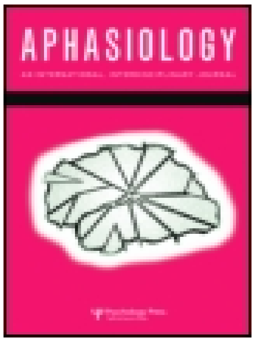
The efficacy of treatments for sentence production deficits in aphasia: a systematic review

Article · October 2021

DOI: 10.1080/02687038.2021.1983152



Aphasiology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/paph20

The efficacy of treatments for sentence production deficits in aphasia: a systematic review

Sarah-Ève Poirier, Marion Fossard & Laura Monetta

To cite this article: Sarah-Ève Poirier, Marion Fossard & Laura Monetta (2021): The efficacy of treatments for sentence production deficits in aphasia: a systematic review, Aphasiology, DOI: 10.1080/02687038.2021.1983152

To link to this article: https://doi.org/10.1080/02687038.2021.1983152

Published online: 11 Oct 2021.

APHASIOLOGY
https://doi.org/10.1080/02687038.2021.1983152

REVIEW

The efficacy of treatments for sentence production deficits in aphasia: a systematic review

Sarah-Ève Poirier[a,b], Marion Fossard[c] and Laura Monetta[a,b]

[a]Department of Rehabilitation, Faculty of Medicine, Laval University, Quebec City, Quebec, Canada; [b]Centre Interdisciplinaire De Recherche En Réadaptation Et Intégration Sociale (Cirris), Quebec City, Quebec, Canada; [c]Département des Sciences du langage et de la communication, Institut Des Sciences Logopédiques, Université De Neuchâtel, Neuchâtel, Switzerland

ABSTRACT

Background: Many individuals with aphasia (IWA) experience sentence production deficits (SPD), which can affect their daily interactions. Even if distinct treatments have been developed to improve these deficits, their efficacy is not always thoroughly measured, which makes it difficult to determine the optimal treatment for a given IWA. Objective: The primary objective of this study is to analyse the efficacy of the treatments that have been proposed for SPD in terms of gains on trained items, generalization to untreated items, maintenance of the acquired gains, and transfer to other contexts. Methods: A systematic review was conducted across the following databases: PubMed, CINHAL, and LLBA. Results: Twenty-five studies met criteria for this review, regrouping 11 different SPD treatments and 84 IWA. Different types of treatment were found. They mainly target verbs, sentence structures, or morphology. Concerning efficacy, gains on trained items and generalization to untreated items were demonstrated for almost every treatment, whereas the other efficacy measures were not always reported or improved. IWA characteristics and intensity treatment variables were also analysed for each treatment. Conclusions: No matter whether they focus on verbs, sentence structures, or morphology, most of the analysed treatments seem to be effective for improving SPD in IWA. Through various treatments, efficacy seems to be dependent on IWA's characteristics such as time post-stroke and aphasia severity.

ARTICLE HISTORY
Received 20 April 2021
Accepted 15 September 2021

KEYWORDS
Aphasia; sentence production; agrammatism; treatment; stroke

Introduction

Aphasia is a communication disorder acquired following a brain injury, frequently a stroke or a degenerative disease that affects the brain's left hemisphere. It occurs for about a third of stroke survivors (Dickey et al., 2010), and it can lead to various language difficulties, including sentence production deficits (SPD). SPDs, also named *agrammatism*, refer to an inability to produce complete or correctly constructed sentences (e.g., "tomato eat"). The prevalence of SPD varies during the course of aphasia (Springer et al., 2000). In the acute phase post-onset, SPDs are found in less than 10% of the individuals with

CONTACT Laura Monetta Laura.Monetta@rea.ulaval.ca Department of Rehabilitation, Faculty of Medicine, Laval University, Quebec City, Quebec, Canada; Centre Interdisciplinaire De Recherche En Réadaptation Et Intégration Sociale (Cirris), 1250 Avenue de la Médecine, Quebec (QC), G1V 0A6, Quebec City, Quebec, Canada

aphasia (IWA), whereas it is present in about 30% of the chronic aphasic population. This increment in prevalence could be explained by a change from global aphasia to Broca's aphasia with SPD (Willmes & Poeck, 1984). The prognosis varies as well, given that spontaneous recovery from acute SPD in Broca's aphasia was reported in 60% of the patients (Willmes & Poeck, 1984), whereas individuals with chronic SPD did not appear to fully recover their grammatic abilities (Springer et al., 2000). Therefore, a speech and language intervention specifically for sentence production is recommended to recover the ability to produce sentences in chronic SPD.

