risk for mortality. In the present review, definitions, natural history and impact of aphasia are discussed. Therapy-based interventions are reviewed including group programs, training conversation partners, computer-based instruction, filmed language instruction constraint-induced therapy, repetitive transcranial magnetic stimulation, and direct current stimulation as well as deficit specific rehabilitation. Pharmacotherapy for aphasia is addressed and reviews of the impact, risk factors, clinical consequences and treatment of apraxia post-stroke are also provided.

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Key points

Computer-based language therapy may produce greater improvements in global speech and language than standard therapy.

Speech and language therapy may not be beneficial for global speech and language or social communication, in addition to activities of daily living.

Constraint induced aphasia therapy may be beneficial for improving repetition and writing.

Intensive language action therapy may be more beneficial than naming therapy for improving global speech and language.

Constraint induced aphasia therapy may not be beneficial for improving global speech and language and social communication.

The literature is mixed concerning constraint induced aphasia therapy's ability to improve auditory comprehension.

Lexical retrieval therapy may not be beneficial for improving aphasia related outcomes, auditory comprehension, and repetition post-stroke.

There is conflicting evidence about the effect of lexical retrieval therapy to improve naming when compared to no therapy.

Volunteer facilitated speech and language therapy may not be beneficial for improving aphasia related outcomes post-stroke.

Group therapies may not be beneficial for improving aphasia related outcomes post-stroke.

Trained conversational partners may be beneficial for improving social communication.

Music-based speech-language therapies may be beneficial for improving verbal fluency and repetition, but not social communication, discourse, or global speech and language when compared to conventional therapy.

Melodic intonation therapy may not have a difference in efficacy when compared to no language therapy for improving global speech and language or repetition.

There is little evidence to support computer-based therapies for improving aphasia.

Computer-based therapy may be beneficial for repetition and discourse.

Filmed speech therapy may not be beneficial for improving discourse of reading comprehension.

Inhibitory rTMS may be beneficial for improving discourse, naming, verbal fluency, social communication and global speech and language.

There is conflicting evidence about the effect of inhibitory rTMS to improve repetition and auditory comprehension.

Frontal anodal tDCS may not have a difference in efficacy when compared to sham stimulation for improving naming, social communication, and repetition post stroke.

There is conflicting evidence about the effect of frontal anodal tDCS to improve verbal fluency when compared to sham stimulation.

Acetylcholinesterase inhibitors may be beneficial for improving naming, but not social communication, repetition, general and auditory comprehension, and global speech and language.

Amphetamines may be beneficial for improving global speech and language post-stroke.

Beta blockers may not be beneficial for improving naming post-stroke.

Dopaminergic medication may be beneficial for improving aphasia related outcomes post-stroke.

Memantine may be beneficial for improving discourse, naming, social communication auditory comprehension and global speech and language, but not repetition.

Moclobemide may not be beneficial for improving social communication or global speech and language.

Bifemelane may be beneficial for improving naming and general comprehension.

Neuropeptides with language therapy may be beneficial for global speech and language.

Piracetam may not be beneficial for improving aphasia related outcomes post-stroke.

Nao-Xue-Shu may be beneficial for improving global speech and language post-stroke.

Scalp acupuncture may be beneficial for improving verbal fluency, writing, reading and global speech and language, but not auditory comprehension.

Apraxia strategy training may be beneficial for improving activities of daily living.

Gesture training for apraxia may be beneficial for improving general comprehension, apraxia and activities of daily living.

Modified Sackett Scale

Level of evidence	**Study design**	**Description**
Level 1a	Randomized controlled trial (RCT)	More than 1 higher quality RCT (PEDro score ≥6).
Level 1b	RCT	1 higher quality RCT (PEDro score ≥6).
Level 2	RCT	Lower quality RCT (PEDro score <6).
	Prospective controlled trial (PCT)	PCT (not randomized).
	Cohort	Prospective longitudinal study using at least 2 similar groups with one exposed to a particular condition.
Level 3	Case Control	A retrospective study comparing conditions, including historical cohorts.
Level 4	Pre-Post	A prospective trial with a baseline measure, intervention, and a post-test using a single group of subjects.
	Post-test	A prospective post-test with two or more groups (intervention followed by post-test and no re-test or baseline measurement) using a single group of subjects
	Case Series	A retrospective study usually collecting variables from a chart review.
Level 5	Observational	Study using cross-sectional analysis to interpret relations. Expert opinion without explicit critical appraisal, or based on physiology, biomechanics or "first principles".
	Case Report	Pre-post or case series involving one subject.

New to the 19th edition of the Evidence-based Review of Stroke Rehabilitation

1) PICO conclusion statements

This edition of Chapter 14: Aphasia and Apraxia rehabilitation synthesizes study results from only randomized controlled trials (RCTs), all levels of evidence (LoE) and conclusion statements are now presented in the Population Intervention Comparator Outcome (PICO) format.

For example:

Population: Stroke survivors

Intervention **Comparator**

SPASTICITY			
LoE	Conclusion Statement	RCTs	References
1b	**Bilateral arm training** may not have a difference in efficacy when compared to **TENS** for improving spasticity.	1	Stinear et al. 2014

Outcome

New to these statements is also the use of colours where the levels of evidence are written.

Red statements like above, indicate that the majority of study results when grouped together show no significant differences between intervention and comparator groups.

Green statements indicate that the majority of study results when grouped together show a significant between group difference in favour of the intervention group.

For example:

Population: Stroke survivors

Intervention

MOTOR FUNCTION			
LoE	Conclusion Statement	RCTs	References
1a	**Bilateral arm training** may produce greater improvements in motor function than **conventional therapy**.	4	Meng et al. 2018; Lee et al. 2017; Stinear et al. 2008; Desrosiers et al. 2005

Outcome **Comparator**

Yellow statements indicate that the study results when grouped together are mixed or conflicting, some studies show benefit in favour of the intervention group, while others show no difference between groups.

For example:

Population: Stroke survivors

Outcome **Intervention**

DEXTERITY			
LoE	Conclusion Statement	RCTs	References
1a	There is conflicting evidence about the effect of **CIMT** to improve dexterity when compared to **conventional therapy or motor relearning programmes** during the acute/subacute phase poststroke.	4	Shah et al. 2016; Yoon et al. 2014; Boake et al. 2007; Ro et al. 2006

Comparator

2) Aphasia and apraxia rehabilitation outcome measures

Outcome measures were classified into the following broad categories:

Discourse: These outcome measures assessed aspects of speech such as content and grammar, as well as the overall ability for giving instructions, storytelling or description.

Naming: These outcome measures assessed an individual's ability to retrieve and name certain objects. This includes fluency, convergent naming, divergent naming and confrontation naming.

Verbal Fluency: These outcome measures assessed the overall fluency of verbal expression. This includes aspects of speech such as prosody, the spontaneity of production or vocabulary and phase length.

Social Communication: These outcome measures assess the more social aspects of communication, such as social appropriateness and turn-taking.

Repetition: These outcome measures assess the ability for an individual to repeat a given word, phrase or text.

Writing: These outcome measures are designed to assess the ability of an individual to produce written language.

General comprehension: These outcome measures assess an individual's ability to comprehend speech and/or language in multiple modalities.

Reading comprehension: These outcome measures specifically assess comprehension of written language and alphanumeric symbols.

Auditory comprehension: These outcome measures specifically assess comprehension of heard speech sounds.

Global speech and language: These outcome measures are generally comprehensive aphasia batteries that examine multiple aspects of speech and language. Should the study report specific subscales of these batteries, they will be counted towards their corresponding category above.

Apraxia: These outcome measures assess apraxia impairment.

Activities of daily living: These outcome measures assessed performance and level of independence in various everyday tasks.

Outcome measures that fit these categories are described in the next few pages.

Outcome Measure Definitions

Expression

Discourse

Content Units: Are clusters of linguistic elements and isolated phrases with high communicative value and which can serve as an indication of the ability to produce language (Loban 1964). Patients with aphasia typically have difficulty stringing together multiple content units (Helm-Estabrooks 1986).

Sabadel Story Retelling Task: evaluates the production of connected speech. The patient must retell a given short story directly after they have heard it from the administrator of the test. It is also supported with photographs (Van der Meulen et al., 2014).

Conversational Rating: is a rating scale from 0-7 (0=normal, 7=severe) that was developed for a particular study by Wertz et al (1981). It is meant to assess conversational ability but is not standardized and therefore has no psychometric data available.

Cookie Theft Picture Description: Is a task from the Boston Diagnostic Aphasia Examination used to assess spontaneous sentence production. This task involves a patient viewing a picture of a chaotic domestic scene and then describing said scene to a trained clinician (Vuksanovic et al., 2018).

Discourse Quality: Is a measure of assessing the speech (discourse) of a participant. Their usage of nouns, verbs and proper grammatical structuring are measured and analyzed by a trained clinician (Brady et al. 2016).

Discourse Quantity, Word and Utterance Count: Is a measure of speech (discourse) in which a participants speaks and then their words are analyzed by a trained clinician using a Systematic Analysis of Language Transcripts (Chapman & Miller, 1984; Altmann et al. 2014).

Information Index: Is a measure of an individual’s language content in which the ratio of the total number of content words to the total number of function words is calculated (Gupta et al. 1995). Content words include nouns, verbs, adverbs, and adjectives, while function words include prepositions, verb auxiliaries, and articles (Gupta et al. 1995).

Speech Content Analysis: is a method of analysing speech based on a standardized rule set for scoring. Although the exact analysis may differ from study to study, all have the same basic principles. Speech is generally recorded, and the rated. There will be a number of different variables, like significant words (verbs,nouns,adjectives etc…), content units (grammatical and semantic unit eg), pauses and other relevant aspects of speech production (Sabe et al., 1995).

Naming

Controlled Oral Work Association Test: Is a common measure of verbal fluency in which patients are assessed on their ability to generate words beginning with a certain letter of the alphabet within a limited amount of time (Strauss et al. 2006; Ross et al. 2007).

Action Communication Test: Is a diagnostic test of aphasia that assesses the ability of utterance-centered object naming and communicative pragmatic social interaction upon verbal request. When naming or requesting objects, two points are given for a correct response, 1 for a correct response after error, or a related utterance, and 0 points for any further errors or omissions. The measure has shown good reliability and sensitivity (Stahl et al. 2017).

Boston Naming Test: Is used as an assessment of the ability to retrieve words, and is commonly used in patients with aphasia (Roth 2011). Sixty line drawings of various difficulty are presented and patients are asked to identify and name objects depicted (Ellis et al. 1992). This assessment has demonstrated good validity and reliability (Pedraza et al. 2011).

Object and Action Naming Battery: Is an assessment of an individual's visual confrontation naming ability through the presentation of black and white line drawings, totaling 162 objects and 100 verbs (Spezzano et al. 2013).

Picture Naming and Category Test: Is an assessment in which line drawings are presented on a screen and patients are instructed to name the pictures or categorize them as accurately and quickly as possible. This test helps assess the patient(s) reasoning skills as well as their verbal fluency and articulation (Kindler et al. 2012).

FAS Phonemic Fluency Task: is a subtest of the Neurosensory Center Comprehensive Examination for Aphasia that examines phonemic fluency. It requires the participant to produce as many words as they can that begin with the letters 'F', 'A', and 'S' with in a given time (Sarno et al., 2005).

Letter Fluency: Is a verbal fluency test of verbal functioning in which individuals are given one minute to produce as many unique words as possible beginning with a certain letter (Shao et al. 2014). The score is the number of unique words that are correctly produced (Shao et al. 2014)

Naming Tests (Fluency Tests): These tests can take many different forms but evaluate a patient's ability to demonstrate proper speech production and fluency. Patients do this by naming various objects and/or words. Common examples include naming items in picture form, naming words that fall into a specific category (eg. animals), or naming words that begin with a specific letter. Results are then analyzed by a trained clinician (Rabbit 2004).

Semantic Fluency Test: Is a cognitive assessment in which patients are instructed to produce as many words as possible from a given category (ex. countries of the world) within a set amount of time (usually 60 seconds). The patient is then rated on two distinct categories: speed and level of fluency(Lezak et al. 2004).

Verbal Fluency Test: Is an assessment in which patients are instructed to produce as many words, either from a specific category (ex. sports teams), or words that begin with a certain letter, all within a set amount of time (usually 60 seconds). Patients are then assessed on two distinct categories: speed and actual fluency. This test is very similar to the semantic fluency test (Lezak et al. 2004).

Verbal fluency

Mean Phrase Length: Is a measure of the number of words produced between pauses as an assessment of fluency. Long phrases in conjunction with short pauses are result in a higher outcome score. (Goodglass et al. 2001).

Mean Vocal Reaction Time: is a measure meant to assess a factor of speech production. The slower one is the begin vocalization, the more impaired they are assumed to be on motor speech planning and execution, and language processing abilities (Towne & Crary, 1988).

Melodic Intonation Therapy Task: Is a measure of intonation ability in patients with non-fluent aphasia, in which phrases with an increasing number of syllables are sung. Patients continue to sing these phrases until they have trouble doing so at which time they are assessed by a trained clinician (Norton et al. 2009).

Spontaneous Speech: is a subtest of the Aachen Aphasia test, and the Western Battery Apahsia. It involves a semi-structured interview that is often recorded and rated afterwards. Spontaneous speech is assessed on 6 scales (production, articulation and prosody, sentence structure, word finding, sound structure and comprehension). All subscales are rated on a scale from 0-5, with smaller scores indicating greater levels of impairment (Miller, Willmes & De Bleser, 2000).

Social communication

Amsterdam-Nijmegen Everyday Language Test: Is a measure of verbal communication in patients with aphasia. It assesses how understandable and intelligible verbal communication is. It contains 10 items, each of which relates to an everyday life situation in which an individual would need to speak. The situation Is briefly described, and the question of 'What do you say?" is posed to participant. Their verbal responses are scored based on a standardized rating scheme. It has shown good reliability, stability and ecological validity (Blomert et al. 1994).

Functional Communication Profile: Is a measure of a patient's communication abilities, mode of communication, and degree of independence. Subtests include sensory/motor, attentiveness, receptive language, expressive language, pragmatic/social language, speech, voice, oral, fluency, non-oral communication.

Communication Effectiveness Index: Is a measure of aphasia in which a relative of a patient with aphasia rates communication function of the patient in 16 functional situations using a visual-analogue rating scale that goes from "not able at all" to "as able as before the stroke" (Pedersen et al. 2001).

Informant's Rating: Is a questionnaire given to the patient's family or caretaker to asses their use of language, and their 'functional' language ability on a scale of 1-5. This was adapted from a previous study by Sarno (1969) (Wertz et al., 1981)

Communication Outcomes After Stroke Scale: is a 29-item (or 20 in modified version), self-rated researcher-administered scale for assessing aphasia and/or dysarthria. Each item is rated on a 5-point Likert scale. Questions assess verbal communication, non-verbal communication, self-efficacy, impact on daily life, and any improvements since onset. It has shown good internal consistency and reliability (Long et al., 2008).

Communicative Activity Log: is a questionnaire completed by the patient and/or a family member or caretaker. The measure has 36 items, 18 concerning active communication, and 18 concerning the quality of comprehension. Each item is rated on a 6-point Likert scale. The maximum score achievable is 90, with higher scores corresponding to better language abilities (Pulvermuller & Berthier, 2008). A Korean language version has shown good reliability and validity (Kim et al., 2015).

Functional Communication Therapy Planner: Is an assessment of a select key goals that are relevant to the individual. Performance in these real-life situations are assessed using a multidimensional seven-point scale of communicative effectiveness (Worrall 1999; Worrall and Yiu 2000).

Measure of Participation in Conversation: Is a measure of the ability of an individual to participate in interactional and transactional elements of conversation. This measure can assess how quickly and appropriately a patient responds to queries (ex. "How are you doing?") and if they respond correctly (ex. "I'm doing well thanks and you?) (Togher et al. 2010).

Speech Questionnaire: Is an assessment of functional communication skills in patients with aphasia (Lincoln 1982). Fifteen questions assess speech, and four assess understanding. Answers are provided by checking off options of often, sometimes, rarely, and never. This assessment has demonstrated adequate test-retest reliability (Lincoln 1982).

Repetition

Phonological Measures – repetition: Is a test of verbal functioning that consists of two tasks including: repetition of non-words and lexical decisions. Non-words are a string of letters that sound like a word and are useful in assessing fluency difficulties. Lexical decisions encompass what words a participant selects to finish a sentence and if they are appropriate ones (Doesborg et al. 2004).

Standardized Language Test: Is an assessment of language production in which syllables, words and sentences are auditorily presented and patients are instructed to repeat the stimuli back. Syllables presented included different places and manners of articulation. Accuracy, as well as reaction time are used to quantify performance on the measure (Marangolo et al., 2013).

Writing

Written Language: is a component of many comprehensive aphasia batteries. Although the exact methodology may differ between types of written language tests, subjects are generally required to write down some requested information, a description or story and/or writing what is dictated to them.

Comprehension

General comprehension

Gesture Comprehension: is an assessment of an individual's ability to comprehend non-verbal transitive and intransitive-symbolic gestures. This measure was developed ad hoc by Smania et al. (2000). The test involves showing the participant pictures of an individual performing a gesture. The pictures contain either an appropriate object/context for the gesture, and semantically related by nonetheless incorrect object/context, and a semantically unrelated inappropriate object/context (Smania et al., 2000).

Semantic Association Test: is an assessment of higher language comprehension whereby, through pictures or words, a target object is shown or listed among other objects. The patient then must select the word/object that semantically relates o the target word/object (Visch-Brink et al., 1997).

Body-Part Identification: is a subtest of the Boston Diagnostic Aphasia Examination that consists of 24 items. Each is a body part that the tester names, and the patient is required to identify on their own person. This particular item is a test of comprehension (Goodglass & Kaplan, 1972).

Discrimination Tasks: are all tests relating to comprehension, and the ability to discriminate words and/or speech sounds. Although the exact nature of the task can vary from study to study, discrimination tests generally require a participant to select target words from a list of distractor words. This discrimination can be made based on words vs non words, word category, or previous exposure to target words during training. These words can either be presented as auditory or written stimuli (Woolf et al., 2014; Seniow et al., 2009).

Reading comprehension

Reading Comprehension Battery for Aphasia: Is a measure of reading impairment in patients with aphasia. Twenty subtests are included, measuring a large range of activities involved in reading. This outcome has demonstrated excellent test/retest reliability and adequate predictive validity in patients with aphasia (van Demark et al. 1982).

Auditory Comprehension

Complex Ideation: is a subtest of the Boston Diagnostic Aphasia Exam. It Is an assessment of sentence comprehension in which brief narratives are read out loud and comprehension of information from the passages is tested through yes or no questions (Erdodi & Roth 2017). There are 12 pairs of semantically related statements, and both must be answered correctly per pair to score points, for a maximum score of 12.

Miscellaneous Commands: Is an assessment of one's ability to comprehend speech, by listening to and obeying simple commands. These commands could be anything from asking the patient to clap their hands together to asking the patient to take a drink of water. This assessment is one of the subtests of the Boston Diagnostic Aphasia Examination (Fong et al., 2019).

Peabody Picture Vocabulary: Is a measure of ability to listen to and understand single-word vocabulary. For this assessment, a clinician holds open a book that has 4 pictures per page. They then say a word that describes one of the 4 pictures and the participant must point to the appropriate picture as quickly and accurately as possible. (Carey et al. 2009).

Token Test: Is an assessment of auditory comprehension in patients with aphasia. This test is crucial for discovering subtle auditory comprehension deficits. It consists of 20 plastic tokens of two sizes (large and small), two shapes (square and round) and five colours. These items are then laid in front of a patient and they are then instructed to point to specific ones by a clinician. For example, the clinician could say: "point to a large token and then a square". The patient is then evaluated on how quickly and accurately they carried out this request (Coupar et al. 1976).

Phonological Measures – lexical decision: Is a test of verbal functioning that consists of two tasks including: repetition of non-words and lexical decisions. Non-words are a string of letters that sound like a word and are useful in assessing fluency difficulties. Lexical decisions encompass what words a participant selects to finish a sentence and if they are appropriate ones (Doesborg et al. 2004).

Global Speech and Language

Aachen Aphasia Test: Is a speech rating scale that includes 6 subscales. Spontaneous language, the Token Test, repetition, written language, naming, and comprehension. Each subscale is made up of multiple subtests, each examining various aspects of language comprehension, processing and production. The test originally developed in german has been translated to multiple different languages, ad has shown good validity and reliability (Miller, Willmes & De Bleser, 2000).

American Speech-Language Hearing Association Functional Assessment of Communication Skills: Is a measure of how speech, language, hearing, or cognitive deficits influence performance on activities of daily living (Frattali et al. 1995). The test includes 2 distinct scales, The Scale of Communication Independence and The Scale of Qualitative Dimensions of Communication. The first contains four assessments (social communication, communication of basic needs, reading, writing and number concepts, and daily planning), all of which are made up of multiple items, scored on a 7-point Likert scale. The second scale contains 4 assessments (adequacy, appropriateness, promptness and communication sharing) that are graded on a 5-point Likert scale. The measure has shown good reliability, consistency and validity in multiple languages (Muò et al., 2015).

Aphasia Severity Rating Scale: Is a neuropsychological assessment of language deficits calculated using the Boston Diagnostic Aphasia Exam (see definition) with 0 representing no usable speech or auditory comprehension, and 5 representing minimal discernable speech or language handicaps (Goodglass & Kaplan 1983; Khedr et al. 2014).

Boston Diagnostic Aphasia Examination: Is a measure of aphasia and evaluates perceptual modalities, processing functions, as well as response modalities. The exam is made up of 8 subdomains (fluency, auditory comprehension, naming, oral reading, automatic speech, reading comprehension and writing) all of which contain multiple subtests. This assessment has demonstrated good construct validity in patients with aphasia (Fong et al. 2019).

Communicative Activities in Daily Living: Is an assessment of functional communication skills in which 50 items are used to assess seven areas of communication ability (Holland 1980). These include reading, writing, and using numbers; social interactions; contextual communication; nonverbal communication; sequential relationships; humor, metaphor, absurdity; and internet basics (Holland 1980).

Comprehensive Aphasia Test: is a battery for assessing aphasia. It has 3 parts; The first screens for cognitive deficits that may influence results. The second assess language performance in many areas (eg auditory comprehension, written comprehension, reading etc..). The third part is a number of visual analog scales that are related to the patient's subjective degree of disability. The test has shown both good validity and reliability (Howard, Swinburn & Porter, 2009).

Concise Chinese Aphasia Test: Is a standardized language assessment that is linguistically and culturally neutral for native Mandarin Chinese speakers (Chung et al. 1998). This test consists of 9 distinct subscales which are: simple response, spoken narrative, object matching, hearing comprehension, word expression, reading comprehension, recruiting sentences, graphical imitation and spontaneous writing (Chung et al. 1998).

Hemispheric Stroke Scale- Language: Is a measure that includes assessments related to level of consciousness, language, other cortical functions and cranial nerves, motor function, and sensory functioning. The language subtest specifically assesses comprehension, naming, repetition, and fluency.

Montreal-Toulouse Aphasia Battery (MT-86): is a battery of tests to assess language deficits in individuals with aphasia. The battery assesses auditory comprehension, oral expression, reading, writing, praxis and arithmetic. It has been shown to have adequate reliability and validity in multiple languages (Pagliarin et al., 2014)

Persian Language Test: Is a language test which assesses seven subtests, including naming, verbal fluency, gesture to command, single-word responses, repetition, automatic speech, prosody, and global score (Ashtary et al. 2006)

Porch Index of Communicative Ability: Is a measure of comprehension, verbal expression, writing, and spelling. The patient is assessed on a 16-point scale (1=no awareness of task and no response, 16=complete/full awareness of the task and complex/thoughtful response) (Meikle et al. 1979).

Psycholinguistic Assessment of Language Processing in Aphasia: Is an assessment of language processing ability. This assessment can rate a patient's ability to both speak and write. This assessment consists of 6 subtests (introduction, auditory processing, reading and spelling, picture and word semantics, sentence comprehension and copy masters) (Kay et al., 1996).

Reinvang's Aphasia Test: Based on the Boston Diagnostic Aphasia Examination, this assessment is a neuropsychological battery used to assess the presence of aphasia. This test consists of 4 subtests which are: fluency, comprehension, naming and repetition (Reinvang & Graves 1975).

Rivermead Perception Assessment Battery: Is an assessment of visual perceptual ability and includes 16 subtests (Picture Matching, Object Matching, Size Recognition, Series, Missing Article, Sequencing-Pictures, Right/Left Copying Words, Colour Matching, Right/Left Copying Shapes, Cube Copying, Three-Dimensional Copying, Cancellation, Figure-Ground Discrimination, Animal Halves, Body-Image Self-Identification and Body Image). A trained clinician then compiles all the results and evaluates the patient

Spreen-Benton Test: Also known as the Neurosesnory Center Comprehensive Examination for Aphasia, this test has 24 subtests assessing language and 4 'control' test of visual and tactile functions. The test score is adjusted for based on age and education. It has shown a very strong sensitivity for moderate to severe aphasia (Bush, 2011; Spreen & Riser, 2003).

Test Lillois de Communication: Is a standardised assessment of communication which is made up of participation, verbal and non-verbal components. More specifically, it is made up of 3 distinct evaluation grids: attention and motivation to communicate, verbal communication, and non-verbal communication. It has been validated in stroke populations, with fair inter-rater reliability (Darrigrand et al., 2011).

Western Aphasia Battery: Is an assessment of linguistic and nonlinguistic skills of individuals with aphasia. It characterizes strengths and weaknesses in fluency, comprehension, repetition, and naming (Pritchard & Dipper 2018). This measure has three composite scores consisting of the language quotient, the cortical quotient, and the aphasia quotient (Shewan & Kertesz 1980). This measure has been demonstrated to be valid, with excellent reliability (Shewan & Kertesz 1980).

Apraxia

Ideomotor Apraxia: Is a disorder which impacts the ability to produce communicative gestures in response to verbal command (ex. waving goodbye). Furthermore, it impacts the patient's ability to perform various pantomimes (dramatic gestures) such as pretending to use a hammer.(Wheaton and Hallet 2007)

Apraxia Battery for Adults: Is a measure of apraxia in which participants perform various tasks and are assessed on diadochokinetic rate, increasing word length, limb and oral apraxia, latency and utterance time for polysyllabic words, repeated trials test, and inventory of articulation characteristics (Dabul et al. 2000)

Activities of Daily Living

Barthel Index (BI): Is a measure of one's ability to perform activities of daily living. The scale consists of 10 items: personal hygiene, bathing, feeding, toilet use, stair climbing, dressing, bowel control, bladder control, ambulation or wheelchair mobility and chair/bed transfers. Each item has a five-stage scoring system and a maximum score of 100 points, where higher scores indicate better performance. The scale is suitable for monitoring on the phone and is shown to have a high inter-rater reliability (Park 2018).

Functional Independence Measure (FIM): Is an 18-item outcome measure composed of both cognitive (5-items) and motor (13-items) subscales. Each item assesses the level of assistance required to complete an activity of daily living on a 7-point scale. The summation of all the item scores ranges from 18 to 126, with higher scores being indicative of greater functional independence. This measure has been shown to have excellent reliability and concurrent validity in its full form (Granger et al. 1998, Linacre et al. 1994; Granger et al. 1993).

Kuriansky Performance Test: Is a measure of performance on selected activities of daily living. The measure contains 73 items which are grouped into 15 'tasks'. Each item is scored from 0-2, with a maximum score of 146. Higher scores indicate greater performance in activities of daily living. (Kruiansky & Gurland 1976).

Therapy Outcome Measure – activity: Is an 11-point scale (0-5 with half points) that can classify a patient's verbal language skills. However, this test can also be used to assess a patient's level of impairment, activity, participation in extracurricular events and general wellbeing (Bowen et al., 2012).

Defining Aphasia

The AHCPR Post-Stroke Rehabilitation Clinical Practice Guidelines defines aphasia as "the loss of ability to communicate orally, through signs, or in writing, or the inability to understand such communications" (Klein, 1995). Darley (1982) noted that aphasia is generally described as an impairment of language as a result of focal brain damage to the language dominant cerebral hemisphere. This serves to distinguish aphasia from the language and cognitive-communication problems associated with non-language dominant hemisphere damage, dementia and traumatic brain injury (Orange & Kertesz, 1998). Ninety-three percent of the population is right-handed, with the left hemisphere being dominant for language in 99% of right-handed individuals (Delaney & Potter, 1993). In left-handed individuals, 70% have language control in the left hemisphere, 15% in the right hemisphere, and 15% in both hemispheres (O'Brien & Pallett, 1978). Language function is almost exclusively the domain of the left hemisphere; for 96.9% of the population language control is localized primarily in the left hemisphere.

Table 1. Boston Classification System - Characteristic Features of Aphasia

Type	Fluency	Comprehension	Repetition
Broca's	Nonfluent	Good	Poor
Transcortical motor	Nonfluent	Good	Good
Global	Nonfluent	Poor	Poor
Wernicke's	Fluent	Poor	Poor
Transcortical sensory	Fluent	Poor	Good
Anomic	Fluent	Good	Good
Conduction	Fluent	Good	Poor

The concept of aphasia as simply a disorder of language fails to do the entity justice. Kertesz (1979) clinically described aphasia as a *"...neurologically central disturbance of language characterized by paraphasias, word finding difficulty, and variably impaired comprehension, associated with disturbance or reading and writing, at times with dysarthria, non-verbal constructional and problem-solving difficulty and impairment of gesture".* The Boston classification system is used frequently by researchers and clinicians to classify type of aphasias (Table 1). Type of aphasia is determined, primarily, by lesion location (Godefroy et al., 2002).

Natural History and Impact of Aphasia

It has been reported that aphasia is one of the most common consequences of stroke in both the acute and chronic phases. Acutely, it is estimated that from 21 – 38% of stroke patients are aphasic (Berthier, 2005). A recent report based on data from the Ontario Stroke Audit (Ontario, Canada) estimated that 35% of individuals with stroke have symptoms of aphasia at the time of discharge from inpatient care (Dickey et al., 2010).

Global aphasia is the most common type in the acute period affecting as many as 25-32% of aphasic patients, while other classic aphasias described within the Boston system of classification are seen less frequently (Godefroy et al., 2002; Laska et al., 2001; Pedersen et al., 2004). The frequency of unclassified or mixed aphasias that cannot be assigned to a classic category is more difficult to determine. Godefroy et al. (2002) reported approximately 25% of patients as having non-classified aphasias, comprised mostly of disorders similar to anomic aphasia in addition to some other impairments. In that study, the presence of non-classified aphasia was significantly associated with a history of previous stroke. Initial stroke severity and lesion volume have been associated with initial severity of aphasia (Ferro et al., 1999; Laska et al., 2001; Pedersen et al., 2004).

Significant risk factors associated with development of aphasia include older age and greater severity of stroke and of disability (Bersano et al., 2009; Croquelois & Bogousslavsky, 2011; Dickey et al., 2010; Engelter et al., 2006; Gialanella & Prometti, 2009; Kyrozis et al., 2009). In a population-based study of aphasia following first-ever ischemic stroke, Engelter et al. (2006) reported that risk for aphasia increased significantly with age, such that each advancing year was associated with 1-7% greater risk. While 15% of individuals under the age of 65 experienced aphasia, in the group of patients 85 years of age and older, 43% were aphasic. In a study of 1,541 consecutive stroke cases, Croquelois et al. (2011) also found cardioembolic origin and superficial middle cerebral artery stoke to be significant risk factors for the development of aphasia.

For many, aphasia improves during the first year following the stroke event. A review by Ferro et al. (1999) reported that approximately 40% of acutely aphasic patients experience complete or almost complete recovery by one year post stroke. Similarly, Maas et al. (2012) found that 86% of stroke patients presenting with aphasia symptoms in an emergency setting experienced partial improvement within six months, 74% of whom had completely resolved.

Within the literature, most longitudinal studies have identified that the greatest amount of spontaneous recovery occurs in the first 3 months following stroke. After this, the rate of recovery slows and little additional spontaneous recovery can be expected after the first 12 months (Ferro et al., 1999). Pedersen et al. (2004) reported that during these first 12 months, aphasia of all types (even global aphasia) tended to evolve to a less severe form. While 61% of aphasic patients in the Copenhagen Aphasia Study still experienced aphasia at one year post stroke, it was usually of a milder form.

Similarly, Bakheit et al. (2007) demonstrated that patients with all types of aphasia experienced significant improvement in the first 6 months post-stroke when treated with conventional speech and language therapy as part of a comprehensive rehabilitation program. Improvements were greatest in the first 4 weeks, and then slowed to a lesser though still significant rate. Further, individuals diagnosed with Broca's aphasia demonstrated the greatest gains despite greater initial impairment. In general, patients with Broca's aphasia made greater gains in terms of scores on the Western Aphasia Battery (WAB) than patients with global aphasia, who in turn demonstrated greater improvement than those with Wernicke's, anomic or conduction aphasia. However, it should be noted that patients with anomic and conduction aphasia demonstrated better WAB scores at baseline and so did not require as much improvement in order to return to normal speech and language abilities as patients with Broca's or Wernicke's aphasias. Bakheit et al. (2007) also cite previous literature that suggests severe and non-fluent aphasia progresses through phases of moderate aphasia such as conduction to less severe aphasia such as anomic aphasia before a full recovery.

Furthermore, in a study of 147 patients, El Hachioui et al. (2013) observed that linguistic component scores in phonology were found to be predictive of functional verbal outcome at 1 year following a stroke. However, Pedersen et al. (2004) reported no significant differences in recovery on the various parts of the Western Aphasia Battery and found that gains ranged from 54% for comprehension to 78% for naming. An additional study by El Hachioui et al. (2011) suggested that it may be beneficial to test performance levels for the various facets of language separately, rather than rely on overall assessments in order to examine recovery patterns.

The most powerful predictor of recovery may be the initial severity of aphasia such that greater severity is associated with poorer recovery (Berthier, 2005; Ferro et al., 1999; Laska et al., 2001; Laska et al., 2011; Pedersen et al., 2004). Lazar et al. (2010) reported that more than 80% of recovery could be predicted based on initial severity of aphasia. In addition, the authors suggested that the relationship between recovery and initial impairment is proportional. Based on 21 stroke patients with mild to moderate aphasia and composite scores from 3 subtests of the Western Aphasia Battery (comprehension, repetition and naming), the authors demonstrated that patients improved by 73% of maximum potential recovery (defined as maximum potential language score minus their initial WAB score) during the first 90 days post stroke. The authors suggested that this may be attributable to mechanisms of spontaneous recovery common to all domains of function.

The influence of other factors on the degree of recovery is less clear. While some studies report recovery to be significantly better for younger patients (Ferro et al., 1999; Laska et al., 2001) others report that age does not predict recovery (Payabvash et al., 2010; Pedersen et al., 2004). Similarly, while there are reported gender differences in type and severity of aphasia, sex does not predict recovery (Laska et al., 2001; Payabvash et al., 2010; Pedersen et al., 2004). Studies examining handedness and education also provide conflicting results (Berthier, 2005; Ferro et al., 1999).

In examining the prediction of language recovery, Payabvash et al. (2010) derived a model based on analysis of admission CT perfusion scans to predict early language improvement in individuals with acute stroke. Using multiple logistic regression, the authors identified 4 factors that could predict improvement on the NIHSS aphasia item with 90% sensitivity (91% specificity): aphasia score on admission NIHSS, presence/absence of proximal cerebral artery occlusion on admission CT, relative cerebral blood flow of the sublobar insular ribbon (lower third) and relative cerebral blood flow of angular gyrus (BA39). The authors present an 8-point scoring system Table 2. to predict language improvement based on these 4 factors (Payabvash et al., 2010).

Table 2. 8-Point Scoring System to measure improvement of Aphasia (Payabvash et al., 2010)

Variable	Absence/Presence, Value	Score (points)
Aphasia score on admission NIHSS	-	1-3
Proximal cerebral artery occlusion on admission CT Angiography	Absent Present	0 2
Relative cerebral blood flow (rCBF) of the sublobar insular ribbon (Lower third)	>1.5 0.66-1.5 0.34-0.66 <0.34	-2 0 1 2
rCBF of angular gyrus GM (BA 39)	>0.66 ≤0.66	0 1
		Total (/8) *(Excellent 1-2, Fair 3-4, Poor 5-6, Dismal 7-8)*

Mortality. The presence of post-stroke aphasia has been associated with higher rates of mortality over both the short and long-term. Laska et al. (2001) demonstrated that mortality among aphasic patients was 11% in the acute period compared to 3% among non-aphasic patients. While this early comparison did not reach statistical significance, it was significant at 18 months (p=0.02). However, more recently, Guyomard et al. (2009) examined in-hospital mortality for individuals with aphasia and reported significant increases in risk associated with speech disorders, even when controlling for age, sex, premorbid Rankin score, previous disabling stroke and stroke type (OR = 2.2, 95% CI 1.8-2.7).

Similarly, Bersano et al. (2009) reported significantly greater rates (11% vs. 4%; p<0.0001) of in-hospital mortality for individuals with aphasia vs. those without. At 2-year follow-up, 34% of individuals with aphasia had died vs. 19% of non-aphasic individuals. Individuals with aphasia did have more severe strokes, greater motor impairments and were more likely to have experienced a haemorrhagic stroke. However, presence of aphasia was associated with significantly greater odds for mortality overall (OR=2.09; 95% CI 1.90-2.32) when controlling for age, sex, atrial fibrillation, cerebral haemorrhage and severity of motor impairment (Bersano et al., 2009).

In the Copenhagen Aphasia Study, Pedersen et al. (2004) reported mortality in aphasic patients to be 27% one year following stroke. In that study, there was a tendency for mortality at one year to be associated with the severity of aphasia at the time of the acute admission.

Rehabilitation Gains. In a study of 240 stroke patients, Paolucci et al. (2005) reported that, while all patients experienced significant gains over the course of rehabilitation, patients with aphasia and comprehension deficits had poorer outcomes in terms of activities of daily living, mobility and urinary continence at discharge than patients with no aphasia or patients with aphasia but no comprehension deficits. The most powerful predictor of effectiveness of rehabilitation as assessed on the Barthel Index and Rivermead Mobility Index was performance on a semantic-associated word comprehension task. For patients with aphasia and comprehension deficits, the risk of poor response to rehabilitation was approximately 5 times greater than for patients with aphasia and no comprehension deficits or patients with no aphasia (Paolucci et al., 2005). Additionally, in a study of 156 patients, Gialanella (2011) demonstrated that comprehension deficits were predictive of total Functional Independence Measure (FIM) score at discharge from inpatient rehabilitation.

Presence of aphasia may result in extended lengths of stay in rehabilitation, with less demonstrated gain over time. Gialanella and Prometti (2009) demonstrated that in a group of 252 stroke patients admitted for inpatient rehabilitation, those with aphasia (n=126) tended to have longer lengths of stay (p=0.056), smaller gains in function (assessed on the motor Functional Independence Measure score; p=0.017) and poorer rehabilitation gains per day (p<0.0001) than individuals with no aphasia (n=126).

Although the presence of aphasia has also been reported to have an adverse effect on mood, functional and social outcomes as well as overall quality of life (Davidson et al., 2008; Ferro et al., 1999; Wade et al., 1986). Williamson et al. (2011) demonstrated no significant association between aphasia severity and overall quality of life in a group of 24 subjects with chronic stroke.

Discharge Destination. Individuals with post stroke aphasia may be less likely to return home following stroke. Dickey et al. (2010) reported that (in Ontario, Canada) twice as many patients with aphasia are discharged directly to long-term care from acute care than individuals without aphasia (14% vs. 7%). However, relatively more individuals with aphasia are discharged to inpatient rehabilitation facilities (34% vs. 24%). In addition to having greater dysfunction at admission to and discharge from inpatient rehabilitation as well poorer rates of recovery compared to non-aphasic patients, Gialanella and Prometti (2009) reported that significantly more individuals with aphasia were discharged to nursing homes (p=0.002). Similarly, Bersano et al. (2009) demonstrated that, at 2 years post stroke, relatively fewer individuals with aphasia still lived at home compared to patients with no aphasia (87% vs. 91%, OR=1.39 [1.17-1.65]). Auditory comprehension, reading comprehension, and tactile naming deficits were more common in individuals discharged somewhere other than home when compared with those discharged home (63.6% vs. 42.9; 70.7% vs. 54.0%; 62.9% vs. 43.6% respectively) (Gonzolez-Fernandez, 2013).

Therapies for Aphasia

Reviewing and critiquing therapies for aphasia was challenging because of the extensive number of heterogeneous studies, many of which relied on small samples and were poorly designed or of overall low quality.

Language Therapy Reviews

Robey (1994) performed a meta-analysis of 21 studies of aphasia treatments that revealed several important findings. The significant findings of this meta-analysis were summarised by Orange and Kertesz (1998) into four points: "(1) the performance of individuals who receive language therapy in the acute stage of recovery is nearly twice as large as the effect of spontaneous recovery alone; (2) language therapy initiated after spontaneous recovery has a positive, albeit small, effect on language performance; (3) a medium to large effect is present in comparisons of treated versus untreated individuals when therapy is begun in the acute phase and (4) a small to medium effect is present in treated versus untreated groups when therapy is begun in the chronic stage of recovery (i.e. 6 – 12 months post onset)".

Robey (1998) conducted a second meta-analysis of 55 articles to investigate the general effectiveness of aphasia treatments across stages of recovery and to assess the different experimental and clinical dimensions of aphasia treatment. Again, Robey found that the average effect for treated recovery was nearly twice that for untreated recovery when treatment was begun in the acute phase. When treatment was initiated in the acute phase, the average effect size, although smaller, was 1.68 times greater than that of spontaneous recovery alone. When treatment was delayed until the chronic phase, the average effect size for treated patients was smaller, but still exceeded that of non-treated patients. In addition, the meta-analysis revealed that the more intensive the therapy, the greater the improvement. Robey suggested that two hours of treatment per week should be the minimum length of time for patients who can tolerate receiving intensive therapy. Finally, it was noted that large gains were made by individuals with severe aphasia treated by speech-language pathologists (Robey, 1998).

Both the Robey meta-analyses (Robey, 1994; Robey & Schultz, 1998) examined aphasia therapy as it pertained to all aphasic patients and not just stroke-based patients with aphasia. Furthermore, both meta-analyses excluded drug treatment therapies. Finally, neither Robey meta-analyses assessed the quality of methodology of the trials reviewed.

A Cochrane Systematic Review by Greener et al. (1999) identified 12 trials investigating speech and language therapy for aphasia following stroke that were rated as suitable for review. However, they noted that most trials were old, and often had poor quality or used methodology that could not be evaluated unambiguously. Overall, the trials lacked sufficient detail for Greener et al. (1999, 2001) to carry out complete descriptions and analyses. Consequently, they were unable to determine whether formal language therapy was more effective than informal support. Kelly et al. (2010) provided an updated Cochrane review including results from a total of 30 trials comparing i) speech and language therapy (SLT) with no SLT, ii) SLT with social support and communication stimulation and iii) two different approaches to SLT (see Table 3). Few significant differences were noted in SLT vs. no SLT comparisons; however, the authors note that there is a consistent direction of results in favour of speech and language therapy, overall. There was some evidence that the provision of social support and stimulation was associated with improved receptive and expressive language skills, although this result was based primarily upon findings of a single study. In examining specific approaches, the authors found that intensive SLT was associated with improved written and receptive language and in overall measures of severity when compared to conventional SLT. Volunteer-facilitated therapy appeared to produce outcomes similar to conventional SLT and, in one study, produced superior results on measures of spoken repetition. Apart from these two notable exceptions (intensity and volunteer-facilitated therapy), the authors state that there was insufficient evidence to support the effectiveness of one approach over the other.

Table 3. Cochrane Review of Effectiveness of Speech and Language Therapy for Post-Stroke Aphasia (Kelly et al., 2010)

Study	Types of Intervention
Bakheit et al. 2007	Intensive vs. conventional SLT
David et al. 1982	Conventional SLT vs. social support & stimulation
Denes et al. 1996	Intensive vs. conventional SLT
DiCarlo et al. 1980	SLT+filmed instruction vs. conventional SLT
Doesborgh et al. 2004a	Semantic treatment vs. phonological treatment
Doesborgh et al. 2004b	Computer-based SLT vs. no SLT
Drummond et al. 1981	Gesture cuing vs conventional SLT
Elman et al. 1999	Conventional SLT vs. social support & stimulation
Hinckley et al. 2001	Functional SLT vs. conventional SLT
Jufeng et al. 2005 (Chinese)	Group SLT vs. conventional SLT vs. no SLT
Katz et al. 1997	Computer-mediated SLT vs. computer-based placebo vs. no SLT or computer-based stimulation
Leal et al. 1993 (abstract)	Conventional vs. volunteer-facilitated SLT
Lincoln et al. 1982	Crossover trial of conventional SLT, operant training SLT and social support and stimulation.
Lincoln et al. 1984a	Conventional SLT vs. no SLT
Lincoln et al. 1984b	Operant training + conventional SLT vs. attention placebo + conventional SLT
Lyon et al. 1997	Functional SLT vs. no SLT
MacKay et al. 1988	Volunteer-facilitated SLT vs. no SLT
Meikle et al. 1979	Volunteer-facilitated SLT vs. conventional SLT
Meinzer et al. 2007	Constraint-induced SLT vs. volunteer-facilitated constraint-induced SLT
ORLA 2006 (poster)	Intensive vs. conventional SLT
Prins et al. 1989	STACDAP SLT vs. conventional SLT
Pulvermuller et al. 2001	Constraint-induced SLT vs. conventional SLT
Rochon et al. 2005	Sentence mapping SLT vs. social support and stimulation
Shewan et al. 1984	Language-oriented SLT vs. conventional SLT vs. social stimulation and support

Smania et al. 2006	Conventional SLT vs. no SLT (limb apraxia therapy only)
Smith et al. 1981	Intensive SLT vs. no SLT vs. conventional SLT
Van Steenbrugge et al. 1981 (Dutch)	Task-specific SLT vs. conventional SLT
Wertz et al. 1981	Group SLT vs. conventional SLT
Wertz et al. 1986	Conventional SLT vs. no SLT vs. volunteer-facilitated SLT
Wu et al. 2004 (Chinese)	Conventional SLT vs. no SLT

In considering the results of their review, the authors point out several important limitations. Included studies were all small and of the 30 studies only two studies performed a power calculation to determine appropriate sample size. Outcome assessment was heterogeneous and data reporting inadequate and/or incomplete, thereby limiting the number of studies that could be included in the meta-analyses. The authors report a substantial use of unpublished data.

Behavioural Interventions

Speech and Language Therapy

Adapted from: https://www.pediastaff.com/blog/the-fun-and-function-of-using-silly-sentences-in-articulation-and-language-therapy-14309

Speech and language therapy for aphasia rehabilitation can take on many different forms, but the underlying principles remain relatively the same. Because of the different types of aphasia and varying levels of severity, treatment is often individualized. Depending on the nature of their deficits, certain tactics can be employed, and certain aspects of language and speech focused on more intensely. Some can be very structured 'lessons' with tasks and instruction, whereas others can consist of a more unstructured, conversational therapy. Many involve some form of auditory stimulation, where phonemes, words or sentences are played to patient. They also may be taught to follow commands that are relevant to their day to day activities. Many will also facilitate the production of speech through repetition, semantic associations and cueing strategies. Many general speech and language therapies also encourage communication through all forms (eg. gesture, writing) so as to provide the patient with the tools for functional communication.

Twenty-four RCTs were found evaluating speech-language therapies for aphasia. Seven RCTs investigated speech-language therapies compared to no therapy, or non language-oriented therapies (Dembrower et al., 2017; Bowen et al., 2012; Laska et al., 2011; Prins et al., 1989; Hartman & Landau, 1987; Lincoln et al., 1984; Shewan & Kertesz, 1984). One RCT investigated an operant training strategy with speech-language therapy compared to a non-specific strategy for speech-language therapy (Lincoln et al., 1982). One RCT examined a narrative-oriented therapy compared to conventional therapy (Whitworth et al., 2015). Four RCTs investigated high intensity speech-language therapy compared to the standard intensity of speech-language therapy (Martins et al., 2013; Bakheit et al., 2007; Denes et al., 1996; Breitenstein et al., 2017). Four RCTs investigated Computer-based speech and language therapy compared to speech and language therapy alone (Kesav et al., 2017; De Luca et al., 2018; Palmer et al., 2020; Zhang et al., 2019). Four RCTs investigated speech and language therapy compared to standard care (Smania et al., 2006; Godecke et al., 2021; Rudd et al., 1997; Wolfe et al., 2000). One RCT investigated constraint induced aphasia therapy compared to standard care (Ciccone et al.; 2016). One RCT investigated action observation therapy compared to standard care (You et al., 2019). One RCT investigated mirror therapy compared to sham stimulation (Chen et al., 2021).

The methodological details and results of all 24 RCTs are presented in **Table 4.**

Table 4. RCTs Evaluating Speech Language Therapy Interventions for Aphasia Rehabilitation

Authors (Year) **Study Design (PEDro Score)** **Sample Size$_{start}$** **Sample Size$_{end}$** **Time post stroke category**	**Interventions** **Duration: Session length, frequency per week for total number of weeks**	**Outcome Measures** **Result (direction of effect)**
	Speech-language Therapy vs No Language Therapy	
Höeg Dembrower et al. (2017) RCT (5) N_{Start}=118 N_{End}=90 TPS=Acute	E: Early Intensive Speech and Language Therapy (LET) C: No Therapy Duration: 45min/d, 5d/wk. 3wks	• Amsterdam-Nijmegen Everyday Language Test (+exp)
Bowen et. al. (2012) RCT (7) N_{Start}=170 N_{End}=153 TPS=Acute	E: Enhanced Communication Therapy C: Attentional Control Duration: 3x/wk, 16wks	• Therapy Outcome Measure: Activity Subscale (-) • Communication Outcomes After Stroke Scale (-)
Laska et al. (2011) RCT (7) N_{Start}=123 N_{End}=99 TPS=Acute	E: Speech-language Therapy (LET) C: No Therapy Duration: 45min, 5d/wk, 3wks	• Amsterdam-Nijmegen Everyday Language Test (-)
Prins et al. (1989) RCT (5) N_{Start}=32 N_{End}=32 TPS=Chronic	E1: Systematic Stimulation Therapy for Auditory Comprehension Disorders E2: Conventional Stimulation Therapy C: No Therapy Duration: 10 sessions	E1/C vs E2 • Word Discrimination - auditory (-) • Body-part Identification (-) • Token Test (-) • Miscellaneous Commands (-) • Reading Comprehension (-) • Naming (-) • Spontaneous Speech (-) • Sentence Construction (+exp1,+con) E1 vs C • Word Discrimination - auditory (-) • Body-part Identification (-) • Token Test (-) • Miscellaneous Commands (-) • Reading Comprehension (-) • Naming (-) • Spontaneous Speech (-) • Sentence Construction (-)
Hartman & Landau (1987) RCT (6) N_{Start}=60 N_{End}= 50 TPS=Acute	E: Language Therapy C: Emotional Support Program Duration: 2x/wk, 6mo	• Porch Index of Communicative Ability (-)
Lincoln et al. (1984) RCT (6) N_{Start}=327 N_{End}= 161 TPS= Subacute	E: Hospital or Home Language Therapy C: No Therapy Duration: 1hr, 2x/wk, 6mo	• Porch Index of Communicative Ability (-) • Boston Diagnostic Aphasia Examination (-) • Functional Communication Profile (-)

Shewan & Kertesz (1984) RCT (5) N_{Start}=100 N_{End}= 79 TPS=Acute/Subacute	E1: Language-oriented Therapy E2: Stimulation-facilitation Therapy E3: Unstructured Stimulation-facilitation Therapy C: No Therapy Duration 1hr, 3x/wk, 1yr	E1 vs C • Western Aphasia Battery – Language Quotient (+exp1) E2 vs C • Western Aphasia Battery – Language Quotient (+exp2) E3 vs C • Western Aphasia Battery – Language Quotient (-) E1 vs E2 vs E3 • Western Aphasia Battery – Language Quotient (-)
Operant Training with Speech Therapy vs Non-specific Training with Speech Therapy		
Lincoln et al. (1982) Crossover RCT (4) N_{Start}=37 N_{End}= 24 TPS=Subacute	E1: Operant Training Procedure + Speech Therapy E2: Non-specific Treatment + Speech Therapy Duration: 30min, 3x/wk, 4wks/intervention	E1 vs E2 • Porch Index of Communicative Ability (-) • Speech Questionnaire (-) • Token Test (-) • Object Naming (-) • Fluency (-) • Picture Description (-)
Narrative Therapy vs Usual Care		
Whitworth et al. (2015) RCT (7) N_{Start}=14 N_{End}=14 TPS=Chronic	E: Narrative Intervention C: Usual Care Duration: 4x/wk, 5wks	• Word-level ○ Noun and Verb Semantics (-) ○ Processing (-) ○ Retrieval (-) • Sentence-level ○ Comprehension (-) ○ Structure (-) • Discourse level ○ Recount (-) ○ Procedure (-) ○ Exposition (-) ○ Narrative (-) • Word Level in Discourse (-) • Sentence Level in Discourse (-) • Discourse Organization ○ Orientation (+exp) ○ Body (-) ○ Conclusion (-)
High Intensity Speech-language Therapy vs Standard Intensity Speech-language Therapy		
Breitenstein et al. (2017) RCT (8) Nstart=158 Nend=156 TPS=Chronic	E: Intensive Speech Language Therapy C: Waitlist Duration: Therapist (2hrs) and Computer Training (1hr), 5d/wk, 3wks	• Amsterdam-Nijmegen Everyday Language Test ○ A scale (+exp) ○ B scale (-) • Aphasia Screening (+exp), ○ Phonology (-) ○ Lexicon (+exp) ○ Syntax (+exp) ○ Language comprehension (+exp) ○ Language Production (+exp)
Martins et al. (2013) RCT (7) N_{Start}=30 N_{End}=14 TPS=Subacute	E: Intensive Speech Therapy (2hr/d, 5d/wk, 10wks) (MSA) C: Standard Speech Therapy (2hrs/wk, 50wks)	• Functional Communication Profile (-) • Western Aphasia Battery (-)
Bakheit et al. (2007) RCT (8) N_{Start}=116 N_{End}= 105 TPS=Acute	E: Intensive Speech Therapy (5hrs/wk) C1: Standard Speech Therapy (2hrs/wk) C2: National Health Service Standard Therapy (2hrs/wk) Duration: 12wks	E vs C1 • Western Aphasia Battery (-) C1 vs C2 • Western Aphasia Battery (+con1)

Denes et al. (1996)
RCT (4)
N_{Start}=17
N_{End}=17
TPS=Subacute
	E: Intensive Language Therapy (range of 94-160 sessions) (45-60min)
	C: Standard Language Therapy (range of 56-70 session)
	Duration: 6mo
		• Aachen Aphasia Test
		  • Written Language (+exp)
		  • Token Test (-)
		  • Repetition (-)
		  • Naming (-)
		  • Comprehension (-)
		  • Profile Level (-)

Computer-Based + SLT vs SLT		
Palmer et al. 2020 RCT(7) Nstart=278 Nend=240 TPS=Chronic	E1: computerized speech and language therapy E2: attention control C: usual care Duration: (computerised speech and language therapy, 3.2 hours; usual care, 3.8 hours; and attention control, 3.2 hours), 6 months	E1 vs C • Word-finding (+E1) • Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-)} E1 vs E2 • Word-finding (+E2) • Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-) E2 vs C • Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-)

Zhang et al. (2019)
RCT(7)
Nstart=45
Nend=40
TPS=Acute
	E: attention training using the training system software + language treatment
	C: language treatment
	Duration: 20 min/d, 6 d/wk, 5 wks
		• Western Aphasia Battery
		  ○ Aphasia quotient (+exp)
		  ○ Spontaneous speech (-)
		  ○ Auditory comprehension (+ep)
		  ○ Repetition (-)
		  ○ Naming (+exp)

De Luca et al. (2018)
RCT (6)
Nstart=18
Nend=18
TPS=Chronic
	E: Computerized Language Therapy
	C: Standard Language Therapy
	Duration: 45min, 3x/wk, 8wks
		• Functional Independence Measure (+exp)
		• Token Test (-)
		• Ideomotor apraxia (-)
		• Neuropsychological Examination for Aphasia
		  ○ Denomination (+exp)
		  ○ Writing (-)
		  ○ Repetition (+exp)
		  ○ Reading (+exp)
		• Comprehension (-)

Kesav et al. (2017) RCT(5) Nstart=24 Nend=20 TPS=Subacute	E: computer based language rehabilitation + standard care sessions C: standard care Duration:1hr/ standard care session, 3 sessions/wk, 4wks, and 1hr/ computer based language rehabilitation session, 3 sessions/wk, 4wks	• Western Aphasia Battery Aphasia Quotient (+Con)
SLT vs Usual Care		
Godecke et al. (2021) RCT (6) Nstart=246	E1: prescribed very Early Rehabilitation for SpEech trial (VERSE) direct aphasia therapy E2: usual care-plus aphasia therapy	E1+E2 combined vs C • Western Aphasia Battery-Revised ○ Aphasia Quotient (-)

Nend=217 TPS=Acute	C: usual care Duration: 45-60 min/session, 20 sessions, within 4 weeks	○ Maximum potential recovery (-)), • Boston naming test (-)
Smania et al. (2006) RCT (4) Nstart=41 Nend=33 TPS=Chronic	E: Rehabilitation program C: Standard Control Duration: 50 mins/session, 3 sessions/wk, 10 wks	• Ideomotor Apraxia (+exp) • ADL (+exp) • Gesture-comprehension (+exp)
Wolfe et al. (2000) RCT (7) NStart=43 NEnd=32 TPS=NR	E: In-Person, Home-Based Rehabilitation Team C: Usual Care Duration: E: 3, 1 hr sessions daily for a max of 3 months; C: NR	• Frenchay Aphasia Screening Test (-) • Barthel Score (-)
Rudd et al. (1997) RCT (7) NStart=331 NEnd=252 TPS=Acute	E: Specialist community outpatient rehabilitation for speech and language C: Standard speech and language therapy Duration: Up to 3 months post-randomisation	• Barthel Index (-)
Constraint Induced Aphasia Therapy vs Standard Care		
Ciccone et al. (2016) RCT (6) Nstart=20 Nend=17 TPS=Acute	E: Constraint-induced aphasia therapy C: Standard Care Duration: 45-60 mins/day, 5 days/wk, 4 wks	• Western Aphasia Battery (-) • Discourse Analysis (DA) score (-)
Action observation therapy + SLT vs Standard Care		
You et al. (2019) RCT (7) Estart=42 Eend=42 TPS=Subacute	E: action observation therapy + conventional language therapy C: conventional language therapy Duration: 30 min, 2x/d, 5 d/ wk, 4 wks. Action observation 20 min, 10 min language therapy/sesssion	• Apraxia of Speech (+exp) • Western Aphasia Battery ○ Information (+exp) ○ Fluency (+exp) ○ Comprehension (+exp) ○ Repetition (+exp) ○ Naming (+exp) • Boston Diagnostic Aphasia Examination (+exp)
Mirror Therapy vs Sham		
Chen et al. (2021) RCT (8) Nstart=35 Nend=32 TPS=Acute	E: Combination of MT and conventional language therapy C: Sham MT and conventional language therapy Duration: once daily for 30 minutes, 5 days per week for two weeks	• Aphasia Quotient (+ exp) • Oral comprehension (exp) • Spontaneous speech (+exp) • Retelling (+exp) • Naming (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Speech and Language Therapy

APRAXIA			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Computer-based language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving apraxia.	1	De Luca et al., 2018
2	**Speech and language therapy** may produce greater improvements in apraxia than **standard therapy**.	1	Smania et al., 2006