SPDs can manifest themselves as diverse combinations of grammatical morpheme omissions (e.g., "You are sleep"), verb retrieval difficulties (i.e., anomia), thematic roles (who did what to whom), assignment difficulties (e.g., "The money will give the man"), omission of function words (e.g., "I am school"), and a lack of complex verbs (e.g., *put* instead of *hang*) (Pillon, 2016; Springer, 2008). Given that the causes of SPD are very heterogeneous, the general conclusion of SPD is insufficient to guide specific clinical intervention. Thus, an assessment based on a theoretical model illustrating the different underlying sentence processing levels is mandatory. In the last 20 years, some clinical tools based on Bock and Levelt (1994) theoretical model have been developed to clinically evaluate the underlying level of SPD in patients with post-stroke and degenerative diseases (i.e., the VAST, in English; Bastiaanse et al., 2003; the NAVS, in English; Thompson, 2012; and the BEPS, in French; Coulombe et al., 2019). In Bock and Levelt (1994) model, four processing levels are distinguished, but only the middle two levels (the functional and positional levels, which are central for grammatical encoding) are evaluated by the VAST, the NAVS, and the BEPS. The functional level involves two sublevels: the lexical selection of the concepts activated in the previous level (i.e., a lexical item's lemma information) and the assignment of thematic roles to the selected lemmas and the encoding according to their grammatical function (subject, verb, object) are achieved. This level of processing is usually evaluated with actions naming task and thematic role attribution tasks. The positional level also involves two sublevels: constituent assembly

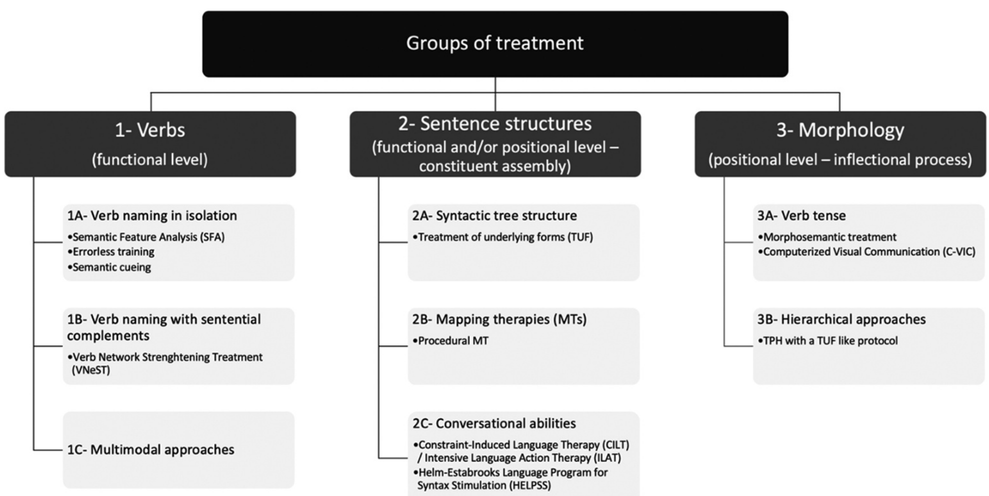


Figure 1. Categorization of some existing treatments for SPD.

and inflectional processes. First, the constituents (i.e., lemmas) are assembled into a sentence frame. Second, the addition of grammatical morphemes (e.g., number and tense) and function words (prepositions, determiners, and auxiliary verbs) provides the sentence's grammatical structure. This level of processing is usually evaluated with constituent assembly tasks and verb inflection tasks.