1b	**Action observation therapy on top of standard therapy** may produce greater improvements in apraxia than **standard therapy**.	1	You et al., 2019

DISCOURSE

LoE	Conclusion Statement	RCTs	References
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving discourse.	1	Prins et al., 1989
2	**Operant training speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving discourse.	1	Lincoln et al., 1982
2	**Narrative Intervention** may not have a difference in efficacy when compared to **usual care** for improving discourse.	1	Whitworth et al., 2015
1a	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **standard therapy** for discourse.	1	Ciccone et al., 2016
1b	**Mirror therapy** may produce greater improvements in discourse than **standard therapy**.	1	Chen et al., 2021

NAMING

LoE	Conclusion Statement	RCTs	References
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving naming.	1	Prins et al., 1989
2	**Operant training Speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving naming.	1	Lincoln et al., 1982
2	**High intensity speech and language therapy** may not have a difference in efficacy when compared to **standard intensity speech and language therapy** for improving naming.	1	Denes et al., 1996
1b	**Computer-based language therapy** may produce greater improvements in naming than **standard therapy**.	1	Zhang et al., 2019
1b	**Speech and language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving naming.	1	Godecke et al., 2021
1b	**Mirror therapy** may produce greater improvements in naming than **standard therapy**.	1	Chen et al., 2021

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving verbal fluency.	1	Prins et al., 1989
2	**Operant training speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving verbal fluency.	1	Lincoln et al., 1982
1a	There is conflicting evidence about the effect of **computer-based language therapy** to improve verbal fluency when compared to **standard therapy.**		Palmer et al., 2020; Zhang et al., 2019
1b	**Mirror therapy** may produce greater improvements in verbal fluency than **standard therapy**.	1	Chen et al., 2021

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1a	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving social communication.	4	Hoeg Dembrower et al., 2017; Bowen et al., 2012; Laska et al., 2011; Lincoln et al., 1984
2	**Operant training speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving social communication.	1	Lincoln et al., 1982
1a	**High intensity speech and language therapy** may not have a difference in efficacy when compared to **standard intensity speech and language therapy** for improving social communication.	2	Breitenstein et al., 2017; Martins et al., 2013
1b	**Computer-based language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving social communication.	1	Palmer et al., 2020

WRITING

LoE	Conclusion Statement	RCTs	References
2	**High intensity speech and language therapy** may produce greater improvements in writing than **standard intensity speech and language therapy**.	1	Denes et al., 1996

GENERAL COMPREHENSION

LoE	Conclusion Statement	RCTs	References
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving general comprehension.	1	Prins et al., 1989
2	**High intensity speech and language therapy** may not have a difference in efficacy when compared to **standard intensity speech and language therapy** for improving general comprehension.	1	Denes et al., 1996

2	**Speech and language therapy** may produce greater improvements in general comprehension than **standard therapy**.	1	Smania et al., 2006

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving reading comprehension.	1	Prins et al., 1989

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving auditory comprehension.	1	Prins et al. 1989
2	**Operant training speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving auditory comprehension.	1	Lincoln et al., 1982
2	**High intensity speech and language therapy** may not have a difference in efficacy when compared to **standard intensity speech and language therapy** for improving auditory comprehension.	1	Denes et al., 1996
1a	There is conflicting evidence about the effect of **computer-based language therapy** to improve auditory comprehension when compared to **standard therapy.**	2	Zhang et al., 2019; De Luca et al., 2018
1b	**Mirror therapy** may produce greater improvements in auditory comprehension than **standard therapy**.	1	Chen et al., 2021

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving global speech and language.	3	Hartman et al., 1987; Lincoln et al., 1984; Shewan & Kertesz, 1984
1a	**High intensity speech and language therapy** may not have a difference in efficacy when compared to **standard intensity speech and language therapy** for improving global speech and language.	3	Breitenstein et al., 2017; Martins et al., 2013; Bakheit et al., 2007
2	**Speech and language therapy** may not have a difference in efficacy when compared to **structured or unstructured stimulation therapy** for improving global speech and language.	1	Shewan & Kertesz, 1984
2	**Operant training speech and language therapy** may not have a difference in efficacy when compared to **non-specific speech and language therapy** for improving global speech and language.	1	Lincoln et al., 1982
1a	**Computer-based language therapy** may produce greater improvements in global speech and language than **standard therapy**.	3	Zhang et al., 2019; De Luca et al., 2018; Kesav et al., 2017

1a	**Speech and language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving global speech and language.	2	Godecke et al., 2021; Wolfe et al., 2000
1b	**Action observation therapy on top of standard therapy** may produce greater improvements in global speech and language than **standard therapy**.	1	You et al., 2019
1b	**Mirror therapy** may produce greater improvements in global speech and language than **standard therapy**.	1	Chen et al., 2021

ACTIVITIES OF DAILY LIVING

LoE	Conclusion Statement	RCTs	References
1b	**Speech and language therapy** may not have a difference in efficacy when compared to **no language therapy** for improving activities of daily living.	1	Bowen et al. 2012
1b	**Computer-based language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving activities of daily living.	1	De Luca et al., 2018
1a	**Speech and language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving activities of daily living.	3	Smania et al., 2006; Wolfe et al., 2000; Rudd et al., 1997
1a	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **standard therapy** for improving activities of daily living.	1	Ciccone et al., 2016

REPETITION

LoE	Conclusion Statement	RCTs	References
1b	**Computer-based language therapy** may not have a difference in efficacy when compared to **standard therapy** for improving repetition.	1	Zhang et al., 2019

Key Points

Computer-based language therapy may produce greater improvements in global speech and language than standard therapy.

Speech and language therapy may not be beneficial for global speech and language or social communication, in addition to activities of daily living

Constraint Induced Aphasia Therapy

Adapted from: https://www.youtube.com/watch?v=VaFeQX7kYoo

Constraint Induced Aphasia Therapy (CIAT) is a specialized form of language training. Forced use paradigms are popular for subsets of stroke patients in an effort to encourage increasing use of non-functional limbs, especially the upper extremity. The use of this paradigm has now been extended to the treatment of aphasia with a form of CI therapy that was developed for treatment of linguistic functioning. Chronic aphasic patients use communication channels that are most accessible to them and which require the least amount of effort, such as drawing and gesturing, or use only those communicative utterances they know they can produce with ease. Therefore, over time they have developed 'learned non-use'. Constraint induced aphasia therapy is based on three principles: (1) use of intensive practice for short time intervals is preferred over long-term, less-frequent training (intensive practice); (2) constraints are used that force the patient to perform communication only in the way that (s)he normally avoids (constraint induction); (3) that the therapy focuses on actions relevant in everyday life (behavioural relevance). Intensive language-action therapy and constraint-induced aphasia therapy are the most common forms, and are minor variations of each other (Kurland et al., 2016). In the image shown above, patients play a game very similar to go-fish, where questions and answers must be vocalized only.

Sixteen RCTs were found evaluating constraint induced aphasia therapy. Eight RCTs were found comparing constraint induced aphasia therapy to conventional care (Vuksanovic et al., 2018; Woldag et al., 2018; Ciccone et al., 2016; Szaflarski et al., 2015; Wilssens et al., 2015; Sickert et al., 2014; Meinzer et al., 2007; Pulvermuller et al., 2001). Two RCTs were found comparing intensive language action therapy to naming therapy (Mohr et al., 2018; Stahl et al., 2016). One RCT was found comparing intensive language action therapy to promoting aphasia communicative effectiveness (PACE) therapy (Kurland et al., 2016). Two RCTs were found comparing a high intensity intensive language action therapy to a lower intensity intensive language action therapy (Stahl et al., 2018; Stahl et al., 2016). One RCT was found comparing CIAT to no therapy (Szaflarski et al., 2015). One RCT was found comparing CIAT plus memantine to placebo plus CIAT (Barbancho et al., 2015).

The methodological details and results of all 16 RCTs are presented in **Table 5.**

Table 5. RCTs Evaluating Constraint Induced Aphasia Therapy Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Constraint Induced Aphasia Therapy vs Conventional Speech-language Therapies		
Vuksanovic et al. (2018) RCT-Crossover (6) N_{Start}=20 N_{End}=17 TPS=Subacute	E1: Aphasia Language Therapy E2: Constraint-Induced Language Aphasia Therapy Duration: 1hr, 5d/wk, 4wks each	• Boston Naming Test (-) • Cookie Theft Picture Description ○ Number of Sentences (-) ○ Syntactic Diversity (-) ○ Information Carrying Words (-)
Woldag et al. (2018) RCT (6) N_{Start}=62 N_{End}=60 TPS=Acute	E1: Constraint-Induced Aphasia Therapy (30 total hrs) E2: Conventional Communication Treatment (30 total hrs) C: Conventional Communication Treatment (14 total hrs) Duration: 3hrs/d, 2wks	• Aachen Aphasia Test (-) • Communicative Activity Log (-)
Ciccone et al. (2016) RCT (6) Nstart=20 Nend=17 TPS=Acute	E: Constraint-induced aphasia therapy C: Standard Care Duration: 45-60 mins/day, 5 days/wk, 4 wks	• Western Aphasia Battery (-) • Discourse Analysis (DA) score (-)
Szaflarski et al. (2015) RCT (7) N_{Start}=24 N_{End}=22 TPS= Chronic	E: Constraint-induced Aphasia Therapy C: Usual care Duration: 4hrs/d, 10d	• Semantic Fluency Test (-) • Complex Ideation (-) • Controlled oral word association test (-) • Peabody Picture Vocabulary (-) • Boston Naming test (-)
Wilssens et al. (2015) RCT (7) N_{Start}=9 N_{End}=9 TPS= Chronic	E: Constraint-induced Aphasia Therapy C: Semantic Therapy Duration: 2-3hrs/d, 10d	• Amsterdam Nijmegen Everyday Language (-) • Communicative Effectiveness Index (-) • Aachen Aphasia Test (comprehension) (-) • Token Test (+exp) • Repetition (+exp) • Naming (+exp) • Written Language (+exp)
Sickert et al., (2014) RCT (7) N_{Start}=100 N_{End}=100 TPS= Subacute	E: Constraint Induced Therapy C: Usual Care Duration: 2hrs/d, 15d over 3wks	• Aachener Aphasia Test (-) • Communicative Activity Log (-)
Meinzer et al. (2007) RCT (5) N_{Start}=20 N_{End}=20 TPS= Chronic	E1: Constraint-induced Aphasia Therapy Administered by Experienced Therapists E2: Constraint-induced Aphasia Therapy Administered by Trained Laypersons Duration: 3hrs/d, 5d/wk, 2wks	• Aachen Aphasia Test: (-)
Pulvermuller et al. (2001) RCT (6) N_{Start}=17 N_{End}=NA TPS= Chronic	E: Constraint-induced Aphasia Therapy (3hrs/d, 5d/wk, 2wks) C: Conventional Language Therapy (3hrs/day, 2-3d/wk, 4wks)	• Aachen Aphasia Test (+exp)
Intensive Language Action Therapy vs Naming Therapy		
Mohr et al. (2018) Crossover RCT (6) N_{Start}=18 N_{End}=17 TPS=Chronic	E: Intensive Language Action Therapy C: Intensive Naming Therapy Duration: 3.5hrs/d, 6d/intervention, 1wk washout period	• Aachen Aphasia Test (+exp)
Stahl et al. (2016) Crossover RCT (7)	E: Intensive Language-Action Therapy C: Naming Therapy	• Aachen Aphasia Test (+exp)

N_{Start}=18 N_{End}=18 TPS=Chronic	Duration: 3.5hrs/d, 6d, 6d washout period	
Intensive Language Action Therapy vs PACE therapy		
Kurland et al. (2016) RCT (7) N_{Start}=27 N_{End}=24 TPS=Chronic	E1: Intensive Language Action Therapy Group E2: Promoting Aphasic Communicative Effectiveness (PACE) Therapy Group Duration: 3hrs/d, 10d	• Boston Diagnostic Aphasia Examination (-) • Boston-Naming Test-Second Edition (-)
Higher Intensity Intensive Language Action Therapy vs Lower Intensity Intensive Language Action Therapy or Naming Therapy		
Stahl et al. (2018) RCT (6) N_{Start}=30 N_{End}=30 TPS=Chronic	E: Highly Intensive Language-action Therapy (4hrs/d) C: Moderately Intensive Language-action Therapy (2hrs/d) Duration: 3x/wk, 4wks	• Aachen Aphasia Test (-) • Action Communication Test (-)
Stahl et al. (2016) RCT Crossover (7) NStart=18 NEnd=17 TPS=Chronic	E: Intensive Language-Action Therapy (ILAT) C: Naming Therapy Duration: 3.5 hr/session, 6 days consecutively, 6d washout period	• Aachen Aphasia Test ○ Total (+exp) ○ Production Subscales (+exp))
rTMS + Intensive Language-action Therapy vs Sham		
Heikkinen et al. (2019) RCT (7) Nstart=17 Nend=17 TPS=Chronic	E1: rTMS E2: ILAT C: Sham Duration: rTMS for 20 mins/day, 5 days/wk, 4 wks. ILAT for 3 hrs/day, 5 days/wk, 2 wks rTMS vs Sham rTMS + ILAT vs Sham + ILAT	• Western Aphasia Battery aphasia quotient AQ (-) • Boston naming test (-) • Action naming test (-)
CIAT vs No Therapy		
Szaflarski et al. (2015) RCT (8) Nstart=24 Nend=22 TPS=Chronic	E: Constraint-induced aphasia therapy C: No intervention Duration: 4 hours/day, 10 consecutive business days	• Semantic Fluency Test (-) • Complex Ideation (-) • Controlled Oral Word Association Test (-) • Peabody Picture Vocabulary Test (-) • Boston Naming Test (-)
Memantine + Constraint Induced Aphasia Therapy		
Barbancho et al. (2015) RCT (8) NStart=28 NEnd=27 TPS=Chronic	E: Memantine Treatment (10mg/d) + Constraint Induced Aphasia Treatment C: Placebo Treatment + Constraint Induced Aphasia Treatment Duration: 16wks on drug, then 2wks language training on drug (3hr/d, 5d/wk)	• Western Aphasia Battery (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Constraint Induced Aphasia Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **conventional speech-language therapy** for improving discourse.	2	Vuksanovic et al., 2018; Ciccone et al., 2016

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **conventional speech-language therapy or no therpay** for improving naming.	3	Vuksanovic et al., 2018; Szaflarski et al., 2015; Wilssens et al., 2015
1b	**Intensive language action therapy** may not have a difference in efficacy when compared to **PACE therapy** for improving naming.	1	Kurland et al., 2016
1b	**Higher intensity intensive language action therapy** may not have a difference in efficacy when compared to **lower intensity intensive language action therapy** for improving naming.	1	Stahl et al., 2018
1b	**Intensive language action therapy + rTMS** may not have a difference in efficacy when compared to **intensity intensive language action therapy + sham therapy** for improving naming.	1	Heikinnin et al., 2019

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **conventional speech-language therapy** for improving social communication.	3	Woldag et al., 2018; Wilssens et al., 2015; Sickert et al., 2014

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Constraint induced aphasia therapy** may produce greater improvements in repetition than **conventional speech-language therapy**.	1	Wilssens et al., 2015

WRITING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Constraint induced aphasia therapy** may produce greater improvements in writing than **conventional speech-language therapy**.	1	Wilssens et al., 2015

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **conventional speech-language therapy** for improving general comprehension.	1	Wilssens et al., 2015

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **constraint induced aphasia therapy** to improve auditory comprehension when compared to **conventional speech-language therapy or no therapy.**	2	Szaflarski et al., 2015; Wilssens et al., 2015

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Constraint induced aphasia therapy** may not have a difference in efficacy when compared to **conventional speech-language therapy** for improving global speech and language.	5	Woldag et al., 2018; Ciccone et al., 2016; Sickert et al., 2014; Meinzer et al., 2007; Pulvemuller et al., 2001
1a	**Intensive language action therapy** may produce greater improvements in global speech and language than **naming therapy**.	2	Mohr et al., 2018; Stahl et al., 2016
1b	**Intensive language action therapy** may not have a difference in efficacy when compared to **PACE therapy** for improving global speech and language.	1	Kurland et al., 2016
1a	There is conflicting evidence about the effect of **higher intensity constraint induced aphasia therapy** to improve global speech and language when compared to **conventional speech-language therapy or naming tasks.**	2	Szaflarski et al., 2015; Wilssens et al., 2015
1b	**Intensive language action therapy and rTMS** may not have a difference in efficacy when compared to **intensity intensive language action therapy + sham** for improving global speech and language.	1	Heikinnin et al., 2019
1b	**Memantine and intensive language action therapy** may produce greater improvements in global speech and language than **placebo**.	1	Barbancho et al., 2015

Key Points

Constraint induced aphasia therapy may be beneficial for improving repetition and writing

Intensive language action therapy may be more beneficial than naming therapy for improving global speech and language

Constraint induced aphasia therapy may not be beneficial for improving global speech and language and social communication

The literature is mixed concerning constraint induced aphasia therapy's ability to improve auditory comprehension

Lexical Retrieval Therapy

Adapted from: http://mercercognitivepsychology.pbworks.com/w/page/32859313/Tip-of-the-Tongue%20Phenomenon

Word finding difficulty, also known as a lexical retrieval deficit, is a phenomenon whereby an individual can usually supply an accurate semantic representation of an object, but they are unable to verbally label that same object (Saito & Takeda, 2001). This deficit is the main feature of anomic aphasia however it is also a common problem in other types of aphasia. In all cases, this deficit can significantly impact the patient's verbal communication. It has been hypothesized that word-retrieval deficits stem from "an impaired access to the phonological form of the intended word" (Saito & Takeda, 2001). Levelt et al. (1991) claim that lexical access involves two stages: lexical item selection, which accesses the syntactically and semantically appropriate representation of the word, and phonological encoding of the selected item, which allows for its verbal articulation. Therapies usually employ associative learning procedures including semantic and/or phonological cueing to aid lexical access and improve word retrieval abilities. Semantic cues require the patient to focus on the meaning of the word whereas phonological cues require the patient to understand the structure of the word (first syllable or its proper spelling). Most studies have administered picture-naming tasks which enable the patient to make a semantic connection with the word, thus if they are to see the picture again, they may be prompted to say the word.

Nineteen RCTs were found evaluating a form of lexical retrieval training for aphasia rehabilitation. Four RCTs compared a lexical retrieval-oriented therapy to no language therapy (Barbieri et al. 2019; Efstratiadou et al., 2019; Nouwens et al., 2018; Mattioli et al., 2014). Three RCTs compared semantic therapy to phonological therapy (Abel et al., 2014; Woolf et al., 2014; Doesborgh et al., 2004). One RCT compared semantic and phonological therapy to a role-playing conversation therapy (De Jong-Hagelstein et al., 2011). One RCT compared high intensity semantic therapy to low intensity semantic therapy (Godecke et al., 2012). Two RCTs compared naming therapy with gesture therapy to naming therapy alone (Altmann et al., 2014; Benjamin et al., 2014). Four RCTs compared lexical retrieval therapy with tDCS to sham therapy (DeMarco et al. 2021; Pisano et al. 2021; Kang et al. 2011; Baker et al. 2010). One RCT compared lexical retrieval therapy with computer-based training to no treatment

(Doesborgh et al. 2004). One RCT compared intensive language action therapy to naming therapy (Stahl et al. 2016). One RCT compared intensive phonological components analysis to standard phonological components analysis (Simic et al. 2021). One RCT compared Errorless naming treatment to gestural facilitation of naming (Raymer et al. 2021).

The methodological details and results of all nineteen RCTs are presented in **Table 6.**

Table 6. RCTs Evaluating Word-retrieval Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Lexical Retrieval Therapies vs No Therapy		
Barbieri et al. (2019) RCT (6) Estart=19 Eend=19 TPS=Chronic	E1: Up to three baseline probes C: Natural history group: No treatment Duration: Twice a week (90 min each) for 12 weeks	• Reversible active transitive sentences (+exp) • Untrained structures (+exp)
Efstratiadou et al. (2019) RCT (6) Nstart=72 Nend=38 TPS=Chronic	E: Elaborated Semantic Feature Analysis C: Control/delayed treatment Duration: 1 hr/session, 3 sessions/wk, 12 wks	• American Speech and Hearing Association Functional Assessment of Communication Skills (-) • Boston Naming Test (-) • General Health Questionnaire 12 (-) • Stoke and Aphasia Quality of Life Scale-39 (+exp) ○ Physical (-) ○ Psychosocial (+exp) ○ Communication (-) • Snodgrass and Vanderwart naming measure (+exp)
Nouwens et al. (2018) RCT (8) N_{Start}=153 N_{End}=142 TPS=Acute	E: Early Intensive Semantic and Phonological Therapy C: No Language Therapy Duration 1hr/d, 4wks	• Amsterdam-Nijmegen Everyday Language Test (-) • The Token Test (-) • Boston Naming Test (-) • Semantic Association Test (-) • Comprehensive Aphasia Test (-) • Nonword Repetition an Auditory Lexical Decision from the Psycholinguistic Assessment of Language Processing in Aphasia (-) • Barthel Index (-)

Mattioli et al. (2014)
RCT (6)
N_{Start}=12
N_{End}=12
TPS=Acute
	E: Language Rehabilitation for Verbal Comprehension and Lexical Retrieval
	C: No Language Rehabilitation
	Duration: 1hr/d, 5d/wk, 2wks
		• Aachen Aphasia Test
		  • Naming (+exp)
		  • Writing (+exp)
		  • Repetition (-)
		  • Reading (-)
		  • Oral comprehension (-)
		  • Written Comprehension (-)
		  • Token Test (-)
		  • Spontaneous speech (-)

Phonological Therapy vs Semantic Therapy		
Abel et al. (2014) Crossover RCT (6) N_{Start}=14 N_{End}=14 TPS=Chronic	E1: Phonological Therapy E2: Semantic Therapy Duration: 4wks	• Picture Naming Ability (-)
Woolf et al. (2014) Crossover RCT (5) N_{Start}=8	E1: Phonological Therapy E2: Semantic Therapy Duration: 1hr/d, 2d/wk, 6wks/condition	• Word and Non-word Discrimination (-) • Discrimination of Trained Words (-)

N_{End}=8 TPS=Chronic		
Doesborgh et al. (2004) RCT (8) N_{Start}=58 N_{End}=55 TPS=Subacute	E1: Phonological Therapy E2: Semantic Therapy Duration: 1.5-3hrs/wk, 5-8mo (40-60hrs total)	• Amsterdam Nijmegen Everyday Language Test (-) • Semantic Measures ○ Semantic Association Test (-) ○ Synonym Judgement (-) • Phonological Measures ○ Repetition Non-words (-) ○ Lexical Decision (+exp1)
Semantic and Phonological Therapy vs Role Playing Conversational Therapy		
De Jong-Hagelstein et al. (2011) RCT (8) N_{Start}=80 N_{End}=75 TPS=Acute	E: Semantic and Phonological Treatment C: Role Playing and Conversation Coaching Duration: 2hr/wk, 6mo	• Semantic Word Fluency (+exp) • Letter Fluency (-) • Psycholinguistic Assessment of Language Processing in Aphasia (-) ○ Amsterdam Nijmegen Everyday Language Test (-)
High Intensity Semantic Therapy vs Low Intensity Semantic Therapy		
Godecke et. al. (2012) RCT (7) N_{Start}=60 N_{End}=52 TPS=Acute	E: Daily Semantic Therapy C: Usual Frequency of Therapy Duration: 5d/wk, 4wks	• Western Aphasia Battery (+exp) • Functional Communication Profile (+exp)
Naming Task Training with Gestural Training vs Naming Task Training Alone		
Altmann et al. (2014) RCT (6) N_{Start}=14 N_{End}=14 TPS=Chronic	E: Picture Naming Task with Word Generation + Gesture Naming Treatment C: Picture Naming Task with Word Generation Duration: 1hr, 2x/d, 5d/wk, 3wks	• Boston Naming Test (-) • Western Aphasia Battery - Aphasia Quotient • (-) • Discourse Quantity - Word and Utterance Count (-) • Discourse Quality ○ Number of Correct Information Units (-) ○ Utterances with New Information (-) ○ Propositions (-) ○ Grammatical Utterances (-) ○ Nouns (-) ○ Verbs (-)
Benjamin et al. (2014) RCT (5) N_{Start}=14 N_{End}=14 TPS=NA	E: Picture and Category Naming Training + Gesture Training C: Picture and Category Naming Training Duration: 10 sessions/wk, 3wks	• Picture Naming and Category Task (-)
Lexical Retrieval Therapy + tDCS		
DeMarco et al. (2021) RCT (6) Nstart=24 Nend=24 TPS=Chronic	E: Anodal tDCS + Speech Therapy C: Anodal tDCS + Sham Duration: 60 mins of speech therapy with first 20 mins of tDCS, 1 session/day, 5 consecutive days	• Western Aphasia Battery-Revised (-) • Picture description task (-) • Fluency tasks (-)
Pisano et al. (2021) RCT (8) Nstart=10 Nend=10 TPS=Chronic	E1: Anodal transpinal direct current stimulation + Language Treatment E2: Anodal direct current stimulation C: Sham + Language Treatment Duration: 20 mins/day, 5 days	E1 vs C • Accuracy (+exp) E1 vs E2 • Accuracy (-)
Kang et al. (2011) RCT Crossover (8) Nstart=10 Nend=10 TPS=Chronic	E: Cathodal tDCS + word-retrieval training C: Sham + word-retrieval training Duration: 20 mins/day, 5 consecutive days, 1 week washout period	• Korean version of the Boston Naming Test ○ Accuracy (-) ○ Reaction time (-) • Percent cued responses (-)
Baker et al. (2010) Crossover RCT (8)	E: Anodal tDCS (20min) + Picture-word Matching	• Naming Test ○ Trained Items (+exp)

NStart=10 NEnd=10 TPS=Chronic	C: Sham tDCS + Picture-word Matching Duration: 20 minutes, 5d/condition, 1wk washout period	○ Untrained Items (+exp))
Computer-Based Therapy + Lexical Retrieval Therapy		
Doesborgh et al. (2004) RCT (4) Nstart=18 Nend=18 TPS=Acute	E: Computerized Word-Finding Training (Multicue) C: No Treatment Duration: 30-45min, 2-3x/wk, 8wks	• Boston Naming Test (-) • Amsterdam-Nijmegen Everyday Language Test - scale A (-)
Constraint induced aphasia therapy + Lexical retrieval therapy		
Stahl et al. (2016) RCT Crossover (7) NStart=18 NEnd=17 TPS=Chronic	E: Intensive Language-Action Therapy (ILAT) C: Naming Therapy Duration: 3.5 hr/session, 6 days consecutively, 6d washout period	• Aachen Aphasia Test ○ Total (+exp) ○ Production Subscales (+exp))
Intensive Phonological Components Analysis (PCA)		
Simic et al. (2021) RCT (9) NStart=16 NEnd=15 TPS=Chronic	E: Intensive Phonological Components Analysis (PCA) C: Standard PCA Duration: 30 hrs (total) *Cumulative treatment intensity was equivalent, but treatment protocols were different	• Naming Accuracy (-) • Quality of Communication Life (-)
Errorless Naming Treatment		
Raymer et al. (2012) RCT Crossover (7) Nstart=8 Nend=8 TPS=Chronic	E1: Errorless naming treatment E2: Gestural facilitation of naming Duration: 1 hr/session, 2-3 sessions/wk, up to 20 sessions	E1 vs E2 • Naming of trained words (-) • Picture naming (-) • Small, generalized naming improvements (-) • Gestures for trained word (+ E2),

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Lexical Retrieval Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Naming task with gestural training** may not have a difference in efficacy when compared to **a naming task** for improving discourse.	1	Altmann et al., 2014
1b	**Lexical retrieval therapy with tDCS** may not have a difference in efficacy when compared to **sham** for improving discourse.	1	DeMarco et al. 2021

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **lexical retrieval therapy** to improve naming when compared to **no therapy.**	3	Efstratiadou et al., 2019; Nouwens et al., 2018; Mattioli et al., 2014

1b	There is conflicting evidence about the effect of **phonological and semantic therapy** to improve naming when compared to **role playing conversation therapy.**	1	De Jong-Hagelstein et al., 2011
1b	**Phonological therapy** may not have a difference in efficacy when compared to **semantic therapy** for improving naming.	1	Abel et al., 2014
1b	**Naming task with gestural training** may not have a difference in efficacy when compared to **a naming task** for improving naming.	2	Altmann et al., 2014; Benjamin et al., 2014
1a	**Anodal tDCS and lexical retrieval therapy** may not have a difference in efficacy when compared to **sham tDCS** for improving naming.	3	DemMarco et al. 2021; Kang et al. 2011; Baker et al. 2010
2	**Lexical retrieval therapy with computer-based training** may not have a difference in efficacy when compared to **naming therapy** for improving naming.	1	Abel et al., 2014
1b	**Errorless naming treatment** may not have a difference in efficacy when compared to **gestural facilitation of naming** for improving naming.	1	Raymer et al. 2012

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving verbal fluency.	1	Mattioli et al., 2014
1b	**Lexical retrieval therapy with tDCS** may not have a difference in efficacy when compared to **sham** for improving verbal fluency.	1	DeMarco et al. 2021

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving social communication.	1	Nouwens et al., 2018
1b	**Phonological therapy** may not have a difference in efficacy when compared to **semantic therapy** for improving social communication.	1	Doesborgh et al., 2004
1b	**Phonological and semantic therapy** may not have a difference in efficacy when compared to **role playing conversation therapy** for improving social communication.	1	De Jong-Hagelstein et al., 2011
1b	**High intensity semantic therapy** may produce greater improvements in social communication than **lower intensity semantic therapy**.	1	Godecke et al., 2012
1b	**Intensive phonological components analysis** may not have a difference in efficacy when compared to **standard phonological component analysis therapy** for improving social communication.	1	Simic et al., 2021

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving repetition.	2	Nouwens et al., 2018; Mattioli et al., 2014
1b	**Phonological therapy** may not have a difference in efficacy when compared to **semantic therapy** for improving repetition.	1	Doesborgh et al., 2004

WRITING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lexical retrieval therapy** may produce greater improvements in writing than **no language therapy**.	1	Mattioli et al., 2014
1b	**Intensive phonological components analysis** may not have a difference in efficacy when compared to **standard phonological component analysis therapy** for improving naming.	1	Simic et al., 2021

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving general comprehension.	1	Nouwens et al., 2018
1b	**Phonological therapy** may not have a difference in efficacy when compared to **semantic therapy** for improving general comprehension.	2	Woolf et al., 2014; Doesborgh et al., 2004

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving reading comprehension.	1	Mattioli et al., 2014

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving auditory comprehension.	2	Nouwens et al., 2018; Mattioli et al., 2014
1b	**Phonological therapy** may produce greater improvements in auditory comprehension than **semantic therapy**.	1	Doesborgh et al., 2004

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving global speech and language.	1	Nouwens et al., 2018

1b	**Phonological and semantic therapy** may not have a difference in efficacy when compared to **role playing conversation therapy** for improving global speech and language.	1	De Jong-Hagelstein et al., 2011
1b	**High intensity semantic therapy** may produce greater improvements in global speech and language than **lower intensity semantic therapy**.	1	Godecke et al., 2012
1b	**Naming task with gestural training** may not have a difference in efficacy when compared to **a naming task** for improving global speech and language.	1	Altmann et al., 2014
1b	**Lexical retrieval therapy with tDCS** may not have a difference in efficacy when compared to **sham** for improving global speech and language.	1	DeMarco et al. 2021
1b	**Constraint induced aphasia therapy with lexical retrieval therapy** may produce greater improvements in global speech and language than **naming therapy.**	1	Stahl et al., 2016

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lexical retrieval therapy** may not have a difference in efficacy when compared to **no language therapy** for improving activities of daily living.	1	Nouwens et al., 2018

Key Points

Lexical retrieval therapy may not be beneficial for improving aphasia related outcomes, auditory comprehension, and repetition post-stroke

There is conflicting evidence about the effect of lexical retrieval therapy to improve naming when compared to no therapy.

Volunteer Facilitated Speech and Language Therapy

Adapted from: https://www.covenanthousebc.org/2014/04/11/a-poem-in-honour-of-our-valuable-volunteers/

A 2012 report estimated that the annual economic burden of stroke in Canada to be $2.5 billion dollars (Mittmann et al., 2012). As of a 2017 report, stroke costs the United States of America $34 billion dollars per year (Benjamin et al., 2017). With an ageing population this number can be expected to grow, ceteris paribus. With that in mind, clinicians and researchers are not only looking for more effective treatments, but more cost-effective treatments as well. With a limited number of therapists available within a given care facility there will be a limit on the number of patients that can be simultaneously treated, and the duration of their treatment. If trained volunteers can provide the same efficacy of care or better, then a large burden would be lifted off of the healthcare system. In addition, the patient will also benefit as their care is not bound by financial or time restrictions.

Four RCTs were found evaluating volunteer delivered speech therapy for aphasia rehabilitation. All four RCTs compared speech-language therapy delivered by a volunteer to therapy delivered by a professional speech-language therapist or pathologist (Marshall et al., 1989; Wertz et al., 1986; David et al., 1982; Meikle et al., 1979).

The methodological details and results of all four RCTs are presented in **Table 7.**

Table 7. RCTs Evaluating Volunteer Facilitated Speech and Language Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Volunteer Administered Speech-language Therapy vs Professional Administered Therapy		
Marshall et al. (1989) Follow-up of Wertz et al. (1986) RCT (5) N_{Start}=121 N_{End}=103 TPS=Subacute	E1: Home Therapy with a Volunteer E2: Speech-language Pathologist Treatment E3: Treatment Deferred for 12wks Duration: 8-10hrs/wk, 12wks	E1 vs E2 • Porch Index of Communicative Ability (-) E1 vs E3 • Porch Index of Communicative Ability (-) E2 vs E3 • Porch Index of Communicative Ability (+exp2)
Wertz et al. (1986) RCT (6) N_{Start}=121 N_{End}=94 TPS=Subacute	E2: Treatment Administered by a Volunteer at Home E1: Clinical Treatment E3: Deferred clinical treatment Duration: 8-10hrs/wk, 12wks	• Porch Index of Communicative Ability (-)
David et al. (1982) RCT (5) N_{Start}=155 N_{End}=96 TPS=Acute	E: Speech-language pathologist therapy C: Volunteer therapy Duration: 30hrs over 15-20wks	• Functional Communication Profile (-)
Meikle et al. (1979) RCT (4) N_{Start}=31 N_{End}=29 TPS=Acute	E: Conventional speech therapy from a speech therapist C: Therapy from a non-professional volunteer Duration: 3-5x/wk Note: duration lasted until no more improvement (range=5-84wks)	• Porch Index of Communicative Ability (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Volunteer Facilitated Speech and Language Therapy

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Volunteer facilitated speech and language therapy** may not have a difference in efficacy when compared to **professionally administered therapy** for improving social communication.	1	David et al., 1982

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Volunteer facilitated speech and language therapy** may not have a difference in efficacy when compared to **professionally administered therapy** for improving global speech and language.	3	Marshall et al., 1989; Wertz et al., 1986; Meikle et al., 1979

Key Points

Volunteer facilitated speech and language therapy may not be beneficial for improving aphasia related outcomes post-stroke.

Social Interaction Therapies

Adapted from: https://www.istockphoto.com/ca/illustrations/group-therapy

Conversation is important in social participation and plays a key role in many social functions such as establishing and maintaining relationships, sharing ideas and opinions or making plans. According to Kagan et al. (2001), it is also the means by which individuals reveal their inner competencies. Individuals living with aphasia have lost, to varying degrees, the tools of conversation. This loss impacts the ability of the individual to participate in social roles and obscures the individual's inner competencies (Kagan et al., 2001; Rayner & Marshall, 2003). Interventions focused on the restoration of conversation and socialization are not restricted to alleviating impairment of language but also attempt to remove barriers to social participation in the settings within which the individual with aphasia lives and interacts with others (Lyon et al., 1997). Group therapy is a way to engage patients directly in the type of social communication that a traditional speech-language therapy aims to improve. Training conversation or communication partners within the aphasic individual's social setting is one way to promote opportunities for restored access to conversation (Marshall et al., 1989; Rayner & Marshall, 2003).

Six RCTs were found evaluating socially-oriented therapies for aphasia. One RCT compared group speech-language therapy to individual therapy (Wertz et al., 1981). Two RCTs compared group speech-language therapy to recreational group activities (Worral & Yiu, 2000; Elman & Berstein-Ellis, 1999). One RCT compared a trained conversational partner to an untrained conversational partner (Kagan et al., 2001). One RCT compared social Interaction with physical activity (Lund et al., 2012). One RCT compared cognitive behaviour language therapy with no treatment (Akabogu et al., 2019).

The methodological details and results of all six RCTs are presented in **Table 8.**

Table 8. RCTs Evaluating Social Interaction Speech and Language Therapy Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Group Speech-language Therapy vs Individual Speech-language Therapy		
Wertz et al. (1981) RCT (6) N$_{Start}$=67 N$_{End}$=34 TPS=Acute	E: Group therapy C: Individual therapy Duration: 8hrs/wk, 48wks	• Porch Index of Communicative Ability (-) • Token Test (-) • Word Fluency (-) • Conversational Rating (-) • Informant's Rating (-)
Group Speech-language Therapy vs Recreational Social Activities		
Worrall & Yiu (2000) Cross-over RCT (5) N$_{Start}$=22 N$_{End}$ =14 TPS=Chronic	E1: Speaking Out Intervention E2: Recreational Activities Program Duration: 1-2hrs/wk, 10wks, 10wk washout period	• American Speech-Language Hearing Association Functional Assessment of Communication Skills (-) • Western Aphasia Battery (-) • Communication Effectiveness Index (-) • Functional Communication Therapy Planner (-)
Elman & Berstein-Ellis (1999) RCT (4) N$_{Start}$=28 N$_{End}$=24 TPS=Chronic	E: Group therapy C: Recreational Social Activities Duration: 5hrs/wk, 4mo	• Western Aphasia Battery (+exp) • Communication Activities in Daily Living (+exp) • Shortened Porch Index of Communicative Abilities (-)
Trained Conversation Partners vs Untrained Conversation Partners		
Kagan et al. (2001) RCT (6) N$_{Start}$=40 N$_{End}$=40 TPS=Chronic	E: Conversation partners trained to acknowledge and reveal competence of aphasia participants C: Conversation partners exposed to an informative aphasia video presentation Duration: 1d workshop, 5.5hrs + 1.5hr hands-on session within 2wks	• Measure of Skill in Providing Supported Conversation for Adults with Aphasia (+exp) • Measure of Participation in Conversation for Adults with Aphasia (+exp)
Social Interaction with Physical Activity		
Lund et al. (2012) RCT (5) Nstart=99 Nend=86 TPS=Subacute	E: A lifestyle course in combination with physical activity C: Physical activity Duration: 2 hrs/session, 1 session/wk, 18 wks	• Short Form Questionnaire 36(-)
Cognitive Behaviour Language Therapy		
Akabogu et al. (2019) RCT (7) Nstart=86 Nend=86 TPS=NR	E: Cognitive behavior language therapy C: No treatment Duration: 2 hours/session, 2 sessions/week over 10 weeks	• Porch Index of Communicative Ability (+exp) • Speech-Language Unhelpful Thoughts and Beliefs (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05.

Conclusions about Social Interaction Speech and Language Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Group speech-language therapy** may not have a difference in efficacy when compared to **individual speech-language therapy** for improving discourse.	1	Wertz et al., 1981

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Group speech-language therapy** may not have a difference in efficacy when compared to **individual speech-language therapy** for improving naming.	1	Wertz et al., 1981

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Group speech-language therapy** may not have a difference in efficacy when compared to **individual speech-language therapy** for improving social communication.	1	Wertz et al., 1981
1b	**Trained conversation partners** may produce greater improvements in social communication than **un-trained conversation partners**.	1	Kagan et al., 2001
2	**Group speech-language therapy** may not have a difference in efficacy when compared to **recreational social activities** for improving social communication.	1	Worrall & Yiu, 2000

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Group speech-language therapy** may not have a difference in efficacy when compared to **individual speech-language therapy** for improving auditory comprehension.	1	Wertz et al., 1981

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Group speech-language therapy** may not have a difference in efficacy when compared to **individual speech-language therapy** for improving global speech and language.	1	Wertz et al., 1981
2	**Group speech-language therapy** may not have a difference in efficacy when compared to **recreational social activities** for improving global speech and language.	2	Worrall & Yiu, 2000; Elman & Berstein-Ellis, 1999
1b	**Cognitive behaviour language therapy** may produce greater improvements in global speech and language than **no treatment.**	1	Akabogu et al., 2019

Key Points

Group therapies may not be beneficial for improving aphasia related outcomes post-stroke

Trained conversational partners may be beneficial for improving social communication

Music-based Therapy

Adapted from: http://www.sarahlangfordstudios.com/blog/singing-aging

Music and music-based therapies in the rehabilitation of speech disorders, such as aphasia, have been used for over a century. This form of therapy has not been extensively studied in randomized controlled trials, however, it shows promise as a potentially effective treatment for this condition. Music and speech production are thought to have shared neural pathways (Tomanino, 2012). Singing also reduces the rate at which words are articulated and, as such, dependence on the left hemisphere is reduced (Marchina, 2010). Similarly, lengthening of syllables provides the ability to distinguish phonemes as well as allows the stringing of words to enhance fluency (Marchina, 2010). Furthermore, rhythmic tapping that is often associated with music-based therapy may engage the right hemisphere sensorimotor network, providing an impulse for verbal production and encourage auditory-motor coupling (Marchina, 2010). There are a number of music-based therapies that may be used when treating aphasia. The most prominent is Melodic Intonation Therapy (MIT). This therapy encompasses the two main components of music-based therapy: melodic intonation (singing) and rhythmic tapping while words, and eventually phrases, are repeated (Marchina, 2010). Other approaches to this type of therapy involve other musical elements such as melody, rhythm, dynamics, tempo, and meter (Hurkmans, 2012). These components of music may be provided as therapies encompassing the singing of familiar songs, musically assisted speech, dynamically cued singing, rhythmic speech cueing, or oral motor exercises (Tomanino, 2012).

Eleven RCTs were found evaluating music-based therapies for aphasia rehabilitation. One RCT was found comparing choir practice to drama class (Zumbansen et al., 2017). Two RCTs were found comparing music therapy group to audiobook therapy group (Sihvonen et al., 2020; Sarkamo et al., 2008). Six RCTs were found comparing music-based therapy to conventional speech-language therapy (Raglio et al., 2016; Van der Meulen et al., 2016; Van der Meulen et al., 2014; Zhang et al., 2021; Aravantinou-Fatorou et al., 2021; Szelag et al., 2014). Two RCTs was found comparing music-based therapy to no therapy (Conklyn et al., 2012, Haro-Martinez et al., 2019).

The methodological details and results of all eleven RCTs are presented in **Table 9.**

Table 9. RCTs Evaluating Music-based Therapy Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Choir Practice vs Drama Practice		
Zumbansen et al. (2017) RCT (7) N_{Start}=22 N_{End}=17 TPS=Chronic	E1: Choir Practice E2: Drama Practice C: Waiting List Duration: 2hrs/wk, 6mo	• Test Lillois de Communication (-) • Apraxia Battery for Adults – Motor-speech Agility Subtest (-) • Language Expression ○ Automatized series (-) ○ Repetition (-) ○ Naming (-) ○ Informativeness (-) • MT86 – Auditory Comprehension (-)
Music Therapy Group vs Audiobook Therapy Group		
Sihvonen et al. (2020) RCT (6) NStart=110 NEnd=83 TPS=Acute	E1: Vocal music therapy group E2: Instrumental music therapy group C: Audiobook therapy group Duration: Daily for 3 mo.	E1 vs C • Verbal Memory (-) • Language Skills (+exp1) • Focused Attention, correct responses (-) • Focused Attention Reaction Times (-) E2 vs C • Verbal Memory (-) • Language Skills (-) • Focused Attention, correct responses (-) • Focused Attention Reaction Times (-) E1 vs E2 • Verbal Memory (+exp1) • Language Skills (-) • Focused Attention, correct responses (-) • Focused Attention Reaction Times (-)
Sarkamo et al. (2008) RCT (7) NStart=60 NEnd=55 TPS:	E1: Music listening therapy E2: Audiobook listening therapy C: Standard care Duration: 2 mo, daily	• Cognitive Domain ○ Verbal Memory (+exp1) ○ Short-term and Working Memory (-) ○ Language (-) ○ Music Cognition (-) ○ Visuospatial cognition (-) ○ Executive Function (-) ○ Focused Attention (correct responses) (+exp1) ○ Focused Attention (RT, s) (-) ○ Sustained Attention (correct responses) (-) ○ Sustained Attention (RT, s) (-)
Music-based Therapy vs Conventional Speech-language Therapy		
Aravantinou-Fatorou et al. (2021) RCT (7) N start=79 N end=79 TPS=Not Reported	E: Daily traditional experiential music listening along with standard care C: Standard care Duration: Daily music listening 4 training sessions/ week, 45 min/ session for 6 months	• Aachener Aphasia Test (+exp)
Zhang et al. (2021) RCT (6) Nstart=40 Nend=40 TPS=Subacute	E: Melodic intonation therapy C: Speech therapy Duration: 30 min/day, 5 days/wk, 8 wks	• Boston Diagnostic Aphasia Examination ○ Spontaneous speech, Information (+exp) ○ Fluency (-) • Repetition (+exp) • Listening Comprehension (+exp) • Naming ○ Objective Naming (-) ○ Spontaneous Naming (+exp)

		○ Sentences Completing (-) ○ Reaction Naming (-) • Aphasia Quotient (+exp))
Raglio et al. (2016) RCT (5) N_{Start}=20 N_{End}=20 TPS= Subacute	E: Music With Speech + Language Therapy (30sessions music + 30 sessions SLT) C: Speech + Language Therapy (SLT) (30sessions) Duration: 15wks	• Aachener Aphasic Scale (-) • Token Test (-) • Boston Naming Test (-) • Picture Description Test (-) • Spontaneous Speech (+exp)
Van Der Meulen et al. (2016) RCT (7) N_{Start} =17 N_{End} =16 TPS=Chronic	E: Melodic Intonation Therapy C: Usual Care Duration: 5hrs/wk, 6wks	• Sabadel Story Retell Task (-) • Amsterdam-Nijmegen Everyday Language Test (-) • Aachen Aphasia Test (-) • Melodic Intonation Therapy Tasks - Untrained (-) • Melodic Intonation Therapy Tasks - Trained (+exp)
Szelag et al. (2014) RCT(5) Nstart=18 Nend=13 TPS=Subacute	E: temporal training C: nontemporal control training Duration: eight 45 minute sessions, 10-trial blocks.	• Measure of fluency ○ Discourse productivity (-) • Language processing ○ Token test (-)

van der Meulen et al. (2014)
Cross-over RCT (6)
N_{Start}=25
N_{End}=24
TPS= Subacute
	E: Intensive Melodic Intonation Therapy
	C: Standard Language Therapy
	Duration: 5h/wk, 6wks
		• Aachen Aphasic Test:
		  • Repetition (+exp)
		  • Naming (-)
		• Melodic Intonation Therapy Repetition Task:
		  • Overall Score (+exp)
		  • Untrained Items (+exp)
		  • Trained Items (+exp)
		• Amsterdam Nijmegen Everyday Language Test (-)

Melodic Intonation Therapy vs No Therapy		
Haro-Martinez et al. (2019) RCT Crossover (7) Nstart=20 Nend=16 TPS=Chronic	E: Melodic Intonation Therapy C: No Treatment Duration: 30 mins/session, 12 sessions over 6 weeks.	• Communicative Activity Log (CAL) questionnaire (+exp) • Boston Diagnostic Aphasia Examination (BDAE) ○ Comprehension (-) • Repetition (-)

Conklyn et al. (2012)
RCT (5)
N_{Start}=32
N_{End}=30
TPS= Acute
	E: Modified Melodic Intonation Therapy
	C: No Language Therapy
	Duration: 10-15min, 3 sessions
		• Western Aphasia Battery
		  • Total Score (-)
		  • Responsiveness (+exp)
		  • Repetition (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
$+exp_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Music-based Speech Language Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving discourse.	1	Zumbansen et al., 2017

1b	**Music-based therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving discourse.	2	Raglio et al., 2016; Van der Meulen et al., 2016
2	**Melodic intonation therapy** may produce greater improvements in discourse than **no language therapy**.	1	Conklyn et al., 2012

NAMING

LoE	Conclusion Statement	RCTs	References
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving naming.	1	Zumbansen et al., 2017
1a	**Music-based therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving naming.	3	Zhang et al., 2021; Raglio et al., 2016; Van Der Meulen et al., 2014
1b	**Music-based therapy** may not have a difference in efficacy when compared to **audiobook-based therapy** for improving naming.	1	Sihvonen et al., 2020

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References
1a	**Music-based therapy** may produce greater improvements in verbal fluency than **conventional therapy**.	4	Raglio et al., 2016; Van Der Meulen et al., 2016; Szelag et al., 2014; Van Der Meulen et al., 2014
1b	**Music-based therapy** may not have a difference in efficacy when compared to **audiobook-based therapy** for improving verbal fluency.	1	Sihvonen et al., 2020

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1a	**Music-based therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving social communication.	2	Van Der Meulen et al., 2016; Van Der Meulen et al., 2014
1b	**Melodic intonation therapy** may produce greater improvements than **no language therapy** for improving social communication.	1	Haro-Martinez et al., 2019

REPETITION

LoE	Conclusion Statement	RCTs	References
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving repetition.	1	Zumbansen et al., 2017
1a	**Music-based therapy** may produce greater improvements in repetition than **conventional therapy**.	2	Zhang et al., 2021; Van Der Meulen et al., 2014
1b	**Melodic intonation therapy** may not have a difference in efficacy when compared to **no language therapy** for improving repetition.	2	Haro-Martinez et al., 2019; Conklyn et al., 2012

AUDITORY COMPREHENSION			
LoE	Conclusion Statement	RCTs	References
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving auditory comprehension.	1	Zumbansen et al., 2017
1b	**Music-based therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving auditory comprehension.	3	Zhang et al., 2021; Szelag et al., 2014; Raglio et al., 2016

GLOBAL SPEECH AND LANGUAGE			
LoE	Conclusion Statement	RCTs	References
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving global speech and language.	1	Zumbansen et al., 2017
1a	**Music-based therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving global speech and language.	4	Aravantinou-Fatorou et al., 2021; Zhang et al., 2021; Raglio et al., 2016; Van der Meulen et al., 2016
1b	**Melodic intonation therapy** may not have a difference in efficacy when compared to **no language therapy** for improving global speech and language.	2	Haro-Martinez et al., 2019; Conklyn et al., 2012
1a	**Music-based therapy** may produce greater improvements than **audiobook-based therapy** for improving global speech and language.	1	Sihvonen et al., 2020

APRAXIA			
LoE	Conclusion Statement	RCTs	References
1b	**Choir practice** may not have a difference in efficacy when compared to **drama practice** for improving apraxia motor speech outcomes.	1	Zumbansen et al., 2017

ACTIVITIES OF DAILY LIVING			
LoE	Conclusion Statement	RCTs	References
1b	**Music-based therapy** may not have a difference in efficacy when compared to **audiobook-based therapy** for improving activities of daily living.	1	Sarkamo et al., 2008

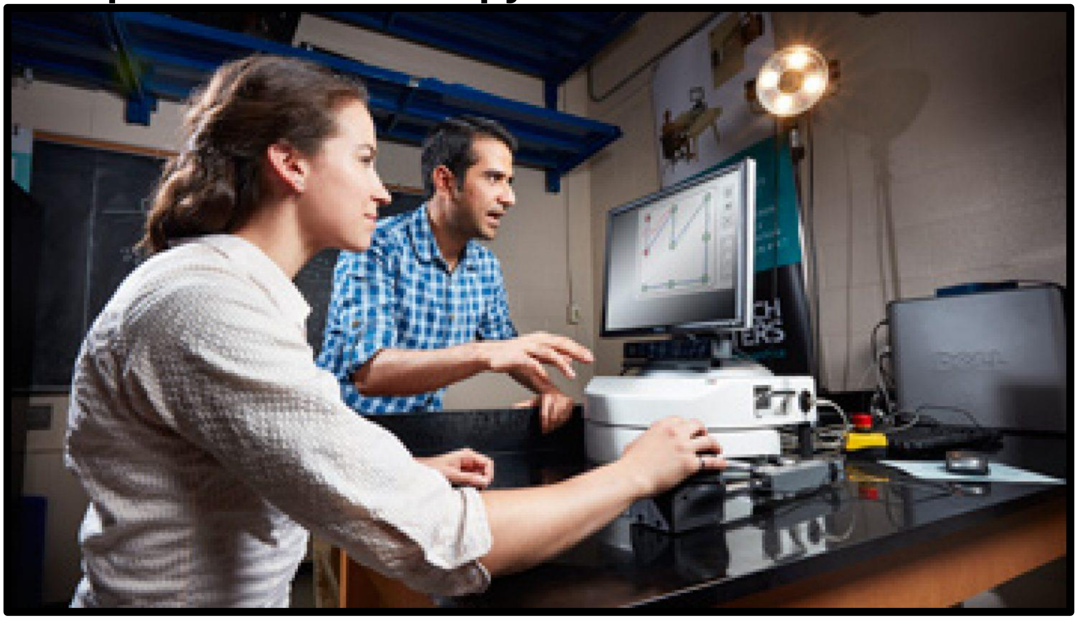
Key Points

Music-based speech-language therapies may be beneficial for improving verbal fluency and repetition, but not social communication, discourse, or global speech and language when compared to conventional therapy

Melodic intonation therapy may not have a difference in efficacy when compared to no language therapy for improving global speech and language or repetition

Technological Interventions

Computer-based Therapy



Adapted from: https://engineerthefuture.ca/rehab-robot-improves-care-for-stroke-patients/

Traditionally, a therapist's physical interactions with a patient were necessary for rehabilitating several different functions. As the strain on hospital resources continues to grow, having physical interactions with a therapist become more difficult, and patient care subsequently suffers. As technology continues to progress, more opportunities are available to use this technology to aid in therapy and rehabilitation as an adjunct or replacement for a human interaction. A computer-based approach is generally more accessible and cost-effective than the same session under the direction of a human therapist. For this reason, computer-based rehabilitation can free up more hospital resources and allow patients to begin and continue rehabilitation as quickly as possible. Furthermore, patients can take a more involved role in their own care, and training can theoretically be performed as often, and whenever the patient wants.

Twenty-nine RCTs were found evaluating computer-based therapies for aphasia rehabilitation. Twelve RCTs compared computer-based speech-language therapy to in-person therapy or sham therapy (Braley et al., 2021; Cherney et al., 2021; Fleming et al., 2021; Tarantino et al., 2021 Palmer et al., 2019; De Luca et al., 2018; Mitchell et al., 2018; Varley et al., 2016; Woolf et al., 2016; Palmer et al., 2012; Whiteside et al., 2012; Cherney et al., 2010). Four RCTs compared computer-based speech-language therapy to no therapy (Palmer et al., 2020; Breitenstein et al., 2017; Kesay et al., 2017; Katz & Wertz, 1997). Five RCTs evaluated computer-based therapies with transcranial direct current stimulation (Sebastian et al., 2020; Fridriksson et al., 2018; Woodhead et al., 2018; Cotelli et al., 2014; Floel et al., 2011). Four RCTs evaluated virtual reality (Giachero et al., 2020; Marshall et al., 2020; Grechuta et al., 2019; Torrisi et al., 2018). One RCT evaluated computer-based therapy and lexical retrieval therapy (Doesborgh et al., 2004). Three RCTs evaluated computer-based telerehabilitation (Ora et al., 2020; Maresca et al., 2019; Meltzer et al., 2018).