Because the manifestations and origins of SPD are heterogeneous, many different speech and language treatments have been developed to date. A recent literature review sorted various treatments for SPD into three major groups, depending on whether the treatment targets (1) verbs, (2) sentence structures, or (3) morphology (see Faroqi-Shah & Baker, 2017; Figure 1). Interestingly, it is possible to establish a link between these three groups and the levels of processing in Bock and Levelt's theoretical model (Bock & Levelt, 1994) that was previously mentioned. Indeed, treatments focusing on verbs and their thematic roles can be associated with the functional level; treatments targeting sentence structures can be associated with the first sublevel of the positional level, i.e., constituent assembly; and treatments targeting morphology can be associated with the second positional sublevel, i.e., inflectional processes. Treatments targeting sentence structures can link the functional and the positional levels or be associated with the first sublevel of the positional-level constituent assembly.

The first group of Faroqi-Shah and Baker's classification, verbs (1), includes three main subtypes of treatments targeting the verbs and their thematic roles as a strategy intervention for SPD. These treatments aim to improve the semantic representation of the verbs either by strengthening their representation or by improving retrieval of the verbs. For doing so, some of these treatments target naming and semantic analysis (e.g., use, association, location) of verbs in isolation (1A), such as Semantic Feature Analysis (SFA; Peach & Reuter, 2010), semantic cueing hierarchy (e.g., Wambaugh et al., 2002), or errorless learning approach with decreasing cues (e.g., Conroy et al., 2009). A recent study reviewed treatments of verbs in isolation and found that improvement was limited to trained verbs (Hickin et al., 2020). Other treatments target verb naming with sentential complements (1B), i.e., the argument structure and its associated thematic roles, or a sentence frame (e.g., Bastiaanse et al., 2006; Edmonds et al., 2009). Verb Network Strengthening Treatment (VNeST; Edmonds et al., 2009) is one of the treatments that target generation of diverse agents (i.e., who does the action) and patients (i.e., who "receives" the action) of trained verbs (e.g., for the verb *measure*: chef-sugar, carpenter-lumber). It shows the patient that the same verb can have different meanings, which come with different agents, which reinforce the semantic representation of the verb. Webster and Whitworth (2012) found that treatments that focus on verbs and their arguments seemed to lead to a better generalization than treatments targeting verbs in isolation. Finally, whereas the treatments previously mentioned use speech and writing, others are multimodal (1 C) and include gestures for verb retrieval, especially with action verbs (e.g., Boo & Rose, 2011; De Ruiter, 2006). A systematic review conducted by Rose et al. (2013) found that treatments including gestures with the oral production seem to be more effective than treatments without gestures.

The second group of treatments targets sentence structures (2) without explicitly discussing lexical difficulties. Some of them rely on the syntactic tree structures (2A) to illustrate the underlying representation of complex sentences requiring constituents' movement (Noam Chomsky, 1995). Treatment of underlying forms (TUF, originally called Linguistic Specific Treatment; Thompson, 2008; Thompson et al., 1997) is one of them. It uses a reverse complexity model, in which the training of complex sentence structures (e.g., object clefts and passives) is assumed to generalize to less complex structures with the same movement operation. This treatment starts with a review of an active sentence and the identification of the verb and its arguments. Then, the clinician trains the knowledge of the verb's thematic roles and changes the linear order of the elements in the sentence to obtain the surface form of the target sentence. Unlike TUF, mapping therapies (MTs; 2B) do not explicitly train sentence structure and do not use a reverse complexity model. They rely on Bock and Levelt's theoretical model (Bock & Levelt, 1994) and target the production of verbs and thematic role assignments (Schwartz et al., 1994). MT researchers propose that SPDs result from an impairment in the mapping from the functional level to the positional level. Thus, procedural MT trains the link between the meaning (i.e., thematic roles) and the structure (i.e., subject vs. object) of the sentence. Other treatments target conversational abilities (2 C), using protocols such as the Constraint-Induced Language Therapy (CILT, or more recently called Intensive Language Action Therapy, ILAT; Pulvermuller & Berthier, 2008) or the Helm-Estabrooks Language Program for Syntax Stimulation (HELPSS), which focus on memorizing and practicing scripts (Helm-Estabrooks, 1981). These two treatments aim to increase the utterance length progressively.