The methodological details and results of all Twenty-nine RCTs are presented in **Table 10.**

Table 10. RCTs Evaluating Computer-based Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	**Interventions Duration: Session length, frequency per week for total number of weeks**	**Outcome Measures Result (direction of effect)**
Computer-based Therapy vs Standard or Sham Therapy		
Braley et al. (2021) RCT (6) Nstart=36 Nend=33 TPS=Chronic	E: "Constant Therapy" speech and language rehabilitation app C: Paper workbooks Duration: 30 min/day, 5 days/week, 10 weeks	• Western Aphasia Battery, Revised, • Aphasia Quotient (+exp) • Language Quotient (+exp) • Cortical Quotient (+exp)) • Test of Adult Cognition by Telephone • Verbal Fluency (-) • Immediate Recall (-) • Digit Span Backwards (-) • Number Series (-) • Backward Counting (-) • Stroke and Aphasia Quality of Life Scale 39 ○ Mean (-) ○ Physical (-) ○ Communication (-) ○ Psychosocial (-) ○ Energy (-)
Cherney et al. (2021) RCT(5) Nstart=35 Nend=32 TPS=Chronic	E: Web ORLAÂ® (Oral Reading for Language in Aphasia) which provides repeated choral and independent reading aloud of sentences with a virtual therapist. C: Commercially available computer game, Bejeweled 2Â©, by PopCap. Duration: 90minutes/day, six days/week for six weeks.	Western Aphasia Battery-Revised Language Quotient (WAB-R LQ) (-)
Fleming et al. (2021) Cross-over RCT (6) Nstart=25 Nend=25 TPS=Chronic	E: self-managed spoken word comprehension therapy (Listen-In) on a computer tablet C: usual daily activities. Duration: 12 weeks of daily, ~80 minutes per day	• Comprehensive Aphasia Test ○ Spoken Words (-) ○ Spoken Sentences (-) • Auditory Comprehension Test (+exp)
Tarantino et al. (2021) RCT (5) NStart=43 NEnd=37 TPS=Subacute	E: Computer-based executive function training C: Ordinary rehabilitation program Duration: 1hr, 5x/wk, 2wks	• Digit Span Forward (+exp) • Digit Span Backward (-) • Cosi Block-Tapping (-) • Attentional Matrices (-) • Trail Making Test A (-) • Naming (-) • Phonemic Fluency (+exp) • Semantic Fluency (-) • Wisconsin Card Sorting Test (WCST) Categories (-) • WCST Errors (+exp) • Five Point Error Index (-) • Stroop Inverse Efficacy Score (+exp) • Barthel Index (+exp) • Functional Independence Measure (-)
Palmer et al. (2019) RCT(5) Nstart=278 Nend=240 TPS=Chronic	E: Self-managed computerized speech and language therapy C1: Attention control plus usual care C2: Usual care Duration: 20-30 mins/session, 1 session/day, 6 months	E vs C2 • Change in word finding (+exp) • Change in functional communication (-) • Change in participant’s perception of communication, social participation, and quality of life (-) E vs C1

		• Change in word finding (+exp) • Change in functional communication (-) • Change in participant's perception of communication, social participation, and quality of life (-) C1 vs C2 • Change in word finding (-) • Change in functional communication (-) Change in participant's perception of communication, social participation, and quality of life (-)
De Luca et al. (2018) RCT (6) Nstart=18 Nend=18 TPS=Chronic	E: Computerized Language Therapy C: Standard Language Therapy Duration: 45min, 3x/wk, 8wks	• Functional Independence Measure (+exp) • Aphasic Depression Rating Scale (-) • Attentive Matrices Test (-) • Token Test (-) • Constructional apraxia (-) • Ideomotor apraxia (-) • Neuropsychological Examination for Aphasia ○ Denomination (+exp) ○ Writing (-) ○ Repetition (+exp) ○ Reading (+exp) Comprehension (-)
Mitchell et al. (2018) RCT (5) Nstart=40 Nend=30 TPS=Acute	E: ReaDySpeech Computer-Based Speech Therapy C: Usual Care Duration: 8-10 wks expected, but no intentsity or duration were specified	• Frenchay Dysarthria Assessment (+exp) • Dysarthria Therapy Outcome Measures Activity (+exp) Communication Outcomes After Stroke Scale (+exp)
Varley et al. (2016) Crossover RCT (6) N_{Start} =50 N_{End} =44 TPS=Chronic	E: Computer Speech Therapy C: Visuospatial Sham Condition Duration: 20min/d, 6wks, 4wk washout period	• Naming (+exp) Repetition (+exp)
Woolf et al. (2016) RCT (4) N_{Start}=20 N_{End} =19 TPS=Chronic	E1: Remote University Word-finding Therapy E2: Remote Clinical Word-finding Therapy C1: In Person Word-finding Therapy C2: Attentional Therapy Duration: 1hr, 2x/wk, 4wks	E1 vs C1 • Picture Naming Task (+con1) E2 vs C1 • Picture Naming Task (+exp2) E1 vs E2 • Picture Naming Task (+exp2)
Palmer et. al. (2012) RCT (8) N=34 N_{Start}=34 N_{End} =24 TPS=Chronic	E: Computer-based Language Therapy C: Daily Language Therapy Duration: 20min, 3d/wk, 5mo	Object and Action Naming Battery (+exp)
Whiteside et al. (2012) Cross-over RCT (8) Nstart=50 Nend=44 TPS=Chronic	E: speech therapy computer program C: visual sham computer program Duration: ~3hr/wk, 6 wks, washout period 4 wks	• Program usage level (-) • Struggle scores (-) • Fluency scores (-)
Cherney et. al. (2010) RCT (6) N_{Start}=25 N_{End}=25 TPS=Chronic	E: Aphasia Therapy Delivered by a Computer C: Aphasia Therapy Delivered by Speech-language Pathologist Duration: 24 total sessions, 1hr, 2-3x/wk	• Western Aphasia Battery (-)
Computer-based Speech-language Therapy vs No Speech-language Therapy		
Palmer et al. (2020) RCT(7)	E1: computerized speech and language therapy	E1 vs C • Word-finding (+E1)

Nstart=278 Nend=240 TPS=Chronic	E2: attention control C: usual care Duration: (computerised speech and language therapy, 3.2 hours; usual care, 3.8 hours; and attention control, 3.2 hours), 6 months	• Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-) E1 vs E2 • Word-finding (+E2) • Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-) E2 vs C • Functional communication (-) • Improvement in Communication Outcomes (-) • Improvement in treated words used in conversation (-) • Improved word-finding of treated words (-)
Breitenstein et al. (2017) RCT (8) Nstart=158 Nend=156 TPS=Chronic	E: Intensive Speech Language Therapy C: Waitlist Duration: Therapist (2hrs) and Computer Training (1hr), 5d/wk, 3wks	• Amsterdam-Nijmegen Everyday Language Test ○ A scale (+exp) ○ B scale (-) • Aphasia Screening (+exp), ○ Phonology (-) ○ Lexicon (+exp) ○ Syntax (+exp) ○ Language comprehension (+exp) ○ Language Production (+exp) • Stroke and Aphasia Quality of Life Scale (+exp) • Nonverbal Learning Test (-) • Train Making test A (-) • Trial Making Test B (-) • Modified Rankin Scale (-)
Kesav et al. (2017) RCT(5) Nstart=24 Nend=20 TPS=Subacute	E: computer based language rehabilitation + standard care sessions C: standard care Duration:1hr/ standard care session, 3 sessions/wk, 4wks, and 1hr/ computer based language rehabilitation session, 3 sessions/wk, 4wks	Western Aphasia Battery Aphasia Quotient (+Con)

Katz & Wertz (1997)
RCT (5)
N_{Start}=63
N_{End}=55
TPS=Chronic
	E1: Computer Reading Treatment
	E2: Computer Stimulation Treatment
	C: No Treatment
	Duration: 3hrs/wk, 26wks
		E1 vs E2
		• Western Aphasia Battery – Overall (+exp1)
		  • Spontaneous Speech (-)
		  • Comprehension (-)
		  • Repetition (+exp1)
		  • Naming (-)
		• Porch Index of Communicative Ability – Overall (+exp1)
		  • Auditory (-)
		  • Verbal (+exp1)
		  • Pantomime (-)
		  • Reading (-)
		  • Writing (-)
		E1 vs C
		• Western Aphasia Battery – Overall (+exp1)
		  • Spontaneous Speech (-)

		• Comprehension (-) • Repetition (+exp1) • Naming (-) • Porch Index of Communicative Ability – Overall (+exp1) • Auditory (-) • Verbal (+exp1) • Pantomime (+exp1) • Reading (-) • Writing (-) E2 vs C • Western Aphasia Battery – Overall (-) • Spontaneous Speech (-) • Comprehension (-) • Repetition (+exp1) • Naming (-) • Porch Index of Communicative Ability – Overall (-) • Auditory (-) • Verbal (-) • Pantomime (+exp2) • Reading (-) • Writing (-)
tDCS + Computer-Based Therapy		
Sebastian et al. (2020) cross over RCT (8) Nstart=24 Nend=21 TPS=chronic	E1: cathodal cerebellar stimulation + standard treatment E2: computerized aphasia therapy + standard treatment Duration: 20 min, 15 sessions 4 weeks (3-5 sessions/wk), 2 months washout period	• Naming 80 test (+exp) • Philadelphia Naming Test-Correct scores (+exp)
Fridriksson et al. (2018) RCT (9) Nstart=74 Nend=69 TPS=Chronic	E: Anodal tDCS with computerized aphasia training C: Sham Duration: 20min tDCS during first 45min of therapy, 5x/wk, 3wks	• Philadelphia Naming Test (-)
Woodhead et al. (2018) RCT crossover (7) Nstart=23 Nend=21 TPS=Chronic	E: iReadMore app with anodal tDCS (first 20min) C: iReadMore app with sham tDCS Duration: 40min therapy, 3x/wk, 4wks, 4wk washout	• Word Reading Test ○ Accuracy (-) ○ Response time (-) • Written Semantic Matching (-) • Sentence Reading (-) • Text Reading (-) • Sustained Attention to Response Task (-) • Communication Disability Profile (-)
Cotelli et al. (2014) RCT(Nstart=16 Nend=16 TPS=NR	E1: Anodal tDCS + computerized language training E2: Placebo tDCS + computerized language training Duration: 25 min, 5 days/wk, 2 wks 2 wks tDCS	• Naming subtest of Aachener Aphasie Test (+exp) ○ Naming correctness(+exp) ○ Naming abilities for the treated items(+exp) ○ Naming abilities for the untreated items (no stats) • Functional communication scales (energy subdomain of Stroke and Aphasia Quality of Life Scale (+exp) • Caregiver's production section of the Speech Questionnaire (+exp)
Floel et al. (2011) RCT Crossover (6) Nstart=12 Nend=12 TPS=Chronic	E1: Anodal transcranial direct current stimulation + computer-assisted naming therapy E2: Cathodal transcranial direct current stimulation + computer-assisted naming therapy	E1 vs C • Correct naming response (exp+) E2 vs C • Correct naming response (exp+) E1 vs E2 • Correct naming response (-)

	C: Sham + computer-assisted naming therapy Duration: 20 mins of transcranial direct current stimulation + 2 hours of computer-assisted naming therapy/day, for 3 days	
Virtual Reality		
Giachero et al. (2020) RCT (6) Nstart=36 Nend=36 TPS=Chronic	E1: virtual reality + conversational therapy C: conversational therapy Duration: 2 hr/wk, 2 sessions/wk, 6 months	• Aachen Aphasia Test (-) ○ Token test (-) ○ Repetition (-) ○ Written language (-) ○ Naming (-), ○ Comprehension (-) • Conversation Analysis Profile for People with Aphasia test (patient's perspective) ○ Frequency ▪ Language ability (-) ▪ Self correction (-) ▪ Turn taking (-) ▪ Topic management (-) ○ Severity ▪ Language ability (-) ▪ Self correction (-) ▪ Turn taking (-) ▪ Topic management (-)
Marshall et al. (2020) RCT (5) Nstart=34 Nend=28 TPS=Chronic	E: Virtual Reality C: Standard Therapy Duration: 1.5 hr/session, 1 session/2 weeks, 14 sessions over 6 months	• Warwick-Edinburgh Mental Well-being Scale (-) • Communication Activities of DailyLiving-2 (-)
Grechuta et al. (2019) RCT (7) NStart=17 NEnd=17 TPS=Chronic	E: Augmented Embodied Therapy C: Standard Treatment Duration: 30-40min/session, 5d/wk, 8 wks	• Boston Diagnostic Aphasia Examination (-) • Communicative Activity Log (-) • Vocabulary Test (+exp) • Fugl-Meyer Upper Extremity Scale (+exp)
Torrisi et al. (2019) RCT (5) NStart=40 NEND=40 TPS=Subacute	E: Virtual Reality Rehabilitation System-Evo C: Standard cognitive training Duration: 50 min/session, 3 session/wk, 12 wks	• Montreal Overall Cognitive Assessment (-) • Attentive Matrices (-) • Trail Making Test B (-) • Rey Auditory Verbal Learning Test (-) • Phonemic Verbal Fluency (-) • Semantic Verbal Fluency (-) • Hamilton Rating Scale for Anxiety (-) • Hamilton Rating Scale for Depression (-)
Computer-Based Therapy + Lexical Retrieval Therapy		
Doesborgh et al. (2004) RCT (4) Nstart=18 Nend=18 TPS=Acute	E: Computerized Word-Finding Training (Multicue) C: No Treatment Duration: 30-45min, 2-3x/wk, 8wks	• Boston Naming Test (-) • Amsterdam-Nijmegen Everyday Language Test - scale A (-)
Telerehabilitation		
Ora et al. (2020) RCT (7) Nstart=62 Nend=57 TPS=Chronic	E: Telerehabilitation + Usual Care C: Usual Care Duration: 1 hr/day, 5 days/wk, 4 wks	• Norwegian Basic Aphasia Assessment ○ Naming (-) ○ Repetition (+exp) ○ Auditory comprehension (-) • Verb and Sentence Test sentence production (+exp) ○ Intransitive verbs (+exp) • Transitive verbs (+exp))

Maresca et al. (2019) RCT (6) Nstart=30 Nend=30 TPS=Subacute	E: Virtual Rehabilitation Program C: Traditional Speech Treatment Duration: 50 mins/day, 5 days/wk, 24 wks	• Token Test (+exp) • Aphasic Depression Rating Scale (+exp) • Euro-Qol-5D (+exp)
Meltzer et al. (2018) RCT(5) Nstart=53 Nend=44 TPS=Chronic	E: tablet-based homework exercises- Telerehabilitation + standard care C: tablet-based homework exercises- in person rehabilitation + standard care Duration: 1hr/wk,10 weeks	• Western Aphasia Battery aphasia quotient (-) ○ Spontaneous speech (-) ○ Auditory verbal comprehension (-) ○ Repetition (-) ○ Naming and wordfinding (-) • Cognitive-Linguistic Quick Test (-) • Communication Effectiveness Index (-) • Communication Confidence Rating Scale for Aphasia (+con)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Computer-based Speech Language Therapy

NAMING

LoE	Conclusion Statement	RCTs	References
1b	There is conflicting evidence about the effect of **computer-based therapy** to improve naming when compared to **in person therapy.**	2	Woolf et al., 2016; Palmer et al., 2012
1b	There is conflicting evidence about the effect of **computer-based therapy** to improve naming when compared to **no language therapy.**	2	Varley et al., 2016; Katz & Wertz, 1997
2	**Virtual reality** may not have a difference in efficacy for improving naming than **standard therapy**	1	Torrisi et al., 2019
1b	**Telerehabilitation** may not have may not have a difference in efficacy when compared to **standard language therapy** for improving naming.	3	Ora et al., 2020; Maresca et al., 2019; Meltzer et al. 2018

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References
1b	**Computer-based** therapy may not have a difference in efficacy for improving verbal fluency when compared to **in-person therapy.**	3	Barley et al. 2021; Palmer et al. 2019; Katz & Wertz, 1997

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1b	**Computer-based training** may not have a difference in efficacy for improving social communication than **in-person therapy.**	2	Palmer et al. 2019; Breitenstein et al. 2017
1b	**Virtual reality** may not have a difference in efficacy for improving social communication than **standard therapy.**	1	Grechuta et al., 2019

2	**Computer-based therapy with lexical retrieval therapy** may not have may not have a difference in efficacy when compared to **standard language therapy** for improving social communication.	1	Doesborgh et al., 2004
2	**Telerehabilitation** may not have may not have a difference in efficacy when compared to **standard language therapy** for social communication	1	Meltzer et al., 2018

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Computer-based therapy** may produce greater improvements in repetition than **no language therapy.**	2	Varley et al., 2016; Katz & Wertz, 1997
1b	There is conflicting evidence about the effect of **telerehabilitation** to improve repetition when compared to **standard therapy.**	2	Ora et a., 2020; Meltzer et al., 2018

WRITING			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Computer-based therapy** may not have a difference in efficacy when compared to **no language therapy** for improving writing.	1	Katz & Wertz, 1997

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	There is conflicting evidence about the effect of **computer-based therapy** to improve general comprehension when compared to **no language therapy.**	1	Katz & Wertz, 1997

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Telerehabilitation** may produce greater improvements in discourse than **standard therapy.**	1	Ora et al. 2020

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**computer-based therapy** may not have a difference in efficacy when compared to **no language therapy** for improving reading comprehension.	1	Katz & Wertz, 1997

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **computer-based therapy** for producing greater improvements auditory comprehension than **in person therapy.**	2	Fleming et al. 2021; De Luica et al. 2018

2	**Computer-based therapy** may not have a difference in efficacy when compared to **no language therapy** for improving auditory comprehension.	1	Katz & Wertz, 1997
1b	**Telerehabilitation** may not have may not have a difference in efficacy when compared to **standard language therapy** for auditory comprehension.	3	Ora et al., 2020; Maresca et al., 2019; Meltzer et al. 2018

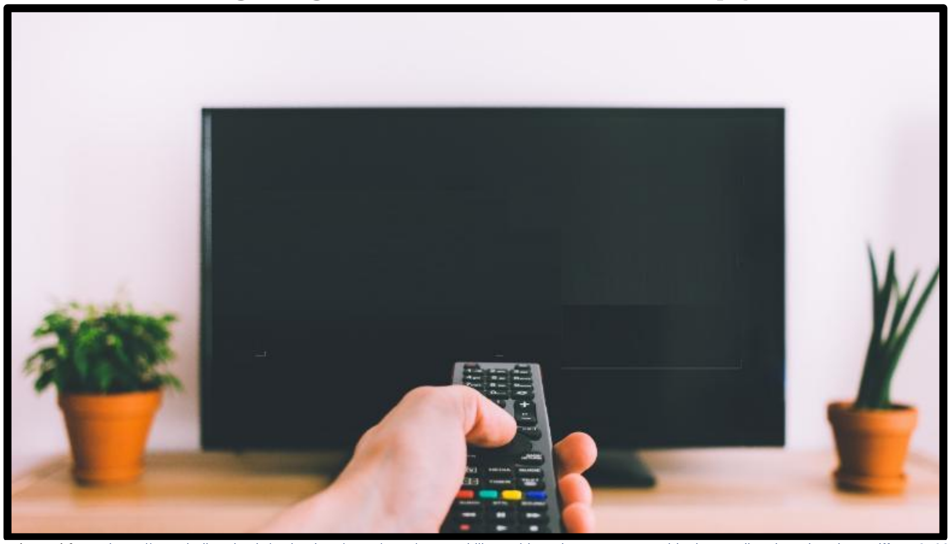
GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **computer-based therapy** for producing greater improvements in global speech and language than **in person therapy.**	6	Barley et al. 2021; Fleming et al. 2021; Breitenstein et al. 2017; Kesav et al. 2017; Cherney et al., 2010; Katz and Wertz, 1997
1b	**Virtual Reality** may not have may not have a difference in efficacy when compared to **standard language therapy** for improving global speech and language.	2	Giachero et al., 2020; Grechuta et al., 2019
2	**Computer-based therapy with lexical retrieval therapy** may not have may not have a difference in efficacy when compared to **standard language therapy** for improving global speech and language.	1	Doesborgh et al., 2004
1b	**Telerehabilitation** may not have may not have a difference in efficacy when compared to **standard language therapy** for improving global speech and language.	1	Meltzer et al. 2018

Key Points

There is little evidence to support computer-based therapies for improving aphasia

Computer-based therapy may be beneficial for repetition and discourse.

Filmed Language Instruction Therapy



Adapted from: https://www.indiatoday.in/technology/news/story/your-tv-bills-could-go-down-soon-as-trai-looks-to-adjust-broadcasting-tariffs-1531096-2019-05-21

As mentioned above, limited human and financial resources in health care have led researchers and clinicians searching more cost-effective and accessible alternatives. Filmed therapy is another way, similar to computer-based therapy, where a patient can receive more therapy at lower cost than they can receive with a speech therapist in person. Filmed therapy could be accessible at anytime of the day in the comfort of the patients own home, and it allows the video to be watched multiple times and more overall therapy to potentially be delivered.

One RCT was found evaluating filmed language therapy for aphasia. The single RCT compared a filmed therapy to traditional speech therapy (Di Carlo et al., 1980).

The methodological details and results of the single RCT are presented in **Table 11.**

Table 11. RCTs Evaluating Filmed Language Instruction for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	**Interventions Duration: Session length, frequency per week for total number of weeks**	**Outcome Measures Result (direction of effect)**
Di Carlo (1980) RCT (4) N_{Start}=14 N_{End}=14 TPS=Chronic	E: Speech therapy with systematic filmed program instruction C: Traditional speech therapy Duration: >80hrs total	• Reading recognition (-) • Reading comprehension (-) • Vocabulary (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Filmed Speech-language Instruction Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Filmed speech therapy** may not have a difference in efficacy when compared to **standard speech therapy** for improving discourse.	1	Di Carlo et al., 1980

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Filmed speech therapy** may not have a difference in efficacy when compared to **standard speech therapy** for improving reading comprehension.	1	Di Carlo et al., 1980

Key Points

Filmed speech therapy may not be beneficial for improving discourse of reading comprehension.

Repetitive Transcranial Magnetic Stimulation (rTMS)

Adapted from: https://www.technologynetworks.com/neuroscience/news/rtms-study-claims-to-improve-working-memory-319448

Transcranial magnetic stimulation is a painless and non-invasive method of affecting neural activity through the exogenous generation of an electromagnetic field through a coil placed on the scalp, that consequently induces a change in the electrical fields of the brain (Peterchev et al. 2012). The voltage and current of the electromagnetic field generated are dependent on the parameters of the stimulation device, which is not distorted by the biological tissues in which it is applied in (Peterchev et al. 2012). The neuromodulatory effects of transcranial magnetic stimulation are attributed largely to neural membrane polarization shifts that can lead to changes in neuron activity, synaptic transmission, and activation of neural networks (Peterchev et al. 2012). Repetitive transcranial magnetic stimulation (rTMS) is the application of repetitive trains of transcranial magnetic stimulation at regular intervals.

After a stroke, interhemispheric competition is altered; with cortical excitability increasing in the unaffected hemisphere increasing and decreasing in the affected hemisphere (Zhang et al. 2017). rTMS can be used to help modulate this interhemispheric competition, with low stimulation frequencies (≤1Hz) decreasing cortical excitability and inhibiting activity of the contralesional hemisphere, while high frequency (>1Hz) stimulation increases excitability and have a facilitatory effect on activity of the ipsilesional hemisphere (Dionisio et al. 2018)

Twenty-two RCTs were found evaluating rTMS interventions for aphasia rehabilitation. Fourteen RCTs compared inhibitory rTMS to a sham condition (Haghighi et al., 2018; Rubi-Fessen et al., 2015; Tsai et al., 2014; Wang et al., 2014a; Barwood et al., 2013; Heiss et al., 2013; Seniów et al., 2013; Theil et al., 2013; Waldowski et al., 2012; Barwood et al., 2011; Barwood et al., 2013; Medina et al., 2012; Bai et al., 2020; Weiduschat et al., 2011). One RCT compared high frequency rTMS to low frequency rTMS and to a sham condition (Hu et al., 2018). One RCT compared dual hemisphere rTMS to a sham condition (Khedr et al., 2014). Two RCTs compared theta burst stimulation to a sham condition (Kindler et al., 2012; Cazzoli et al., 2012). One RCT compared anodal tDCS to inhibitory rTMS (Dos Santos et al., 2017). One RCT compared cathodal tDCS with inhibitory rTMS and sham (Zumbansen et al., 2020). One RCT compared constraint induced aphasia therapy combined with rTMS vs constraint induced aphasia therapy combined with sham (Heikkinen et al., 2019). One RCT compared low frequency rTMS over Borca’s area to Wernicke’s area (Ren et al., 2019).

The methodological details and results of all 22 RCTs are presented in **Table 12.**

Table 12. RCTs Evaluating rTMS Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Low Frequency (Inhibitory) rTMS vs Sham		
Bai et al. (2020) RCT (6) NStart=30 NEnd=30 TPS=Subacute	E1: Once daily repetitive transcranial magnetic stimulation (rTMS) plus once daily deceptive rTMS E2: Twice daily rTMS plus once daily deceptive rTMS C: Once daily deceptive rTMS Duration: 1 group/d, 5d/wk, 4wks	E1 vs C • Western Aphasia Battery (+exp1) • Brain Derived Neurotropic Factor (+exp1) E2 vs C • Western Aphasia Battery (+exp2) • Brain Derived Neurotropic Factor (+exp2) E1 vs E2 • Western Aphasia Battery (+exp2) • Brain Derived Neurotropic Factor (+exp2)
Haghighi et al. (2018) RCT (7) N_{Start}=12 N_{End}=12 TPS=Subacute	E: Inhibitory rTMS (30min) C: Sham rTMS Duration: 5x/wk, 2wks	• Western Aphasia Battery-Revised (-)
Rubi-Fessen et al. (2015) RCT (7) N_{Start}=40 N_{End}=30 TPS= Subacute	E: Inhibitory rTMS C: Sham rTMS Duration: 20min/session 10 sessions (45min speech + language therapy), 2wks	• Aachen Aphasia Test (+exp) • Naming (+exp) • Amsterdam Nijmegen Everyday Language Test (+exp) • Token Test (-) • Naming Screening (-) • Functional Independence Measure (-)
Tsai et al. (2014) RCT (9) N_{Start}=56 N_{End}=53 TPS= Subacute	E: Inhibitory rTMS (10min) + Conventional Speech Rehabilitation (1hr) C: Sham rTMS + Conventional Speech Rehabilitation Duration: 10d	• Concise Chinese Aphasia Test ○ Conversation (+exp) ○ Description (+exp) ○ Expression (+exp) ○ Repetition (+exp) • Picture Naming Test ○ Naming Accuracy (+exp) ○ Naming Reaction Time (+exp)
Wang et al. (2014a) RCT (8) N_{Start}=45 N_{End}=43 TPS=Chronic	E1: Inhibitory rTMS (20min) + Synchronous Picture-naming E2: Inhibitory rTMS (20min) + Picture-naming Task C: Sham rTMS + Concurrent Naming Duration: 10d	• Concise Chinese Aphasia ○ Conversation (+exp) ○ Description (+exp) ○ Expression (+exp) ○ Repetition (+exp) • Picture Naming Test ○ Action Naming (+exp) ○ Object-Naming (+exp)
Barwood et al. (2013) RCT (8) N_{Start}=12 N_{End}=12 *Follow-up of Barwood et al. (2011)* TPS=Chronic	E: Low Frequency rTMS (20min) C: Sham rTMS Duration: 10d	• Boston Diagnostic Aphasia Examination: ○ Naming Actions (+exp) ○ Naming Tools and Instruments (+exp) ○ Complex Ideational Materials (+exp) ○ Picture Description (+exp) ○ Repetition of Sentences (+exp) ○ Repetition of Non-words (+exp) ○ Commands (+exp) ○ Word Comprehension (-) ○ Repetition of Single Words (-) ○ Responsive Naming (-) ○ Naming Screening of Special Categories (-) ○ Naming Colours (-) • Picture Naming Test

		○ Accuracy (+exp) ○ Latency (+exp)
Heiss et al. (2013) RCT (5) N_{Start}=41 N_{End}=31 TPS=Subacute	E: Inhibitory rTMS (20min) C: Sham Stimulation Duration: 10d	• Aachen Aphasia Test (+exp)
Senіów et al. (2013) RCT (8) N_{Start}=40 N_{End}=38 TPS=Subacute	E: Inhibitory rTMS (30min) + Speech-language Therapy C: Sham rTMS + Speech-language Therapy Duration: 5d/wk, 3wks	• Boston Diagnostic Aphasia Examination ○ Comprehension (-) ○ Repetition (-) ○ Naming (-)
Thiel et al. (2013) RCT (5) N_{Start}=30 N_{End}=24 TPS=Subacute	E: Inhibitory rTMS (20min) + Aphasia Therapy C: Sham rTMS + Aphasia Therapy Duration: 10d	• Aachen Aphasia Test (+exp)
Medina et al. (2012) RCT (4) Nstart=10 Nend=10 TPS=Chronic	E: Low Frequency rTMS C: Sham Duration: 1200 pulses/d, 5d/wk, 2wks	• Discourse Productivity (-) • Sentence Productivity (-) • Grammatical Accuracy (-) • Lexical Selection (-)
Waldowski et. al. (2012) RCT (8) N_{Start}=26 N_{End}=26 TPS=Subacute	E: Inhibitory rTMS (30min) + Speech Therapy C: Sham rTMS + Speech Therapy Duration: 5d/wk, 3wks	• Picture Naming Test ○ Accuracy (-) ○ Reaction Time (+exp)
Barwood et al. (2011) RCT (8) N_{Start}=12 N_{End}=12 TPS=Chronic	E: Low Frequency rTMS (20min) C: Sham rTMS Duration: 10d	• Boston Diagnostic Aphasia Examination (+exp) • Picture Naming ○ Accuracy (+exp) ○ Latency (+exp) • Boston Naming Test (+exp)
Weiduschat et al. (2011) RCT (6) Nstart=10 Nend=10 TPS=Subacute	E: Low-frequency rTMS + Speech and Language Therapy C: Sham + Speech and Language Therapy Duration: 20 mins/day, 5 days/wk, 2 wks	Aachen Aphasia Test (+exp)
High Frequency rTMS vs Low Frequency rTMS vs Sham vs Conventional Therapy		
Hu et al. (2018) RCT (3) N_{Start}=40 N_{End}=40 TPS=Chronic	E1: High-frequency rTMS (10min) E2: Low-frequency rTMS (10min) C1: Sham rTMS C2: Conventional Therapy (30min) Duration: 10d	E1 vs E2 • Western Aphasia Battery ○ Spontaneous Speech (+exp2) ○ Auditory Comprehension (+exp2) ○ Repetition (-) ○ Aphasia Quotient (+exp2) E1 vs C1 • Western Aphasia Battery ○ Spontaneous Speech (-) ○ Auditory Comprehension (-) ○ Repetition (-) ○ Aphasia Quotient (-) E1 vs C2 • Western Aphasia Battery: ○ Spontaneous Speech (-) ○ Auditory Comprehension (-) ○ Repetition (+exp1) ○ Aphasia Quotient (-) E2 vs C1 • Western Aphasia Battery ○ Spontaneous Speech (+exp2) ○ Auditory Comprehension (+exp2) ○ Repetition (-)

		○ Aphasia Quotient (+exp2) E2 vs C2 • Western Aphasia Battery ○ Spontaneous Speech (+exp2) ○ Auditory Comprehension (+exp2) ○ Repetition (-) ○ Aphasia Quotient (+exp2)
Dual Hemisphere rTMS vs Sham		
Khedr et al. (2014) RCT (7) N_{Start}=30 N_{End}=29 TPS= Subacute	E: Dual Hemisphere rTMS C: Sham rTMS Duration 5d/wk, 2wks	• Aphasia Severity Rating Scale (+exp) • Hemispheric Stroke Scale-Language: ○ Overall Score (+exp) ○ Comprehension (+exp) ○ Naming (+exp) ○ Repetition (+exp) ○ Fluency (+exp)
Theta Burst Stimulation vs Sham		
Cazzoli et al. (2012) RCT (8) NStart=24 NEnd=24 TPS=Subacute	E1: Continuous Theta Burst Stimulation (cTBS) followed by sham stimulation E2: Sham stimulation followed by cTBS C: No stimulation Duration: E1= 44s/stimulation, 15min, 60 min and 75 min interval between the 4 stimulations, respectively, complated on 2 consecutive days on week 1 (after week 0), sham condition same protocol completed on week 2; E2=Same protocol as E1, but cTBS and sham switched (sham week 1, cTBS week 2)	• Two-Part Picture Test (+exp1exp2) • Munich Reading Texts (-)
Kindler et. al. (2012) Crossover RCT (5) N_{Start}=18 N_{End}=NA TPS=Subacute, Chronic	E: Theta Burst Stimulation C: Sham Stimulation Duration: 1 session, 1wk washout period	• Picture Naming Test (exp)
Anodal tDCS vs inhibitory rTMS		
Dos Santos et al. (2017) Crossover RCT (2) N_{Start}=13 N_{End}=13 TPS=Chronic	E1: Anodal tDCS (20min) E2: Inhibitory TMS (20min) C: Sham Stimulation Duration: 1 week/ condition	• Picture Naming (-) • Response Time (-) • Picture Naming Strategy (-) • Response Time Strategy (-) • Total Response Time (-)
tDCS vs rTMS vs Sham		
Zumbansen et al. (2020) RCT(8) Nstart=63 Nend=63 TPS=Subacute	E1: Low frequency transcranial magnetic stimulation + sham E2: cathodal transcranial direct current stimulation C: sham Duration: 45 min/session, 10 sessions over two weeks	E1vsE2 • Boston naming test (+E1) • Semantic fluency (-) E1 vs C • Boston naming test (+E1) • Semantic fluency (-) E2 vs C • Token test (+con)
Constraint Induced Aphasia Therapy + rTMS vs Sham		
Heikkinen et al. (2019) RCT (7) Nstart=17 Nend=17 TPS=Chronic	E: rTMS + ILAT C: Sham + ILAT Duration: rTMS for 20 mins/day, 5 days/wk, 4 wks. ILAT for 3 hrs/day, 5 days/wk, 2 wks	• Western Aphasia Battery aphasia quotient AQ (-) • Boston naming test (-) • Action naming test (-)
Low Frequency rTMS over Borca's Area vs Wernicke's Area		
Ren et al. (2019) RCT (7) Nstart=54 Nend=45 TPS=Subacute	E1: Low frequency rTMS over right pars triangularis (pIFG), Borca's area homolog E2: Low frequency rTMS over right pSTG, Wernicke's area homolog	E1 vs C • Western Aphasia Battery ○ Spontaneous Speech (+exp1) ○ Auditory Comprehension (-)

	C: Sham group Duration: 20 min, 5d/wk, 3wks, followed by 30min speech and language therapy.	○ Repetition (-) ○ Naming (-) ○ Aphasia Quotient (-) E2 vs C • Western Aphasia Battery ○ Spontaneous Speech (-) ○ Auditory Comprehension (+exp2) ○ Repetition (-) ○ Naming (-) ○ Aphasia Quotient (-) E1 vs E2 • Western Aphasia Battery ○ Spontaneous Speech (-) ○ Auditory Comprehension (-) ○ Repetition (-) ○ Naming (-) ○ Aphasia Quotient (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about rTMS Therapy

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Inhibitory rTMS** may produce greater improvements in discourse than **sham stimulation.**	3	Tsai et al., 2014: Wang et al., 2013; Medina et al., 2012

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Inhibitory rTMS** may produce greater improvements in naming than **sham stimulation**.	8	Zumbansen et al., 2020; Rubi-Fessen et al., 2015; Tsai et al., 2014: Wang et al., 2014; Barwood et al., 2013; Seniow et al., 2013; Waldowski et al., 2012; Barwood et al., 2011
1b	**Dual hemisphere rTMS** may produce greater improvements in naming than **sham stimulation**.	1	Khedr et al., 2014
1b	**Theta burst stimulation** may produce greater improvements in naming than **sham stimulation**.	2	Cazzoli et al., 2012; Kindler et al., 2012
2	**Anodal tDCS** may not have a difference in efficacy when compared to **inhibitory rTMS** for improving naming.	1	Dos Santos et al., 2017
1b	**Constraint induced aphasia therapy with rTMS** may not have a difference in efficacy when compared to **with sham stimulation** for improving naming.	1	Heikkinen et al., 2019

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**

1b	**Theta burst stimulation** may not have a difference in efficacy when compared to **sham stimulation** for improving naming.	1	Cazzoli et al., 2012

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References
1a	**Inhibitory rTMS** may produce greater improvements in verbal fluency than **sham stimulation**.	3	Hu et al., 2018; Tsai et al., 2014; Wang et al., 2014
1b	**Dual hemisphere rTMS** may produce greater improvements in verbal fluency than **sham stimulation**.	1	Khedr et al., 2014
2	**Excitatory rTMS** may not have a difference in efficacy when compared to **sham stimulation** for improving verbal fluency.	1	Hu et al., 2018
2	**Inhibitory rTMS** may produce greater improvements in verbal fluency than **excitatory rTMS**.	1	Hu et al., 2018
2	**Anodal tDCS** may not have a difference in efficacy when compared to **inhibitory rTMS** for improving verbal fluency.	1	Dos Santos et al., 2017

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1a	**Inhibitory rTMS** may produce greater improvements in social communication than **sham stimulation**.	3	Rubi-Fessen et al., 2015; Tsai et al., 2014; Wang et al., 2014

REPETITION

LoE	Conclusion Statement	RCTs	References
1a	There is conflicting evidence about the effect of **inhibitory rTMS** to improve repetition when compared to **sham stimulation.**	5	Hu et al., 2018; Tsai et al., 2014; Wang et al., 2014; Barwood et al., 2013; Seniow et al., 2013
1b	**Dual hemisphere rTMS** may produce greater improvements in repetition than **sham stimulation**.	1	Khedr et al., 2014
2	**Excitatory rTMS** may not have a difference in efficacy when compared to **sham stimulation** for improving repetition.	1	Hu et al., 2018
2	**Inhibitory rTMS** may produce greater improvements in repetition than **excitatory rTMS**.	1	Hu et al., 2018

GENERAL COMPREHENSION

LoE	Conclusion Statement	RCTs	References
1b	**Inhibitory rTMS** may not have a difference in efficacy when compared to **sham stimulation** for improving general comprehension.	1	Seniow et al., 2013
1b	**Dual hemisphere rTMS** may produce greater improvements in general comprehension than **sham stimulation**.	1	Khedr et al., 2014

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **inhibitory rTMS** to improve auditory comprehension when compared to **sham stimulation.**	3	Hu et al., 2018; Rubi-Fessen et al. ,2015; Barwood et al., 2013
2	**Excitatory rTMS** may not have a difference in efficacy when compared to **sham stimulation** for improving auditory comprehension.	1	Hu et al., 2018
2	**Inhibitory rTMS** may produce greater improvements in auditory comprehension than **excitatory rTMS**.	1	Hu et al., 2018

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Inhibitory rTMS** may produce greater improvements in global speech and language than **sham stimulation**.	11	Bai et al., 2020; Ren et al., 2019; Haghigi et al., 2018; Hu et al., 2018; Rubi-Fessen et al., 2015; Wang et al., 2014; Barwood et al., 2013; Heiss et al., 2013; Thiel et al., 2013; Barwood et al., 2011; Weiduschat et al., 2011
1b	**Dual hemisphere rTMS** may produce greater improvements in global speech and language than **sham stimulation**.	1	Khedr et al., 2014
2	**Excitatory rTMS** may not have a difference in efficacy when compared to **sham stimulation** for improving global speech and language.	1	Hu et al., 2018
2	**Inhibitory rTMS** may produce greater improvements in global speech and language than **excitatory rTMS**.	1	Hu et al., 2018
1b	**Constraint induced aphasia therapy with rTMS** may not have a difference in efficacy when compared to **with sham stimulation** for improving global speech and language.	1	Heikkinen et al., 2019

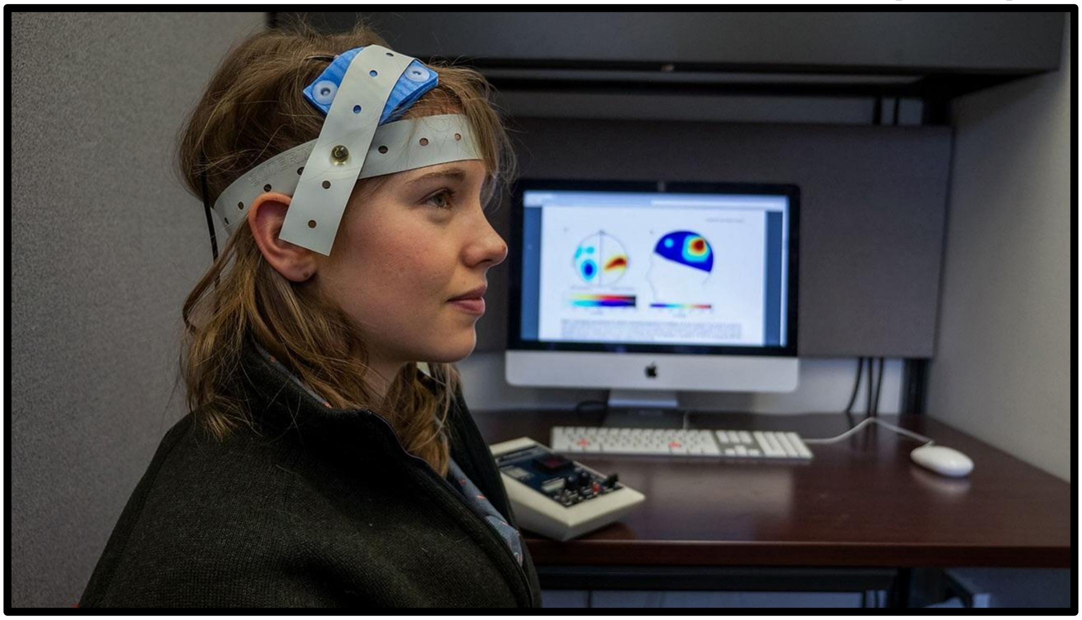
ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Inhibitory rTMS** may not have a difference in efficacy when compared to **sham** for improving activities of daily living.	1	Rubi_Fessen et al., 2015

Key Points

Inhibitory rTMS may be beneficial for improving discourse, naming, verbal fluency, social communication and global speech and language.

There is conflicting evidence about the effect of inhibitory rTMS to improve repetition and auditory comprehension.

Transcutaneous Direct Current Stimulation (tDCS)



Adapted from: https://www.sciencemag.org/news/2016/02/brain-zapping-therapies-might-be-hitting-lefties-wrong-side-head

Another form of non-invasive brain stimulation is transcranial direct-current stimulation (tDCS). This procedure involves the application of mild electrical currents (1-2 mA) conducted through two saline-soaked, surface electrodes applied to the scalp, overlaying the area of interest and the contralateral forehead above the orbit. Anodal stimulation is performed over the affected hemisphere and increases cortical excitability, while cathodal stimulation is performed over the unaffected hemisphere and decreases cortical excitability (Alonso-Alonso et al. 2007). Additionally, tDCS can be applied on both hemispheres concurrently, this is known as dual tDCS. In contrast to transcranial magnetic stimulation, tDCS does not induce action potentials, but instead modulates the resting membrane potential of the neurons (Alonso-Alonso et al. 2007). This technique can also be applied to the spinal cord.

Fourty RCTs were found evaluating tDCS intervention for aphasia rehabilitation. Twenty-seven RCTs investigated the effects of frontal tDCS (Spielmann et al., 2018a; Polanowska et al., 2013a; Polanowska et al., 2013b; Baker et al., 2010; Norise et al., 2017; Vestito et al., 2014; Ihara et al., 2020; Pestalozzi et al., 2018; Cotelli et al., 2014; Woodhead et al., 2018; Zhao et al., 2021; Vines et al., 2011; Wang et al., 2019; Spielmann et al., 2018b; Pisano et al., 2021; Rosso et al., 2014; Kang et al., 2011; Monti et al., 2008; Marangolo et al., 2013a; Marangolo et al., 2013c; Fiori et al., 2013; Marangolo et al., 2014; Marangolo et al., 2013b; Eisenhut et al., 2019; Guillouet et al., 2020; Lee et al., 2013; Zumbansen et al., 2020). Five RCTs investigated the effects of motor tDCS (Branscheidt et al., 2018; Bolognini et al., 2015; Meinzer et al., 2016; Darkow et al., 2017; Wang et al., 2019). Seven RCTs investigated the effects of temporal tDCS (Spielmann et al., 2018; Fridriksson et al., 2018; You et al., 2011; Floel et al., 2011; Marangolo et al., 2013a; Marangolo et al., 2013c; Fiori et al., 2013). Three RCTs investigated the effects of cerebellar tDCS (DeMarco et al., 2021; Marangolo et al., 2018; Sebastian et al., 2020). Two RCTs investigated the effects of Spinal tDCS (Pisano et al., 2021; Marangolo et al., 2018). Three RCTs investigated the effects of perilesional tDCS (Cherney et al., 2021; deAguiar et al., 2015; Richardson et al., 2015).

The methodological details and results of all 40 RCTs are presented in **Table 13.**

Table 13. RCTs Evaluating tDCS Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Frontal Cortex tDCS		
Pisano et al. (2021) RCT (8) Nstart=10 Nend=10 TPS=Chronic	E1: Bihemispheric transpinal direct current stimulation + Language Treatment E2: Bihemispheric direct current stimulation C: Sham + Language Treatment Duration: 20 mins/day, 5 days	E1 vs C • Accuracy (+exp) E1 vs E2 • Accuracy (-)
Zhao et al. (2021) RCT (8) Nstart=18 Nend=18 TPS=Subacute	E: Anodal tDCS + Speech language therapy C: Sham + Speech language therapy Duration: 20 mins of tDCS concurrent with 30 min of language therapy	• The Chinese version of the WAB ○ AQ (+exp) ○ Information Content (+exp) ○ Fluency (+exp) ○ Naming (+exp) ○ Repetition (+exp) ○ Comprehension (-)
Guillouet et al. (2020) RCT Crossover (6) Nstart=14 Nend=10 TPS=Chronic	E1: Bihemispheric tDCS E2: Speech-language therapy C: Sham Duration: Cross over of tDCS and sham with speech-language therapy 20 mins/sessions, 2-5 sessions/wk, 3 wks followed by 1 week of washout	• Flow Measures (-) • Quality Measures (-) • Verbal Working Memory (-) • Categorical fluency (-) • Literal fluency (-)
Ihara et al. (2020) Cross over RCT (7) Nstart=6 Nend=6 TPS=Chronic	E: Anodal tDCS+ language training C: sham+ language training Duration: 20 min/day, 4 days over 3 wks	• Naming accuracy (-)
Zumbansen et al. (2020) RCT(8) Nstart=63 Nend=63 TPS=Subacute	E1: transcranial magnetic stimulation + sham E2: cathodal transcranial direct current stimulation C: sham Duration: 45 min/session, 10 sessions over two weeks	E1vsE2 • Boston naming test (+E1) • Semantic fluency (-) E1 vs C • Boston naming test (+E1) • Semantic fluency (-) E2 vs C • Token test (+con)
Eisenhut et al. (2019) RCT (8) Nstart=12 Nend=12 TPS: Subacute	E: Bihemispheric tDCS + speech therapy C: sham tDCS + speech therapy Duration : speech therapy 30-45 min, 5 days/week, 2 weeks	• Picture naming test ○ Number of nouns(+exp) ○ Naming verbs (-) • Aachen Aphasia test (-) • Spontaneous speech (-)
Wang et al. (2019) RCT (8) NStart=52 NEnd=52 TPS=Chronic	E1: tDCS over the left lip region of M1 E2: tDCS over Broca's area C: Sham tDCS Duration: 2 sessions/d, 5 consecutive days	E1 vs Control • Chinese Phonetic Alphabet Repetition (+exp1) • Monosyllable Word Repetition (+exp1) • Bisyllable Word Repetition (+exp1) E2 vs C • Chinese Phonetic Alphabet Repetition (-) • Monosyllable Word Repetition (-) • Bisyllable Word Repetition (-) E1 vs E2 • Chinese Phonetic Alphabet Repetition (+exp1) • Monosyllable Word Repetition (+exp1) • Bisyllable Word Repetition (+exp1)

Pestalozzi et al. (2018) Cross over RCT (6) Nstart=19 Nend=14 TPS=Chronic	E: Anodal tDCS C: Sham tDCS Duration: 20 min (one session only), washout 1wk	• Phonemic fluency task (+exp) • Repetition (-) • Picture naming (-) • Word Frequency for very high frequency (+exp)
Spielmann et al. (2018a) RCT (9) N_{Start}=58 N_{End}=56 TPS=Subacute	E: Anodal tDCS C: Sham-tDCS Duration: 5d/wk, 2wks of intervention, separated by 2wks	• Boston Naming Test (-) • Naming Performance of Trained Items (-) • Naming Performance on Untrained Items (-) • Aphasia Severity Rating Scale (-) • The Amsterdam Nijmegen Everyday Language Test (-)
Spielmann et al. (2018b) RCT Crossover (6) NStart=14 NEnd=13 TPS=Chronic	E1: Anodal tDCS over 1-IFG E2: Anodal tDCS over 1-STG C: Sham anodal tDCS Duration: tDCS=20 min, 15s fade in and fade out; Sham tDCS=15s fade in, 30s tDCS, 15s fade out, session still lasted 20 min	• Naming Task (Trained) (+exp1) • Naming Task (Untrained) (-)
Woodhead et al. (2018) RCT crossover (7) Nstart=23 Nend=21 TPS=Chronic	E: iReadMore app with anodal tDCS (first 20min) C: iReadMore app with sham tDCS Duration: 40min therapy, 3x/wk, 4wks, 4wk washout	• Word Reading Test ○ Accuracy (-) ○ Response time (-) • Written Semantic Matching (-) • Sentence Reading (-) • Text Reading (-) • Sustained Attention to Response Task (-) • Communication Disability Profile (-)
Norise et al. (2017) Cross over RCT (5) nstart=11 Nend=9 TPS=Chronic	E: tDCS C: sham tDCS Duration: 20 min, 10 days over 2 wks	• Measure of fluency ○ Discourse productivity (-) ○ Sentence length (-) ○ Proportion of well-formed sentences (-) ○ Proportion of pronouns (-)
Cotelli et al. (2014) RCT(7) Nstart=16 Nend=16 TPS=NR	E1: Anodal tDCS + computerized language training E2: Placebo tDCS + computerized language training Duration: 25 min, 5 days/wk, 2 wks 2 wks tDCS	• Naming subtest of Aachener Aphasie Test (+exp) ○ Naming correctness(+exp) ○ Naming abilities for the treated items(+exp) • Functional communication scales (energy subdomain of Stroke and Aphasia Quality of Life Scale (+exp)
Marangolo et al. (2014) Cross-over RCT (8) N_{Start}=7 N_{End}=6 TPS=Chronic	E: Anodal tDCS over Left Broca's Area + Cathodal tDCS (20min) over Right Homologue + Language Therapy C: Sham tDCS + Language Therapy Duration: 5d/wk, 2wks/condition, 2wk washout period	• Picture Description (+exp) • Verb Naming (+exp) • Noun Naming (+exp)
Rosso et al. (2014) Cross-over RCT (7) N_{Start}=25 N_{End}=25 TPS=Chronic Note: All Patients with Broca's Aphasia	E: Cathodal tDCS over Right Broca's Area + Sham Stimulation (15min) C: Sham Stimulation Duration: 1 session/condition, 2hr washout period	• Naming Accuracy (+exp)
Vestito et al. (2014) RCT Crossover (7) Nstart=3 Nend=3 TPS=Chronic	E: Anodal tDCS C: Sham Duration: 20 mins/day, 5 days/wk, 2 wks with 2 days of washout period	• Aachener Aphasie Test (AAT) (+exp) • Boston Naming Test (BNT) (+exp)
Fiori et al. (2013) RCT crossover (8) Nstart=7	E1: Anodal tDCS over Wernicke's Area E2: Anodal tDCS over Broca's Area C: Sham stimulation	E1 vs E2 • Naming ○ Nouns (+exp1)

Nend=7 TPS=Subacute	Duration: 20min, 5x/wk, 3wks/condition, 6d washout period	○ Verbs (+exp2) E1 vs C • Naming ○ Nouns (+exp1) ○ Verbs (-) E1vs E2 • Naming ○ Nouns (-) ○ Verbs (+exp2)
Lee et al. (2013) Cross-over RCT (6) N_{Start}=11 N_{End}=11 TPS=Chronic	E: Single tDCS (30min) (Anodal tDCS over Left Broca's Area) C: Dual tDCS (Anodal tDCS over Left Broca's Area + Cathodal tDCS over Right Homologue) Duration: 1 session/condition, 24hr washout period	• Picture Naming Test ○ Response Time (+exp) ○ Accuracy (-) • Verbal Fluency Test (-)
Marangolo et al. (2013a) Cross-over RCT (9) N_{Start}=12 N_{End}=12 TPS=Chronic	E1: Anodal tDCS (20min) over Left Broca's Area + Language Therapy E2: Anodal tDCS (20min) over Left Wernicke's Area + Language Therapy E3: Sham Stimulation + Language Therapy Duration: 5d/wk, 2wks/condition, 2wk washout period	E1 vs E2 • Content Units (+exp1) • Verbs (+exp1) • Sentences (+exp1) E1 vs E3 • Content Units (+exp1) • Verbs (+exp1) • Sentences (+exp1) E2 vs E3 • Content Units (-) • Verbs (-) • Sentences (-)
Marangolo et al. (2013c) Cross-over RCT (7) N_{Start}=7 N_{End}=6 TPS=Chronic	E1: Anodal tDCS over Left Broca's Area + Language Therapy E2: Anodal tDCS over Left Wernicke's Area + Language Therapy E3: Sham tDCS + Language Therapy Duration: 5d/wk, 3wks/condition, 6d washout period	E1 vs E2 • Naming (+exp1) E1 vs E3 • Naming (+exp1) E2 vs E3 • Naming (-)
Polanowska et al. (2013a) RCT (8) N_{Start}=40 N_{End}=37 TPS=Subacute	E: Anodal tDCS (10min) over Left Broca's Area + Language Therapy (45min) C: Sham tDCS + Language Therapy Duration: 5d/wk, 3wks	• Naming (-) • Comprehension (-) • Repetition (-)
Marangolo et al. (2013b) Cross-over RCT (8) N_{Start}=8 N_{End}=8 TPS=Chronic	E: Anodal tDCS over left Broca's area + Cathodal tDCS over right homologue + Language therapy C: Sham tDCS + Language Therapy Duration: 5d/wk, 2wks/condition, 2wk washout period	• Standardized Language Test ○ Mean Response Accuracy (+exp) • Mean Vocal Reaction Time (+exp)
Polanowska et al. (2013b) RCT (7) N_{Start}=26 N_{End}=24 TPS=Subacute	E: Anodal tDCS (10min) over Left Broca's Area + Language Therapy C: Sham tDCS + Language Therapy Duration: 5d/wk, 3wks	• Naming Accuracy (-) • Response Time (-) •
Kang et al. (2011) RCT Crossover (8) Nstart=10 Nend=10 TPS=Chronic	E: Cathodal tDCS + word-retrieval training C: Sham + word-retrieval training Duration: 20 mins/day, 5 consecutive days, 1 week washout period	• Korean version of the Boston Naming Test ○ Accuracy (-) ○ Reaction time (-)
Vines et al. (2011) RCT Crossover (8) NStart=6 NEnd=6 TPS=Chronic	E: Anodal tDCS to the right posterior inferior frontal gyrus (IFG) C: Sham tDCS to the right posterior IFG Duration: 1 session/d for 3 consecutive days, 1 week washout period	• Verbal Fluency (+exp)

Baker et al. (2010) Crossover RCT (8) N_{Start}=10 N_{End}=10 TPS=Chronic	E: Anodal tDCS (20min) + Picture-word Matching C: Sham tDCS + Picture-word Matching Duration: 5d/condition, 1wk washout period	• Naming Test ○ Trained Items (+exp) • Untrained Items (+exp)
Monti et al. (2008) RCT (8) Nstart=8 Nend=8 TPS=Chronic	E1: Cathodal tDCS E2: Anodal tDCS C: Sham Duration: 10 minutes sham stimulation	• Naming accuracy (+Exp1)
Motor Cortex tDCS		
Wang et al. (2019) RCT (8) NStart=52 NEnd=52 TPS=Chronic	E1: tDCS over the left lip region of M1 E2: tDCS over Broca's area C: Sham tDCS Duration: 2 sessions/d, 5 consecutive days	E1 vs Control • Chinese Phonetic Alphabet Repetition (+exp1) • Monosyllable Word Repetition (+exp1) • Bisyllable Word Repetition (+exp1) E2 vs C • Chinese Phonetic Alphabet Repetition (-) • Monosyllable Word Repetition (-) • Bisyllable Word Repetition (-) E1 vs E2 • Chinese Phonetic Alphabet Repetition (+exp1) • Monosyllable Word Repetition (+exp1) • Bisyllable Word Repetition (+exp1)
Branscheidt et al. (2018) cross over RCT (7) Nstart=16 Nend=16 TPS=Chronic	E: Anodal tDCS C: Sham tDCS Duration: 20min, single session/condition, 7d washout period	• Lexical Decision Task ○ Reaction Time (-)
Darkow et al. (2017) RCT Crossover (4) Nstart=16 Nend=16 TPS=Chronic	E: Anodal tDCS C: Sham tDCS Duration: 1 session, 20min, 1wk washout	• Naming Accuracy (-) • Naming Speed (-)
Meinzer et al. (2016) RCT (7) N_{Start}=26 N_{End}=26 TPS=Chronic	E: Anodal tDCS (20min) + Naming Therapy C: Sham + Naming Therapy Duration: 1.5hrs, 2x/d, 4d/wk, 2wks	• Trained naming (+exp) • Untrained naming (+exp) • Aachen Aphasia Test (+exp) • Communicative Effectiveness Index (+exp)
Bolognini et al. (2015) RCT Crossover (8) Nstart=12 Nend=12 TPS=chronic	E1: Anodal tDCS on left posterior parietal cortex E2: Anodal tDCS on right motor cortex C: Sham Duration: 6 sessions in total, 10 min under each condition with 24 hrs of washout	• Ideomotor Apraxia Test (-) • Planning time (-) • Execution time (-) • Phonemic fluency (-)
Temporal Cortex tDCS		
Fridriksson et al. (2018) RCT (9) Nstart=74 Nend=69 TPS=Chronic	E: Anodal tDCS with computerized aphasia training C: Sham Duration: 20min tDCS during first 45min of therapy, 5x/wk, 3wks	• Philadelphia Naming Test (-)
Spielmann et al. (2018b) RCT Crossover (6) NStart=14 NEnd=13 TPS=Chronic	E1: Anodal tDCS over 1-IFG E2: Anodal tDCS over 1-STG C: Sham anodal tDCS Duration: tDCS=20 min, 15s fade in and fade out; Sham tDCS=15s fade in, 30s	• Naming Task (Trained) (+exp1) • Naming Task (Untrained) (-)

	tDCS, 15s fade out, session still lasted 20 min	
Fiori et al. (2013) RCT crossover (8) Nstart=7 Nend=7 TPS=Subacute	E1: Anodal tDCS over Wernicke's Area E2: Anodal tDCS over Broca's Area C: Sham stimulation Duration: 20min, 5x/wk, 3wks/condition, 6d washout period	E1 vs E2 • Naming ○ Nouns (+exp1) ○ Verbs (+exp2) E1 vs C • Naming ○ Nouns (+exp1) ○ Verbs (-) E1vs E2 • Naming ○ Nouns (-) ○ Verbs (+exp2)
Marangolo et al. (2013a) Cross-over RCT (9) N_{Start}=12 N_{End}=12 TPS=Chronic	E1: Anodal tDCS (20min) over Left Broca's Area + Language Therapy E2: Anodal tDCS (20min) over Left Wernicke's Area + Language Therapy E3: Sham Stimulation + Language Therapy Duration: 5d/wk, 2wks/condition, 2wk washout period	E1 vs E2 • Content Units (+exp1) • Verbs (+exp1) • Sentences (+exp1) E1 vs E3 • Content Units (+exp1) • Verbs (+exp1) • Sentences (+exp1) E2 vs E3 • Content Units (-) • Verbs (-) • Sentences (-)
Marangolo et al. (2013c) Cross-over RCT (7) N_{Start}=7 N_{End}=6 TPS=Chronic	E1: Anodal tDCS over Left Broca's Area + Language Therapy E2: Anodal tDCS over Left Wernicke's Area + Language Therapy E3: Sham tDCS + Language Therapy Duration: 5d/wk, 3wks/condition, 6d washout period	E1 vs E2 • Naming (+exp1) E1 vs E3 • Naming (+exp1) E2 vs E3 • Naming (-)
Floel et al. (2011) RCT Crossover (6) Nstart=12 Nend=12 TPS=Chronic	E1: Anodal transcranial direct current stimulation + computer-assisted naming therapy E2: Cathodal transcranial direct current stimulation + computer-assisted naming therapy C: Sham + computer-assisted naming therapy Duration: 20 mins of transcranial direct current stimulation + 2 hours of computer-assisted naming therapy/day, for 3 days	E1 vs C • Correct naming response (exp+) E2 vs C • Correct naming response (exp+) E1 vs E2 • Correct naming response (-)
You et al. (2011) RCT (6) Nstart=33 Nend=21 TPS=Chronic	E1: Anodal tDCS E2: Cathodal tDCS C: Sham Duration: 30 mins/session, 5 sessions/wk, 2 wks	• Korean-Western Aphasia Battery ○ Spontaneous speech (-) ○ Auditory verbal comprehension (+exp2) ○ Repetition (-) ○ Naming (-) ○ Aphasia quotient (-)
	Cerebellar tDCS	
DeMarco et al. (2021) RCT (6) Nstart=24 Nend=24 TPS=Chronic	E: anodal tDCS + Speech Therapy C: Sham + Speech Therapy Duration: 60 mins of speech therapy with first 20 mins of tDCS, 1 session/day, 5 consecutive days	• Western Aphasia Battery-Revised (-) • Fluency tasks (-)
Sebastian et al. (2020) cross over RCT (8) Nstart=24	E1: cathodal cerebellar stimulation + standard treatment E2: computerized	• Naming (+exp)