Finally, the third group comprises treatments targeting morphology (3), which focus on verb tenses and aspectual markings (i.e., how it extends over time, e.g., perfective vs imperfective). Among these, some treatments train verb tense (3A). For example, Mitchum et al. (1993) trained the production of verb morphology for three verb tenses (future, present progressive, and present perfect). Similarly, Faroqi-Shah (2008) intervened on SPD with a morphosemantic treatment. This treatment's main focus is to link the morphological shape of a verb with the associated meaning (e.g., *will* + *verb* expresses a future activity, whereas *walked* expresses an action in the past). Also, Weinrich and colleagues developed a computer-based iconic system (C-VIC, see Boser & Weinrich, 1998; Boser et al., 2000). In this treatment, the patient forms canonical sentences with icons and is then encouraged to produce them orally. In contrast, proponents of syntactic theories use hierarchical approaches (3B) to assess the tree-pruning hypothesis (TPH; e.g., Friedmann & Grodzinsky, 1997; Hagiwara, 1995), which postulate that a deficit at any level of the syntactic tree will impair every level above it. They use a treatment protocol similar to TUF (Thompson, 2008) to test their hypothesis.

Overall, many treatments for SPD have been developed, focusing on different levels of the sentence production models. With all of these choices of treatments, one could ask whether and to what extent all of these treatments are effective for IWA. The concept of treatment *efficacy* has, indeed, evolved through the years, including not only gain of trained items but also generalization to untrained items requiring the trained ability (Lavoie & Macoir, 2018), cross-modality generalization (e.g., from oral production to oral comprehension; Segaert et al., 2012), transfer to another context of communication (e.g., from naming to discourse; Herbert et al., 2014), and maintenance of acquired gains on trained items for a specific period after the end of therapy (e.g., one month post-treatment; Wisenburn & Mahoney, 2009). Thus, the question arises: which are the optimal evidence-based treatments for SPD focusing on verbs, sentence structures, or morphology that have shown to be effective?

The main goal of this study is to analyse the efficacy of the various treatments that have been proposed for SPD in terms of gains on trained items (post-treatment efficacy), generalization to untreated items, maintenance of the acquired gains (long-term efficacy), and transfer to other contexts.

Methods

Search strategy

We conducted a systematic search across the following databases: PubMed, CINHAL, and LLBA. Also, a search of the grey literature was undertaken using Google Scholar. Controlled vocabulary was used, and filters were customized depending on each database's particularities. We used the following terms: (stroke* OR cerebrovascular disorder OR cerebrovascular disease OR brain damage OR ischemic disease OR lesion) AND (aphasi* OR language OR speech-language OR communication) AND (syntax OR sentence* OR production OR syntactic OR verb OR mapping OR oral production OR thematic roles) AND (treatment OR therapy OR rehabilitation OR intervention).

Study selection and data extraction

In the first phase of selection, two independent reviewers (SEP and LM) read titles and abstracts and included articles respecting these inclusion criteria: (1) reporting primary data, (2) including adults with chronic aphasia (6+ months post-stroke), (3) monolingual speakers, (4) using treatment centered on oral syntactic production as a primary results, (5) articles published in French or English from 1990 to April 2020. They excluded articles according to these criteria: (1) participants having speech-language therapy during the study, (2) participants presenting a co-occurring history of psychiatric or other neurological disabilities (epilepsy, diagnosed mental health disability, neurodegenerative disease, previous brain lesion), (3) studies only focused on lexical access of verbs. The same two reviewers (SEP and LM) then performed a full-text screening of the remaining articles. Reviewer 1 (SEP) read each article, and Reviewer 2 (LM) read half of them. We collected data relative to study design, participants, materials and procedures, as well as the efficacy outcomes on syntax production. When this information was not clearly identifiable, we considered it as not reported.