Nend=21 TPS=chronic	aphasia therapy + standard treatment Duration: 20 min, 15 sessions 4 weeks (3-5 sessions/wk), 2 months washout period	• Philadelphia Naming Test-Correct scores (+exp)
Marangolo et al. (2018) RCT Crossover (8) Nstart=12 Nend=12 TPS=Chronic	E: Cathodal tDCS C: Sham + Verb Duration: 20 mins/day, 5 consecutive days/wk, 4 wks	• Verbal Generation (+exp) • Verbal Naming (-)
Spinal tDCS		
Pisano et al. (2021) RCT (8) Nstart=10 Nend=10 TPS=Chronic	E1: Bihemispheric transpinal direct current stimulation + Language Treatment E2: Bihemispheric direct current stimulation C: Sham + Language Treatment Duration: 20 mins/day, 5 days	E1 vs C • Accuracy (+exp) E1 vs E2 • Accuracy (-)
Marangolo et al. (2018) Crossover RCT (7) N_{Start}=14 N_{End}=14 TPS=Chronic	E1: Anodal Transcutaneous Spinal Direct Current Stimulation (tsDCS) (20min) + Language therapy E2: Cathodal tsDCS (20min) + Language therapy C: Sham tsDCS + Language therapy Duration: 5d/wk, 3wks/condition, 6d washout period	E1 vs E2 • Word Naming Task Accuracy ○ Verbs (+exp1) ○ Nouns (-) • Mean Vocal Reaction Time ○ Verbs (exp1) ○ Nouns (-) E1 vs C • Word Naming Task Accuracy ○ Verbs (+exp1) ○ Nouns (-) • Mean Vocal Reaction Time ○ Verbs (exp1) ○ Nouns (-) E2 vs C • Word Naming Task ○ Verbs (-) ○ Nouns (-) • Mean Vocal Reaction Time ○ Verbs (-) ○ Nouns (-)
Perilesional tDCS		
Cherney et al. (2021) RCT (9) Nstart=12 Nend=12 TPS=Chronic	E1: Anodal tDCS + speech language therapy E2: Cathodal tDCS + speech language therapy C: Sham tDCS + speech language therapy Duration: 13min tDCS during 90min therapy, 5d/wk, 6wks	E1 vs C • Western Aphasia Battery ○ Aphasia Quotient (-) • Naming and Oral Reading for Language in Aphasia ○ Accuracy (-) ○ Speed (-) E2 vs C • Western Aphasia Battery ○ Aphasia Quotient (-) • Naming and Oral Reading for Language in Aphasia ○ Accuracy (-) ○ Speed (-) E1 vs E2 • Western Aphasia Battery ○ Aphasia Quotient (-) • Naming and Oral Reading for Language in Aphasia ○ Accuracy (-) • Speed (-)

deAguiar et al. (2015) Cross-over RCT (8) Nstart=9 Nend=9 TPS=Not reported	E: Dual tDCS + Speech-Language Therapy C: sham tDCS + Speech-Language Therapy Duration: 20 min tDCS, for controls stimulator was turned off after 30 sec Daily 1-hour/day, 10 days treatment sessions/treatment phase, two treatment phases In assessment phase three testing sessions were spread over a period of 2 weeks	• Treated verbs (+exp) • Untreated verbs (+exp)
Richardson et al. (2015) Crossover RCT (6) N_{Start}=8 N_{End}=8 TPS=Chronic	E: High Definition Anodal tDCS (20min) C: Conventional Anodal tDCS (20min) Duration: 5d/wk, 2wks/condition, 1wk washout period	• Naming Accuracy (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about tDCS Therapy

APRAXIA			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Motor anodal tDCS** may not have a difference in efficacy when compared to **sham** for improving apraxia outcomes.	1	Bolognini et al., 2015

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Frontal anodal tDCS** may produce greater improvements in discourse than **sham tDCS**.	1	Marangolo et al., 2013a
1b	**Temporal anodal tDCS** may not have a difference in efficacy when compared to **sham** for improving discourse.	1	Marangolo et al., 2013a
1b	**Frontal anodal tDCS** may produce greater improvements in discourse than **temporal anodal tDCS**.	1	Marangolo et al., 2013a

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Frontal Anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving naming.	10	Ihara et al., 2020; Pestalozzi et al., 2018; Spielmann et al., 2018a; Spielmann et al., 2018b; Cotelli et al., 2014; Vestito et al., 2014; Marangolo et al., 2013c; Polanowska et al., 2013a; Polanowska et al., 2013b; Baker et al., 2010
1a	There is conflicting evidence about the effect of **frontal cathodal tDCS** to improve naming when compared to **sham stimulation.**	3	Rosso et al., 2014; Kang et al., 2011; Monti et al., 2008

1a	**Frontal anodal tDCS** may produce greater improvements in naming than **temporal anodal tDCS.**	2	Fiori et al., 2013; Marangolo et al., 2013c
1a	**Frontal dual tDCS** may produce greater improvements in naming than **sham stimulation**.	2	Eisenhut et al., 2019; Marangolo et al., 2014
1b	**Perilesional tDCS with high definition** may produce greater improvements in naming than **conventional stimulation.**	1	Richardson et al., 2015
1b	**Perilesional dual tDCS** may produce greater improvements in naming than **sham stimulation.**	1	deAguiar et al., 2015
1b	**Perilesional anodal tDCS** may not have a difference in efficacy when compared to **sham and perilesional cathodal tDCS** for improving naming.	1	Cherney et al., 2021
1b	**Cathodal spinal tDCS** may not have a difference in efficacy when compared to **sham** for improving naming.	1	Marangolo et al., 2018
1b	There is conflicting evidence about the effect of **anodal spinal tDCS** to improve naming when compared to **sham stimulation.**	1	Marangolo et al., 2018
1b	There is conflicting evidence about the effect of **anodal spinal tDCS** to improve naming when compared to **cathodal spinal tDCS.**	1	Marangolo et al., 2018
1b	**Spinal dual tDCS** may not have a difference in efficacy when compared to **sham** for improving naming.	1	Pisano et al., 2021
1b	**Spinal dual tDCS** may not have a difference in efficacy when compared to **dual tDCS** for improving naming.	1	Pisano et al., 2021
1b	**rTMS** may produce greater improvements in naming than **frontal cathodal tDCS**.	1	Zumbansen et al., 2020
1b	**Temporal anodal tDCS** may not have a difference in efficacy when compared to **temporal cathodal tDCS** for improving naming.	1	Floel et al., 2011
1a	There is conflicting evidence about the effect of **temporal anodal tDCS** to improve naming when compared to **sham stimulation.**	3	Fiori et al., 2013; Floel et al., 2011; Marangolo et al., 2013c
1b	There is conflicting evidence about the effect of **frontal anodal tDCS** to improve naming when compared to **frontal dual tDCS.**	1	Lee et al., 2013
1a	There is conflicting evidence about the effect of **cerebellar cathodal tDCS** to improve naming when compared to **sham stimulation.**	2	Sebastian et al., 2020; Marangolo et al., 2018
1a	**Motor anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving naming.	3	Bolognini et al., 2015; Meinzer et al., 2016; Darkow et al., 2017

VERBAL FLUENCY

LoE	Conclusion Statement	RCTs	References

1b	**Motor anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving verbal fluency.	1	Bolognini et al., 2015
1b	**Cerebellar cathodal tDCS** may produce greater improvements in verbal fluency than **sham stimulation**.	1	Marangolo et al., 2018
1b	**Cathodal spinal tDCS** may not have a difference in efficacy when compared to **sham** for improving verbal fluency.	1	Marangolo et al., 2018
1b	There is conflicting evidence about the effect of **anodal spinal tDCS** to improve verbal fluency when compared to **sham.**	1	Marangolo et al., 2018
1b	There is conflicting evidence about the effect of **anodal spinal tDCS** to improve verbal fluency when compared to **cathodal spinal tDCS.**	1	Marangolo et al., 2018
1b	There is conflicting evidence about the effect of **frontal anodal tDCS** to improve verbal fluency when compared to **sham stimulation.**	4	Pestalozzi et al., 2018; Norise et al., 2017; Polanowska et al., 2013b; Vines et al., 2011
1a	**Frontal dual tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving verbal fluency.	3	Guillouet et al., 2020; Eisenhut et al., 2019; Marangolo et al., 2013b

SOCIAL COMMUNICATION

LoE	Conclusion Statement	RCTs	References
1a	**Frontal anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving social communication.	3	Spielmann et al., 2018a; Woodhead et al., 2018; Cotelli et al., 2014
1b	**Motor anodal tDCS** may produce greater improvements in social communication than **sham stimulation**.	1	Meizner et al., 2016

REPETITION

LoE	Conclusion Statement	RCTs	References
1a	**Frontal anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving repetition.	3	Wang et al., 2019; Pestalozzi et al., 2018; Polanowska et al., 2013a
1a	There is conflicting evidence about the effect of **motor anodal tDCS** to improve global speech and language when compared to **sham stimulation.**	2	Wang et al., 2019; Branscheidt et al., 2018
1b	**Frontal anodal tDCS** may produce greater improvements in repetition than **motor anodal tDCS**.	1	Wang et al., 2019

GENERAL COMPREHENSION

LoE	Conclusion Statement	RCTs	References
1b	**Frontal anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving general comprehension.	1	Polanowska et al., 2013a

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Sham stimulation** may produce greater improvements in auditory comprehension than **frontal cathodal tDCS**.	1	Zumbansen et al., 2020

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **frontal anodal tDCS** to improve global speech and language when compared to **sham stimulation.**	3	Zhao et al., 2021; Spielmann et al., 2018; Vestito et al., 2014
1b	**Motor anodal tDCS** may produce greater improvements in global speech and language than **sham stimulation**.	1	Meizner et al., 2016
1b	**Frontal dual tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving global speech and language.	1	Eisenhut et al., 2019
1b	**Temporal anodal tDCS** may not have a difference in efficacy when compared to **temporal cathodal tDCS** for improving global speech and language.	1	You et al., 2011
1b	**Cerebellar anodal tDCS** may not have a difference in efficacy when compared to **sham** for improving global speech and language.	1	DeMarco et al., 2021
1b	**Perilesional anodal tDCS** may not have a difference in efficacy when compared to **sham and perilesional cathodal tDCS** for improving global speech and language.	1	Cherney et al., 2021

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Frontal anodal tDCS** may not have a difference in efficacy when compared to **sham stimulation** for improving reading comprehension.	1	Woodhead et al., 2018

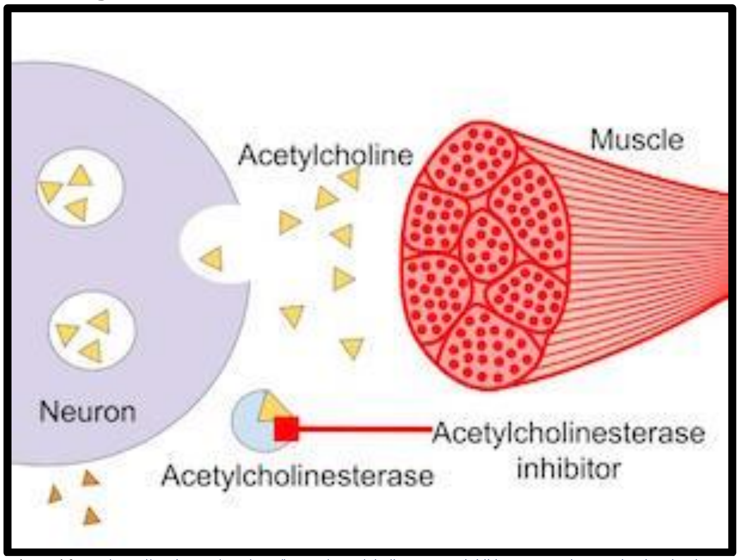
Key Points

Frontal anodal tDCS may not have a difference in efficacy when compared to sham stimulation for improving naming, social communication, and repetition post stroke

There is conflicting evidence about the effect of frontal anodal tDCS to improve verbal fluency when compared to sham stimulation

Pharmacological Interventions

Acetylcholinesterase Inhibitors



Adapted from: https://study.com/academy/lesson/acetylcholinesterase-inhibitors-examples-mechanism.html

Acetylcholinesterase inhibitors, (rivastigmine, donepezil and galantamine) which have been used in the treatment of Alzheimer's disease, act by preventing the breakdown of acetylcholine, therefore causing levels to increase (Narasimhalu et al., 2010). These drugs have been used in association with treatments for cognitive disorders and may help improve cognitive functioning (Narasimhalu et al., 2010; Whyte et al., 2008).

Four RCTs were found evaluating acetylcholinesterase inhibitors for aphasia rehabilitation. Two RCTs compared donepezil to a placebo (Woodhead et al., 2017, Berthier et al., 2016). One RCT compared galantamine to no drug therapy (Hong et al., 2012). One RCT compared scolpolamine to midazolam (Lazar et al., 2010)

The methodological details and results of all four RCTs are presented in **Table 14.**

Table 14. RCT Evaluating Donepezil Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Donepezil vs Placebo		
Woodhead et al. (2017) RCT Crossover (8) Nstart=27 Nend=20 TPS=Chronic	E1: Donepezil only E2: Donepezil and Earobics E3: Placebo only E4: Placebo and Earobics Duration: 5mg daily dose of donepezil and two 40min daily sessions of Earobics, each block runs for 5 weeks with a 5-week washout period after 2 blocks	E1 vs E3 • Speech comprehension (+exp3) E4 vs E3 • Speech comprehension (+exp4)

Berthier et al. (2006)
RCT (7)
N$_{Start}$=26
N$_{End}$=26
TPS=Chronic
	E: Donepezil Treatment
	C: Placebo Treatment
	Duration: 4wks titration starting at 5mg, 12 wks at 10mg
		• Western Aphasia Battery (+exp)
		• Psycholinguistic Assessments of Language Processing in Aphasia
		  • Picture Naming (+exp)
		  ○ Non-word Repetition (-)
		  ○ Word Repetition (-)
		  ○ Spoken Word-picture Matching (-)
		  ○ Spoken Sentence-picture Matching (-)
		  ○ Auditory Lexical Decision (-)
		  ○ Auditory Phonemic Discrimination-word Pairs (-)
		• Communicative Activity Log (-)

Galantamine vs Placebo		
Hong et. al. (2012) RCT (7) N$_{Start}$=45 N$_{End}$=43 TPS=Chronic	E: Galantamine Treatment C: No Treatment Duration: 8mg/d for 4wk titration, 16mg/d, 12wks	• Western Aphasia Battery (+exp)
Benzodiazapine vs Anticholinergic		
Lazar et al. (2010) RCT Crossover (7) 90 day washout period NStart=12 NEnd=12 TPS=Chronic	E1: Midazolam given as an IV bolus, 2mg, titrated in 0.5 or 1mg aliquots until subject was able to count backward from 20 to 1 with no errors, no more than 5mg. E2: Scopolamine given as IV, .2mg bolus and then in 0.1 or 0.2 mg doses until counting was impaired and there was a 10cm change in vision near point, no more than 5mg. Duration: 2 hours after sedation set in	• Language Change (+exp2)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Acetylcholinesterase Inhibitors

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Donepezil** may produce greater improvements in naming than **a placebo.**	1	Bertheir et al., 2006

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Donepezil** may not have a difference in efficacy when compared to **a placebo** for improving social communication.	1	Berthier et al., 2006

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Donepezil** may not have a difference in efficacy when compared to **a placebo** for improving repetition.	1	Berthier et al., 2006

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **Donepezil** when compared to **a placebo** for improving general comprehension.	2	Woodhead et al. 2017, Berthier et al., 2006

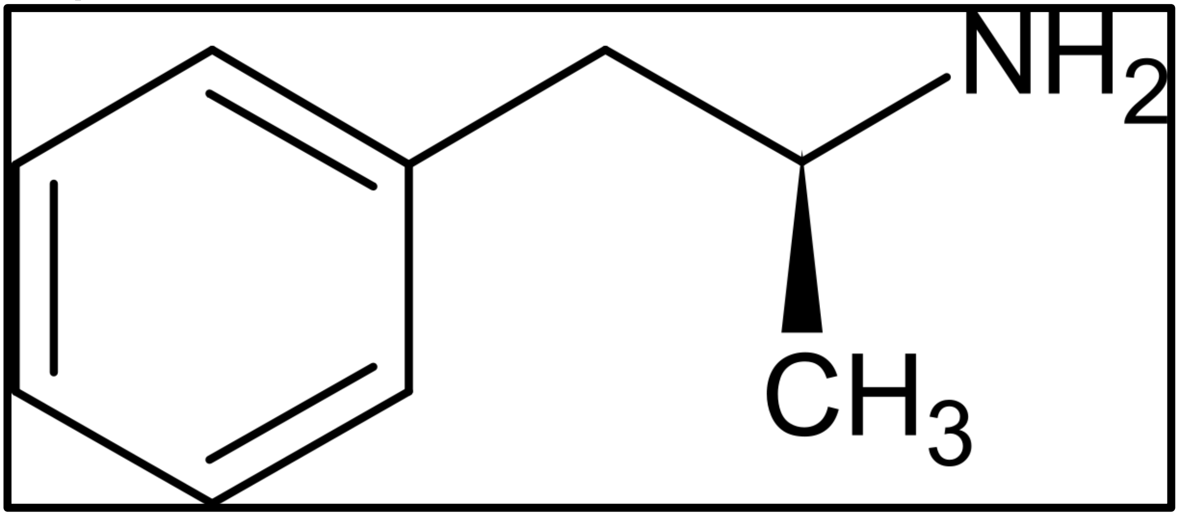
AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Donepezil** may not have a difference in efficacy when compared to **a placebo** for improving auditory comprehension.	1	Berthier et al., 2006

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Galantamine** may produce greater improvements in global speech and language than **a placebo.**	1	Hong et al., 2012
1b	**Donepezil** may produce greater improvements in global speech and language than **a placebo.**	1	Bertheir et al., 2006
1b	**Scolpolamine** may produce greater improvements in global speech and language than a **placebo.**	1	Lazar et al., 2010

Key Points

Acetylcholinesterase inhibitors may be beneficial for improving naming, but not social communication, repetition, general and auditory comprehension, and global speech and language.

Amphetamines



Adapted from: https://en.wikipedia.org/wiki/Dextroamphetamine

Amphetamines are central nervous system stimulants. Central nervous system stimulants increase the synaptic concentration and transmission of dopamine, serotonin, and noradrenaline throughout the brain, and neurobehavioral gains ascribed to central nervous system stimulants include enhanced arousal, mental processing speed, and/or motor processing speed (Herrold et al. 2014). Common stimulants used in rehabilitation include amphetamines and methylphenidates. Methylphenidate has been shown to enhance motor recovery after partial cortex ablation in rodents, and to modulate poststroke cerebral reorganization, improving motor function in stroke patients (Wang et al. 2014b). Stimulants such as amphetamines have been reported to enhance plasticity through axonal sprouting (Papadopoulos et al. 2009).

Two RCTs were found evaluating amphetamines for aphasia rehabilitation. Both RCTs compared dextroamphetamine to a placebo (Keser et al., 2018; Walker-Batson et al., 2001).

The methodological details and results of all two RCTs are presented in **Table 15**

Table 15. RCTs Evaluating Amphetamines Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	**Interventions Duration: Session length, frequency per week for total number of weeks**	**Outcome Measures Result (direction of effect)**
Keser et al. (2018) RCT-Crossover (7) N_{Start}=10 N_{End}=10 TPS=Chronic	E: Dextroamphetamine (10mg) + Anodal tDCS (20min) + Speech Language Therapy (1hr) C: Placebo + Anodal tDCS + Speech Language Therapy Duration: 2 sessions	• Western Aphasia Battery-Revised - Aphasia and Language Quotient (+exp)
Walker-Batson et al. (2001) RCT (7) N_{Start}=25 N_{End}=21 TPS=Acute/Subacute	E: Dextroamphetamine (10mg) + Speech Language Therapy (1hr) C: Placebo + Speech Language Therapy Duration: 10 sessions	• Porch Index of Communicative Ability (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Amphetamines

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Amphetamines** may produce greater improvements in global speech and language than **a placebo.**	2	Keser et al., 2018; Walker-Batson et al., 2001

Key Points

Amphetamines may be beneficial for improving global speech and language post-stroke

Beta Blockers

Adapted from:https://www.definitivehc.com/blog/prescription-patterns-of-beta-blockers

Beta blockers are a class of competitive adrenergic receptor antagonist medication that is used to manage abnormal heart rhythms, prevent myocardial infarction, and lower blood pressure. Beta blockers work through both the heart and the vasculature system. In stroke research, beta blockers have been investigated for secondary prevention in addition to neuroprotective effects (Laowattana and Oppenheimer, 2007).

One single RCT was found evaluating beta blockers for aphasia rehabilitation. The single RCT compared propranolol to a placebo (Beversdorf et al., 2007).

The methodological details and results of one single RCT are presented in **Table 16.**

Table 16. RCTs Evaluating Beta Blockers for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Propranolol		
Beversdorf et al. (2007) RCT Crossover (7) Nstart=4 Nend=4 TPS=Chronic	E: Oral administration of propranolol C: Oral administration of placebo Duration: 40 mg/session, 3 sessions/condition, alternating.	• Boston Naming Test (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

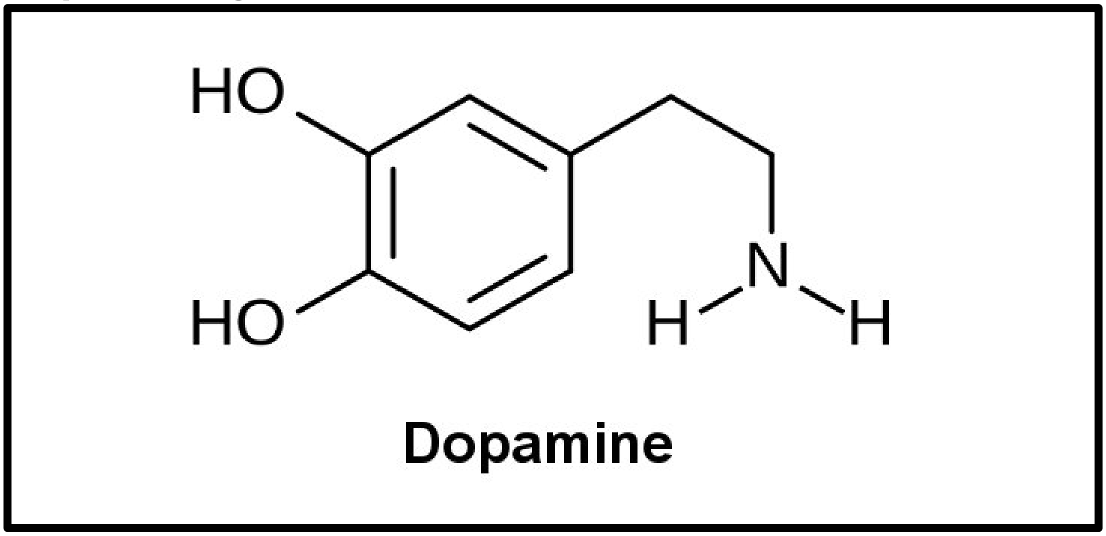
Conclusions about Beta Blockers

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Propranolol** may not have a difference in efficacy when compared to **a placebo** for improving naming.	1	Beversdorf et al., 2007

Key Points

Beta blockers may not be beneficial for improving naming post-stroke

Dopaminergic Medications



Adapted from: http://www.unique-design.net/library/nature/brain/neurotransmitter.html

Levodopa is dopamine precursor molecule and has been the hallmark pharmaceutical for the treatment of Parkinson's disease. However, its ability to affect motor movements in Parkinson's disease is limited by its narrow therapeutic window, short half-life, and poor bioavailability (Tambassco et al. 2018). Bromocriptine is another dopamine agonist, mainly acting on D_2 receptors (Whyte et al., 2008). These drugs may be able to improve the motor production side of speech.

Six RCTs were found evaluating dopaminergic drug compounds for aphasia rehabilitation. Three RCTs examined levodopa compared to a placebo (Breitenstein et al., 2015; Leeman et al., 2011; Seniow et al., 2009). Three RCTs compared bromocriptine to a placebo (Ashtray et al., 2006; Gupta et al., 1995; Sabe et al., 1995).

The methodological details and results of all six RCTs are presented in **Table 17.**

Table 17. RCTs Evaluating Dopaminergic Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Levadopa vs Placebo		
Breitenstein et al. (2015) Cross-over RCT (5) N$_{Start}$=10 N$_{End}$=10 TPS=Chronic	E: Levodopa (100mg)/carbidopa (25mg) + Intensive Language Treatment (4hrs/d) C: Placebo Treatment + Intensive Language Treatment Duration: 2wks/condition 4wk washout period	• Object Naming (-) • Amsterdam Nijmegen Everyday Language Test (-) • Communicative Activity Log (-)
Leeman et al. (2011) Cross-over RCT (7) N$_{Start}$=17 N$_{End}$=12 TPS=Acute, Subacute	E: Levodopa (100mg) + Computer-assisted Therapy C: Placebo + Computer-assisted Therapy Duration: 2wks/condition, 1wk washout period	• Naming Accuracy (-)

Seniow et al. (2009)
RCT (7)
N$_{Start}$=40
N$_{End}$=39
TPS=Subacute
	E: Levodopa (100mg) + Speech-language Therapy (45min)
	C: Placebo + Speech-language Therapy
	Duration: 5x/wk, 3wks
		• Boston Diagnostic Aphasia Examination
		  • Animal naming (+exp)
		  • Repetition (+exp)
		  • Word Discrimination (-)
		  • Commands (-)
		  • Complex Ideational Material (-);
		  • Visual Confrontation Naming (-)
		  • Body Part Naming (-)
		  • Body Part Identification (-)

Bromocriptine vs Placebo		
Ashtary et al. (2006) RCT (7) N$_{Start}$=38 N$_{End}$=38 TPS=Subacute	E: Bromocriptine Treatment (2.5mg/d to 10mg/d) C: Placebo Duration: 16wks	• Persian Language Test (-)
Gupta et al. (1995) Cross-over RCT (7) N$_{Start}$=20 N$_{End}$=NA TPS=Chronic	E: Bromocriptine (15mg/d) C: Placebo Duration: 8wks/condition, 6wk washout period	• Western Aphasia Battery (-) • Boston Naming Test (-) • Mean Phrase Length (-) • Information Index (-)
Sabe et al. (1995) Cross-over RCT (6) N$_{Start}$=7 N$_{End}$=7 TPS=Chronic	E: Bromocriptine (up to 60mg/d) C: Placebo Duration: 6wks/condition, 3wk washout period	• Speech Component Analysis (-) • Controlled Oral Work Association Test (-) • Boston Naming Test (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Dopaminergic Medications

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Bromocriptine** may not have a difference in efficacy when compared to **a placebo** for improving discourse.	2	Gupta et al., 1995; Sabe et al., 1995

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Bromocriptine** may not have a difference in efficacy when compared to **a placebo** for improving naming.	2	Gupta et al., 1995; Sabe et al., 1995
1a	**Levadopa** may not have a difference in efficacy when compared to **a placebo** for improving naming.	3	Breitenstein et al., 2015; Leeman et al., 2011; Seniow et al., 2009

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Levadopa** may not have a difference in efficacy when compared to **a placebo** for improving social communication.	1	Breitenstein et al., 2015

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Levadopa** may produce greater improvements in repetition than **a placebo.**	1	Seniow et al., 2009

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Levadopa** may not have a difference in efficacy when compared to **a placebo** for improving general comprehension.	1	Seniow et al., 2009

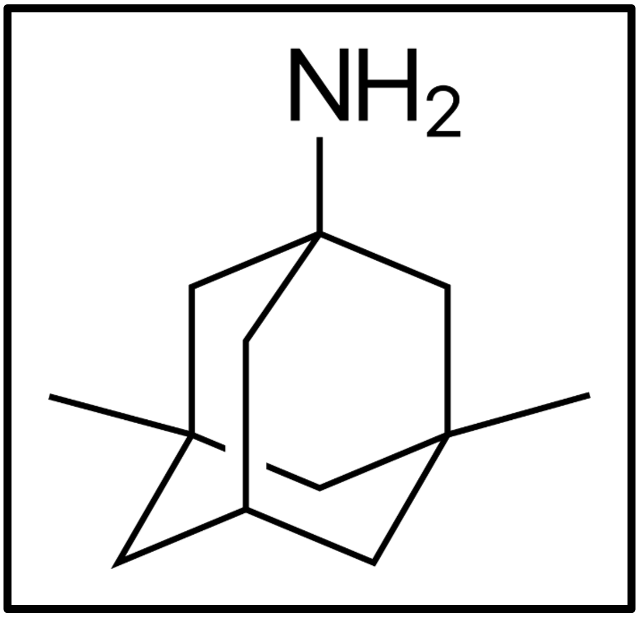
AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Levadopa** may not have a difference in efficacy when compared to **a placebo** for improving auditory comprehension.	1	Seniow et al., 2009

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Bromocriptine** may not have a difference in efficacy when compared to **a placebo** for improving global speech and language.	2	Ashtray et al., 2006; Gupta et al., 1995

Key Points

Dopaminergic medication may be beneficial for improving aphasia related outcomes post-stroke.

Memantine



Adapted from: https://en.wikipedia.org/wiki/Memantine

Memantine is an antagonist of the N-methyl-D-aspartate (NMDA) receptor. Therefore, it modulates brain activity by blocking glutamate signalling. Its use has been evaluated among patients with Alzheimer's Dementia and those with vascular dementia. In a review of memantine treatment for dementia, the drug was able to improve language functions, as well as other cognitive functions, activities of daily living and mood issues (McShane, Sastre & Minakaran, 2006).

Two RCTs were found evaluating memantine for aphasia rehabilitation. Both RCTs compared memantine to a placebo (Barbancho et al., 2015;. Berthier et al., 2009).

The methodological details and results of all two RCTs are presented in **Table 18.**

Table 18. RCT evaluating Memantine Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Memantine vs Placebo		
Barbancho et al. (2015) RCT (8) N_{Start}=28 N_{End}=27 TPS=Chronic	E: Memantine Treatment (10mg/d) + Constraint Induced Aphasia Treatment C: Placebo Treatment + Constraint Induced Aphasia Treatment Duration: 16wks on drug, then 2wks language training on drug (3hr/d, 5d/wk):	• Western Aphasia Battery (+exp)

Berthier et al. (2009)
RCT (8)
N_{Start}=28
N_{End}=27
TPS=Chronic
	E: Memantine Treatment (20mg/d) + Constraint Induced Aphasia Treatment
	C: Placebo Treatment+ Constraint Induced Aphasia Treatment
	Duration: 16wks on drug, then 2wks language training on drug
		• Western Aphasia Battery
		  • Aphasia Quotient (+exp)
		  • Naming (+exp)
		  • Spontaneous Speech (+exp)
		  • Auditory Comprehension (+exp)
		  • Repetition (-)
		• Communicative Activity Log (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group

+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Memantine

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Memantine** may produce greater improvements in discourse than **a placebo.**	1	Berthier et al., 2009

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Memantine** may produce greater improvements in naming than **a placebo.**	1	Berthier et al., 2009

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Memantine** may produce greater improvements in social communication than **a placebo.**	1	Berthier et al., 2009

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Memantine** may not have a difference in efficacy when compared to **a placebo** for improving repetition.	1	Berthier et al., 2009

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Memantine** may produce greater improvements in auditory comprehension than **a placebo.**	1	Berthier et al., 2009

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Memantine** may produce greater improvements in global speech and language than **a placebo.**	1	Barbancho et al., 2015; Berthier et al., 2009

Key Points

Memantine may be beneficial for improving discourse, naming, social communication auditory comprehension and global speech and language, but not repetition.