Methodological quality

To ascertain the methodological quality of each article, the Single-Case Experimental Design scale (SCED; Tate et al., 2008), which results in a score out of 10 points, was used. The scores were then rated as weak (0–4), moderate (5–7), or strong (8–10) (Health Evidence, 2019). Single-case studies can provide strong evidence despite the small sample size (OCEBM Levels of Evidence, 2011). For each study, design suitability was also

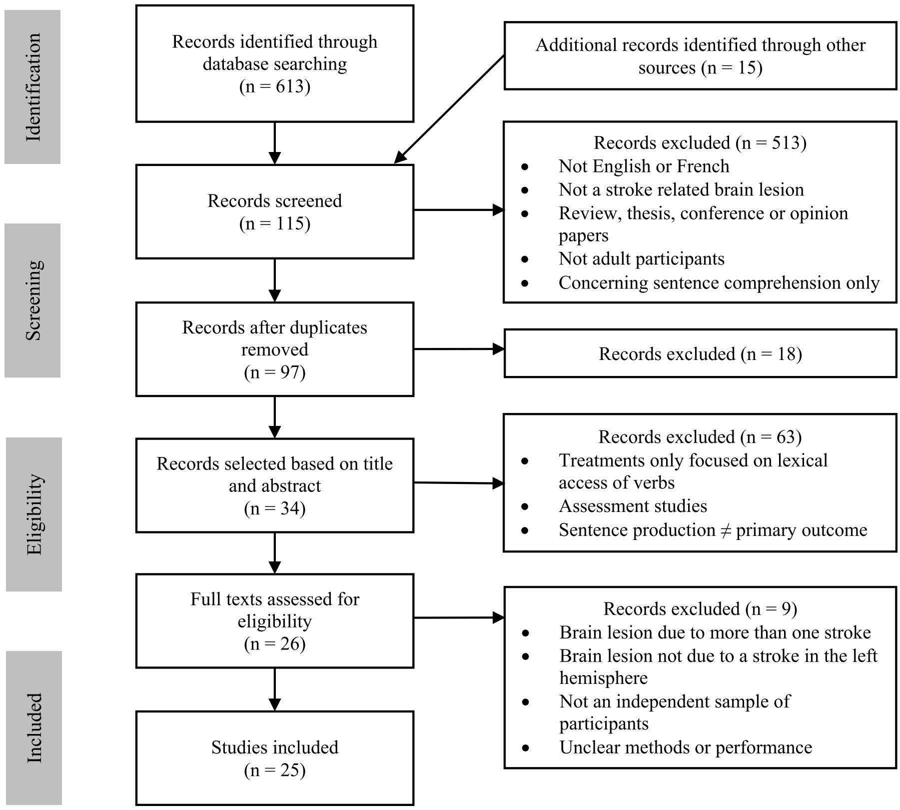


Figure 2. Flow diagram of the review process.

determined using Briss et al. (2000) guidelines. The strength of evidence for each treatment was determined using Briss et al. (2000) criteria, which suggest a level of strength for a set of studies based on their methodological quality and design suitability. For example, the strength of evidence of a treatment may be rated *strong* if there are at least two studies with good execution and design suitability; *sufficient* if there is only one study with good execution and design suitability; *expert opinion* if the quality of execution and design suitability varies; or *insufficient* if there are not enough studies and designs or executions are insufficient.

Results

Database and grey literature searches yielded a total of 613 articles. Additional searches through other sources (e.g., reference lists of identified articles) added 15 articles. Of these 628 articles, 603 were excluded because they did not meet the selection criteria (513 were excluded after the screening and 89 excluded after abstract and full-text reading; see Figure 2 for details). Therefore, 25 studies were included in the review, reporting on a total of 85 participants with post-stroke aphasia. All of these studies were single- or multiple-case studies with a single-case experimental design.

A total of 11 different treatments were presented in the studies included in this review (see Table 1). Studies were found for each treatment categories described by Faroqi-Shah and Baker (2017): *verbs* (*n* = 5), *sentence structures* (*n* = 15), *morphology* (*n* = 3), and treatments that did not fit in any of these three categories (*n* = 2). Moreover, some treatments were recurrent among these groups (e.g., TUF, which was applied in 9/25). Among the treatments targeting verbs, those focusing on lexical access of isolated verbs (1A) have not been selected for this literature review since they are not closely related to the sentence as a final result (see Figure 2). Therapies similar to CILT/ILAT have also been discarded because of their more general conversational approaches (see Figure 2).