Monoamine Oxidase Inhibitors

	MAO-A	MAO-B
Substrates	Serotonin Norepinephrine Dopamine Tyramine	Dopamine Phenylethylamine
Tissue localization	Brain, gut, liver, placenta, skin	Brain, platelets, lymphocytes

Adapted from: https://www.mdedge.com/node/153015/path_term/48404

Monoamine oxidase (MAO) is the enzyme responsible for breaking down dopamine, noradrenaline and serotonin. MAO-A and MAO-B. MAO-A preferentially deaminates serotonin, epinephrine, norepinephrine, dopamine, and tyramine, while MAO-B primarily deaminates dopamine. MAO inhibitors have been proposed as a treatment for atypical depression, when more traditional classes of antidepressants have failed. By administering an inhibitor, greater concentrations of these neurotransmitters persist in the synapse and contribute to a greater signal strength. Although originally used as antidepressants, by modulating these neurotransmitters, MAO inhibitors can improve cognition, and potentially ameliorate deficits, including aphasia.

Two RCTs were found evaluating monoamine oxidase inhibitors for aphasia rehabilitation. One RCT examined moclobemide compared to a placebo (Laska et al., 2005; Tanaka et al., 1997). One RCT compared bifemelane to no drug therapy.

The methodological details and results of all two RCTs are presented in **Table 19.**

Table 19. RCT evaluating Moclobemide Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Moclobemide vs Placebo		
Laska et al. (2005) RCT (9) N_{Start}=90 N_{End}=77 TPS=Acute	E: Moclobemide Treatment (600mg/d) C: Placebo Treatment Duration: 6mo	• Reinvang's Aphasia Test (-) • Amsterdam-Nijmegen Everyday Language Test (-)
Bifemelane vs Placebo		
Tanaka et al. (1997) RCT (6) N_{Start}=4 N_{End}=4 TPS=Subacute	E: Bifemelane (300mg/d) +Conventional Aphasia Therapy (3x/wk) C: No Treatment Duration: 1mo	• Comprehension (+exp) • Naming (Animal category) (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Monoamine Oxidase Inhibitor Medications

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Bifemelane** may produce greater improvements in naming than **a placebo.**	1	Tanaka et al., 1997

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Moclobemide** may not have a difference in efficacy when compared to **a placebo** for improving social communication.	1	Laska et al., 2005

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Bifemelane** may produce greater improvements in general comprehension than **a placebo.**	1	Tanaka et al., 1997

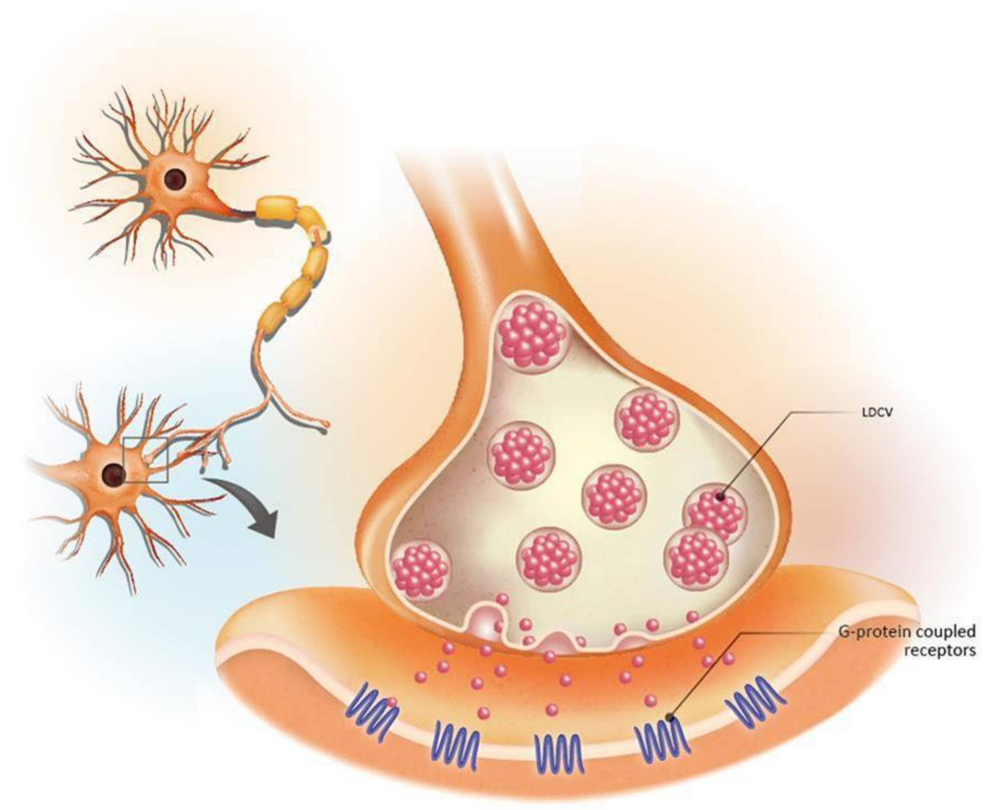
GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Moclobemide** may not have a difference in efficacy when compared to **a placebo** for improving global speech and language.	1	Laska et al., 2005

Key Points

Moclobemide may not be beneficial for improving social communication or global speech and language.

Bifemelane may be beneficial for improving naming and general comprehension.

Neuropeptides



Adapted from:https://www.genetex.com/Research/Overview/neuroscience/Neuropeptides

Neuropeptides are small amino-acid chains synthesized by neurons. Neuropeptides can act as both neurotransmitters and trophic factors and are often co-released with other bio-signalling molecules from the synaptic terminal. They have a broad range of action, working through autocrine, paracrine, and endocrine fashions. Neuropeptides often stimulate G-protein coupled receptors. Neuropeptides are often upregulated after a brain injury or stressor. (Hökfelt et al. 2018). There is interest in using neuropeptides for their neuroprotective and neuroplastic effects in post stroke patients (Karamyan, 2021). Common neuropeptides include cerebrolysin, cortexin and actovegin (Kurkin et al. 2021).

Two RCTs (Kotoy et al. 2019; Jianu et al. 2010) were found evaluating neuropeptides for aphasia rehabilitation. RCTs compared neuropeptides to a standard therapy or complex language therapy.

The methodological details and results of all two RCTs are presented in **Table 20**.

Table 20. RCTs Evaluating Neuropeptide Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Neuropeptide + SLT		
Kotov et al. (2018) RCT (6) Nstart=40 Nend=40 TPS=Subacute	E: Complex Language Therapy + Cellex Injection C: Complex Language Therapy Duration: Dose of 1.0 ml/day,10 days and repeat 10 days after	• Aphasia Patient Study Program (+exp) • Goodglass Kaplan Scale (+exp)
Cerebrolysin		
Jianu et al. (2010) RCT(5) Nstart=156 Nend=134 TPS=Acute	E1: Cerebrolysin + standard therapy + adjuvant therapy E2: standard therapy C: standard therapy + placebo treatment	• Mean aphasia quotient scores (+exp) • Spontaneous Speech-Western Aphasia Battery (+exp) ○ Repetition (+exp) ○ Naming (+exp))

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

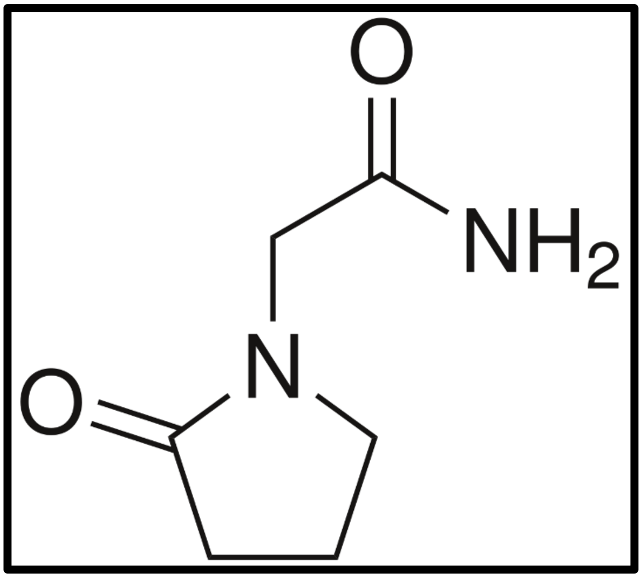
Conclusions about Neuropeptide Interventions

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Cellex and complex language therapy** may produce greater improvements in global speech and language than **complex language therapy** alone**.**	1	Kotoy et al., 2018
2	**Cererbrolysin, standard and adjuvant therapy** may produce greater improvements in global speech and language than **standard therapy and placebo** alone**.**	1	Jianu et al. 2010

Key Points

Neuropeptides with language therapy may be beneficial for global speech and language

Piracetam



Adapted from: https://en.wikipedia.org/wiki/Piracetam

Piracetam is a γ-aminobutyrate derivative, a pharmacological agent with a potential effect on cognition and memory. Piracetam is thought to improve learning and memory by facilitating release of acetylcholine and excitatory amino acids, with increases in blood flow and energy metabolism (Kessler et al., 2000).

Five RCTs were found evaluating piracetam for aphasia rehabilitation. Four RCTs compared piracetam to a placebo (Szelies et al., 2001; Huber et al., 1997; Orgogozo et al., 1998; Gungor et al., 2011). One RCT compared piracetam to no drug therapy Enderby et al., 1994).

The methodological details and results of all 5 RCTs are presented in **Table 21.**

Table 21. RCTs Evaluating Piracetam Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Gungor et al. (2011) RCT (5) Nstart=49 Nend=30 TPS=acute	E: Oral piracetam C: Placebo Duration: 24 weeks	• Global aphasia score (-) • Spontaneous speech (-) • Reading (-) • Auditory comprehension (-) • Reading comprehension (-) • Repetition (-) • Naming (-)

Szelies et al. (2001)
RCT (6)
N_{Start}=24
N_{End}=19
TPS=Acute
	E: Piracetam Treatment (2 x 2400mg/d)
	C: Placebo
	Duration: 6wks
		• FAS Phonemic Fluency Task (-)
		• Spreen-Benton Test (-)
		• Aachen Aphasia Test
		  • Syntactic Structure (+exp)
		  • Communicative Behaviour (-)
		  • Articulation and Prosody (-)
		  • Automatized Speech (-)
		  • Semantic Structure (-)
		  • Phonemic Structure (-)
		  • Token Test (-)
		  • Repetition (-)
		  • Written Language (-)
		  • Confrontation Naming (-)
		  • Comprehension (-).

Orgogozo et al. (1998) RCT(8) Nstart=927 Nend=927 TPS=Acute	E: Piracetam C: Placebo Duration: iv. Piracetam 12 to 14 days, followed by oral piracetam remainder of the 4-week treatment	• Barthel score (-) • Normal Frenchay Aphasia Screening Test (+exp)

Huber et al. (1997)
RCT (7)
N_{Start}=66
N_{End}=50
TPS=Chronic
	E: Piracetam Treatment (4.8g/d) + Intensive Language Therapy
	C: Intensive Language Therapy
	Duration: 6wks
		• Aachen Aphasia Test
		  • Token Test (-)
		  • Repetition (-)
		  • Written Language (+exp)
		  • Naming (-)
		  • Comprehension (-)

Enderby et al. (1994) RCT (6) N_{Start}=158 N_{End}=137 TPS=Subacute	E: Piracetam Treatment (4.8g/d) C: Placebo Duration: 12wks	• Aachen Aphasia Test (+exp) • Barthel Index (-) • Rivermead Perception Assessment Battery (-) • Kuriansky Performance Test (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Piracetam

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving discourse.	1	Szelies et al., 2001

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving naming.	3	Gungor et al., 2011; Szelies et al., 2001; Huber et al., 1997

VERBAL FLUENCY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving verbal fluency.	2	Gungor et al., 2011; Szelies et al., 2001

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving social communication.	1	Szelies et al., 2001

REPETITION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving repetition.	3	Gungor et al., 2011; Szelies et al., 2001; Huber et al., 1997

WRITING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **piracetam** to improve writing when compared to **a placebo.**	2	Szelies et al., 2001; Huber et al., 1997

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving general comprehension.	2	Szelies et al., 2001; Huber et al., 1997

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving reading comprehension.	1	Gungor et al., 2011

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving auditory comprehension.	3	Gungor et al., 2011; Szelies et al., 2001; Huber et al., 1997

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving global speech and language.	4	Gungor et al., 2011; Szelies et al., 2001; Orgogozo et al. 1998; Enderby et al., 1994

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Piracetam** may not have a difference in efficacy when compared to **a placebo** for improving activities of daily living.	2	Orgogozo et al. 1998; Enderby et al., 1994

Key Points

Piracetam may not be beneficial for improving aphasia related outcomes post-stroke.

Alternative Medicine

Nao-Xue-Shu

Traditional Chinese and Japanese herbal medicine are complementary and alternative forms of medicine that have been utilized as a healthcare system in Asian countries for hundreds of years and are widely used for stroke treatment today (Tsai et al. 2017; Han et al. 2017). Different herbal medicines have various beneficial properties such as anti-inflammatory, increasing cerebral blood flow velocity, inhibiting platelet aggregation, increasing tissue tolerance to hypoxia, etc. (Han et al. 2017). Chinese and Japanese herbal medicines commonly used for stroke rehabilitation generally consist of a mixture of different plant and animal extracts with these varying properties (Han et al. 2017). Nao-Xue-Shu is an oral liquid which is thought to increase cerebral blood flow by clearing away static blood and improving blood circulation, thereby decreasing the risk of thrombi forming (Xue et al., 2007). Its main ingredients are leech, astragalus root, Rhizome Chuanxiong calamus and Achyranthes (Song et al., 2018).

One RCT was found evaluating Nao-Xu-Shu for aphasia rehabilitation. The single RCT compared Nao-Xue-Shu with western medicine to western medicine alone (Yan et al., 2015).

The methodological details and results of the single RCT are presented in **Table 22.**

Table 22. RCT Evaluating Nao-xue-shu Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Yan et al. (2015) RCT (6) N_{Start}=116 N_{End}=105 TPS=Acute	E: Nao-Xue-Shu (10ml, 3x/d) + Western Medicine C: Western Medicine Duration: 4wks	• Western Aphasia Battery (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

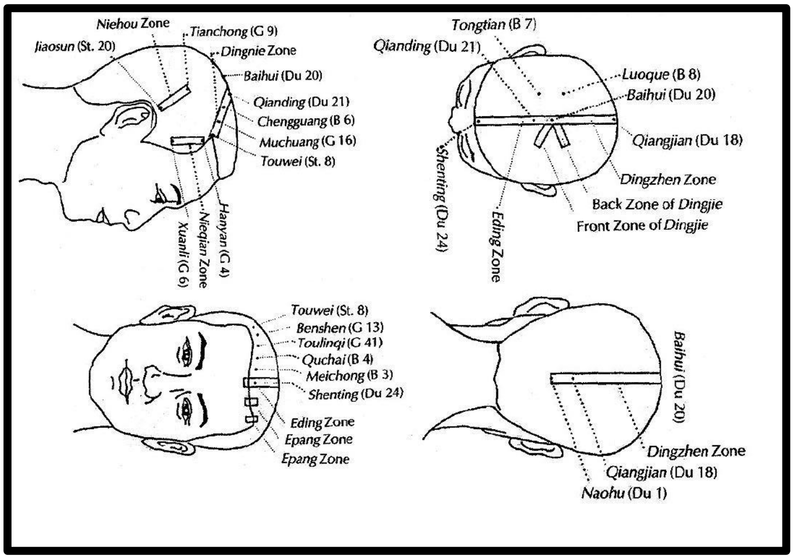
Conclusions about Nao-Xue-Shu

GLOBAL SPEECH AND LANGUAGE			
LoE	Conclusion Statement	RCTs	References
1b	**Nao-Xue-Shu** may produce greater improvements in global speech and language than **western medicine.**	1	Yan et al., 2015

Key Points

Nao-Xue-Shu may be beneficial for improving global speech and language post-stroke.

Scalp Acupuncture



Adapted from: https://www.scribd.com/document/260200308/Zhu-s-Scalp-Acupuncture

The use of acupuncture has recently gained attention as an adjunct to stroke rehabilitation in Western countries even though acupuncture has been a primary treatment method in China for about 2000 years (Baldry, 2005). In China, acupuncture is an acceptable, time-efficient, simple, safe and economical form of treatment used to ameliorate motor, sensation, verbal communication and further neurological functions in post-stroke patients," (Wu et al. 2002). According to Rabinstein and Shulman (2003), "Acupuncture is a therapy that involves stimulation of defined anatomic locations on the skin by a variety of techniques, the most common being stimulation with metallic needles that are manipulated either manually or that serve as electrodes conducting electrical currents". There is a range of possible acupuncture mechanisms that may contribute to the health benefits experienced by stroke patients (Park et al. 2005). For example, acupuncture may stimulate the release of neurotransmitters (Han & Terenius, 1982) and have an effect on the deep structure of the brain (Wu et al. 2002). Lo et al. (2005) established acupuncture, when applied for at least 10 minutes, led to long-lasting changes in cortical excitability and plasticity even after the needle stimulus was removed. With respect to stroke rehabilitation, the benefit of acupuncture has been evaluated most frequently for pain relief and recovery from hemiparesis, but some acupoints correspond to language functions.

Two RCTs were found evaluating scalp acupuncture for aphasia rehabilitation. One RCT compared scalp acupuncture with speech therapy to speech therapy alone (Teng et al., 2017). One RCT compared heart-Gallbladder acupuncture to conventional acupuncture (Wu at al., 2016).

The methodological details and results of the two RCTs are presented in **Table 23.**

Table 23. RCT Evaluating Scalp Acupuncture Interventions for Aphasia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Scalp Acupuncture vs Conventional Therapy		

Teng et al. (2017)
RCT (5)
N_{Start}=91
N_{End}=91
TPS=Subacute
	E: Scalp Acupuncture + Speech Therapy
	C: Conventional Therapy + Speech Therapy
	Duration: 30min/d, 1mo
		• Boston Diagnostic Aphasia Examination (+exp)
		• Aphasia Battery of Chinese
		  • Oral Expression (+exp)
		  • Auditory Comprehension (-)
		  • Reading (+exp)
		  • Writing (+exp)
		• Global Score (+exp)

Heart-Gallbladder Acupuncture vs Conventional Acupuncture		

Wu at al. (2016)
RCT (6)
Nstart=60
Nend=55
TPS=NR (no average)
	E: Heart-Gallbladder acupuncture treatment
	C: Conventional acupuncture treatment
	Duration: 25 mins/day, 5 days/wk, 3 wks
		• Aphasia Battery of Chinese
		  ○ Information (-)
		  ○ Verbal fluency (+exp)
		  ○ Understanding (-)
		  ○ Retelling (+exp)
		  ○ Naming (+exp)
		  ○ Reading (+exp)
		• Chinese functional communication profile (+exp)
		• Boston diagnostic aphasia examination (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.

+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group

+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group

+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group

\- indicates no statistically significant between groups differences at α=0.05

Conclusions about Scalp Acupuncture

NAMING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in naming than **conventional acupuncture.**	1	Wu at al., 2016

SOCIAL COMMUNICATION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in social communication than **conventional acupuncture.**	1	Wu at al., 2016

DISCOURSE			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in discourse than **conventional acupuncture.**	1	Wu at al., 2016

VERBAL FLUENCY			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Scalp acupuncture with conventional speech therapy** may produce greater improvements in verbal fluency than **conventional speech therapy alone.**	1	Teng et al., 2017
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in verbal fluency than **conventional acupuncture.**	1	Wu at al., 2016

WRITING			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Scalp acupuncture with conventional speech therapy** may produce greater improvements in writing than **conventional speech therapy alone.**	1	Teng et al., 2017

READING COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Scalp acupuncture with conventional speech therapy** may produce greater improvements in reading comprehension than **conventional speech therapy alone.**	1	Teng et al., 2017
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in reading comprehension than **conventional acupuncture.**	1	Wu at al., 2016

AUDITORY COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Scalp acupuncture with conventional speech therapy** may not have a difference in efficacy when compared to **conventional speech therapy alone** for improving auditory comprehension.	1	Teng et al., 2017

GLOBAL SPEECH AND LANGUAGE			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Scalp acupuncture with conventional speech therapy** may produce greater improvements in global speech and language than **conventional speech therapy alone.**	1	Teng et al., 2017
1b	**Heart-Gallbladder acupuncture** may produce greater improvements in global speech and language than **conventional acupuncture.**	1	Wu at al., 2016

Key Points

Scalp acupuncture may be beneficial for improving verbal fluency, writing, reading and global speech and language, but not auditory comprehension.

Apraxia

Apraxia is a disorder of voluntary movement where one cannot execute willed, purposeful activity despite the presence of adequate mobility, strength, sensation, co-ordination, comprehension, and motivation. Common apraxias are listed in Table 22.

Table 24. Types of Apraxias

Type	Site of Lesion	Manifestation
Motor or Ideomotor	Often left hemisphere.	Can automatically perform a movement but cannot repeat it on demand.
Ideational	Often bilateral parietal.	Can perform separate movements but cannot co-ordinate all steps into an integrated sequence.
Constructional	Either parietal lobe but right more often than left.	Unable to synthesize individual spatial elements into a whole (e.g., cannot draw a picture).
Dressing	Either hemisphere, right more often than left.	Inability to dress oneself despite adequate motor ability.

The Importance of Apraxia Post-Stroke

Roughly 30% of patients in the acute phase of stroke show evidence of apraxia (Donkervoort et al., 2000; Faglioni & Basso, 1985). However, as noted by Koski and colleagues (2002), there is considerable variability in the estimate across studies because of the lack of standardized assessment tools and the wide variations in criteria for diagnosing the disorder. Elsewhere, incidence rates of apraxia in left hemispheric stroke patients have ranged from 28% (De Renzi et al., 1980) to 57% (Barbieri & De Renzi, 1988). Typically, incidence of apraxia is higher after damage to the left hemisphere (50%), than to the right hemisphere (<10%) (De Renzi et al., 1980).

Information provided by analysis of the data from the Copenhagen Study suggested that the frequency of apraxia may be substantially lower than previously reported. Out of 618 stroke patients, Pedersen et al. (2001) identified apraxia of any type in 9.1%. Manual apraxia was found in 7% of patients and oral apraxia in 6%. Manual and oral apraxia were both associated with left-sided stroke lesions and strokes of greater severity (Pedersen et al., 2001).

While it has been suggested that the presence of apraxia can lead to severe disabilities in activities of daily living (Bjorneby & Reinvang, 1985; Saeki et al., 1995; Sundet et al., 1988; Foundas et al., 1995; Rothi & Heilman, 1997), results of the Copenhagen Study suggest that this is not necessarily the case. When the influence of manual and oral apraxia on functional outcome (represented by performance on the Barthel Index) was examined, taking initial Barthel Index scores, initial stroke severity and history of prior stroke, comorbidity, gender, age and handedness into account, no significant independent relationship could be found between apraxia and functional outcome. Unsal-Delialioglu et al. (2008) demonstrated that patients with apraxia may experience significant gains in function over the course of rehabilitation, although admission and discharge FIM scores may be significantly lower than their non-apraxic counterparts (Unsal-Delialioglu et al., 2008).

It has been suggested that apraxia and aphasia are associated (Papagno et al., 1993). Unsal-Delialioglu et al. (2008) reported that, in a group of patients with right-sided post-stroke hemiplegia, patients with apraxia recorded lower aphasia assessment scores than non-apraxic patients (Unsal-Delialioglu et al., 2008). In the Copenhagen Study, the association between apraxia and other neurological symptoms was investigated (Pedersen et al., 2001). While apraxia was found to be significantly associated with aphasia ($r=0.28$ for manual apraxia and $r=0.36$ for oral apraxia, $p<0.001$ for both), associations with body hemineglect and anosognosia for hemiplegia were of a similar magnitude.

Anatomical Substrates of Apraxia

Although apraxia is more commonly associated with strokes affecting the left parietal lobe, it may also occur in lesions to the right parietal lobe, the temporal or frontal lobes, and even subcortical regions including white matter and the basal ganglia (Leiguarda, 2001). According to Koski et al. (2002), *"…the parietal cortex subserves an important component of the praxis system, especially concerned with the knowledge or representation of overlearned actions. It is recognized, however, that damage to cortical and/or subcortical regions outside the left parietal cortex, including the right hemisphere, have also been associated with apraxia and it is assumed that each of these different neural regions makes its own distinct contribution to the representation of action…*"

Recovery of Apraxia Post-Stroke

While apraxia usually improves over time, spatiotemporal errors in imitation or tool use may persist (Maher & Ochipa, 1997). Basso and colleagues (1987) (as cited by van Heugten et al. (2000)) investigated the recovery from ideomotor apraxia (IMA) in acute stroke patients and attempted to identify predictive variables of IMA. They observed that recovery was related to the site of lesion in that patients with anterior lesions demonstrated better recovery. Recovery was not related to age, education, sex, type of aphasia and the initial severity or the size of the lesion

Treatment of Apraxia

The presence of apraxia in the acute phase post-stroke serves as a barrier to rehabilitation since the process of motor learning may depend on imitation. Moreover, in aphasic patients, the presence of apraxia prevents the teaching of gestural communication as part of therapeutic interventions (Koski et al., 2002).

A recent review of the literature identified studies describing 10 treatment approaches; multiple cues, error reduction, six-stage task hierarchy, conductive education, strategy training, transitive/intransitive gesture training, rehabilitative treatment and errorless completion + exploration training (Buxbaum et al., 2008). Most of the reports identified are single-case, or single-case series. Only two of these treatment approaches have been investigated using randomized controlled trials and are described below. Please note that "rehabilitative treatment" is sufficiently similar to gesture training to be included with it for the purposes of the present review.

Ideomotor Apraxia/ Ataxia Interventions

Apraxia Training

Adapted from: https://www.speechbuddy.com/blog/speech-therapy-techniques/speech-therapy-for-adults-with-apraxia/

Apraxia, as discussed above, is a disorder of planning and/or execution of appropriate motor commands. Some therapies revolve around creating strategies that a patient can employ to help compensate for their apraxia impairment. These strategies can be internal and external, and generally focus on teaching individuals how to improve their functioning in activates of daily living, as opposed to remediation of the underlying deficit (Donkervoort et al., 2001).

Four RCTs were found evaluating apraxia training. Two RCTs compared ADL apraxia strategy training with conventional occupational therapy (Geusgens et al., 2006; Donkervoort et al., 2001). One RCT compared gesture training with conventional aphasia therapy (Smania et al., 2006). One RCT compared upper limb apraxia with conventional care (Aguilar-Ferrandiz et al., 2021).

The methodological details and results of the four RCTs are presented in **Table 25.**

Table 25. RCTs Evaluating Interventions for Ideomotor Apraxia and Ataxia Rehabilitation

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
ADL Strategy Training + Conventional Care vs Conventional Care		
Geusgens et al. (2006) RCT (8) N_{Start}=113 N_{End}=102 TPS=Subacute	E: Strategy Training to Compensate for Apraxia + Usual Occupational Therapy C: Usual Occupational Therapy Only Duration: 8wks	• ADL Functioning (+exp)
Donkervoort et al. (2001) RCT (8) N_{Start}=113 N_{End}=102 TPS=Subacute	E: Strategy Training to Compensate for Apraxia + Usual Occupational Therapy C: Usual Occupational Therapy Only Duration: 8wks	• Barthel Index (+exp)
Gesture Training vs Conventional Aphasia Treatment		
Smania et al. (2006) RCT (5) N_{Start}=41 N_{End}=17 TPS=Chronic	E: Limb Apraxia Gesture Training (50min) C: Conventional Aphasia Treatment Duration: 3x/wk, 10wks	• Ideomotor Apraxia (+exp) • Gesture Comprehension (+exp) • ADL Functioning (+exp)
Upper Limb Apraxia vs Conventional Care		
Aguilar-Ferrandiz et al. (2021) RCT (8) NStart=38 NEnd=38 TPS=chronic	E: Combined Upper Limb Apraxia (ULU) functional rehabilitation C: Traditional health care education Duration: 30min/d, 3 days per week, 8wks for ULU	• Barthel Index (-) • Ideation and Ideomotor apraxia (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05.

Conclusions about Apraxia Training

GENERAL COMPREHENSION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Apraxia gesture training** may produce greater improvements in general comprehension than **usual aphasia treatments.**	1	Smania et al., 2006

APRAXIA			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Apraxia gesture training** may produce greater improvements in apraxia than **usual aphasia treatments.**	1	Smania et al., 2006
1b	**Upper limb apraxia** may produce greater improvements in apraxia than **conventional care**	1	Aguilar-Ferrandiz et al., 2021

ACTIVITIES OF DAILY LIVING

LoE	Conclusion Statement	RCTs	References
1a	**Apraxia strategy training** may produce greater improvements in activities of daily living than **usual care.**	2	Geusgens et al., 2006; Donkervoort et al., 2001
2	**Apraxia gesture training** may produce greater improvements in activities of daily living than **usual aphasia treatments.**	1	Smania et al., 2006
1b	**Upper limb apraxia** may not have a difference in improving activities of daily living than **conventional care**	1	Aguilar-Ferrandiz et al., 2021

Key Points

Apraxia strategy training may be beneficial for improving activities of daily living.

Gesture training for apraxia may be beneficial for improving general comprehension, apraxia and activities of daily living.

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