Based on the SCED ratings, the methodological quality of the included studies ranged from 60% to 100% (average of 83.6%, which is associated with a strong quality; see Table 1). The most prevalent methodological limitation was the independence of assessors (i.e., having someone uninvolved in the study to evaluate the participants), which was only present in 32% of the articles, whereas the other criteria were all present in at least 72% of the articles.

Additional data relative to participants and treatments are presented in Table 2. Each study used tests to evaluate the initial deficits of their participants, but only 11/25 used a test that allowed an identification of the deficits through different levels similar to the ones of Bock and Levelt (1994) (e.g., NAVS; Thompson, 2012). The other studies used more general aphasia tests or batteries that do not lead to the same level of precision for the underlying SPD but instead give a standard global conclusion on syntactic production abilities (e.g., Boston Diagnostic Aphasia Examination, BDAE; Goodglass et al., 2001; Philadelphia Comprehension Battery for Aphasia, PCBA; Saffran et al., 1988).

Concerning efficacy, different measures were reported in the analysed studies. The four main ones were (a) *gains on trained items*, (b) *generalization*, (c) *transfer to other contexts*, and (d) *maintenance of the acquired gains*. Two of these were divided further. *Generalization* includes *generalization to untrained items* and *inter-modality generalization*, whether it is from oral production towards oral comprehension or towards written production. *Transfer to other contexts* includes *narrative discourse* and *conversation* (see Table 3). Efficacy was measured differently from one study to another. Each study measured gains on trained items and generalization to untrained items. However, the other efficacy measures (i.e., inter-modality generalization, transfer to other contexts, and maintenance of the acquired gains) were not reported in each study. To determine whether each participant improved or not on each efficacy measure, a dichotomic method (i.e., presence or absence of improvement) was used based on what was reported by the authors of the original articles (frequently a percentage of improvement with or without a significance level). Overall, the efficacy, in terms of gains on trained items, was 95.2% (80/84 participants). Table 3 reports the number of participants for which each measure was taken and for which it improved for each treatment.

The body of evidence of the four treatments also showed a strong quality: VNeST, TUF, MTs, and C-VIC (see Table 3). The other treatments did not have enough studies replicating the same treatment or the studies applying these treatments had a moderate methodological quality. Thus, their strength of evidence was deemed *sufficient* or *expert opinion*.

Table 1. Methodological quality and strength of evidence for each treatment.

References	Studies' methodological quality[a]	Groups of treatments	Treatments[b]	Number of participants
Edmonds and Babb (2011)	Strong	Verbs (1)[c]	VNeST (1B)	16
Edmonds et al. (2014)	Strong			
Edmonds et al., (2009)	Strong			
Thompson et al. (2013)	Strong		Complex Structures (1B)	4
Webster et al. (2005)	Strong		Verb and Argument Retrieval (1B)	1
Ballard and Thompson (1999)	Strong	Sentence structure (2)	TUF (2A)	32
Dickey and Thompson (2007)	Moderate			
Jacobs and Thompson (2000)	Strong			
Murray et al. (2004)	Moderate			
Thompson, den Ouden et al. (2010)	Strong			
Thompson et al. (2010)	Strong			
Thompson et al. (1993)	Strong			
Thompson et al. (1997)	Strong			
Thompson et al. (1996)	Strong			
Byng et al. (1994)	Strong		MTs (2B)	16
Carragher et al. (2015)	Strong			
Marshall et al. (1993)	Strong			
Rochon et al. (2005)	Strong			
Lee and Man (2017)	Moderate		Structural Priming (2B)	1
Fink et al. (1995)	Moderate		HELPSS (2 C)	4
Weinrich et al. (1997)	Strong	Morphology (3)	C-VIC (3A)	4
Boser et al. (2000)	Strong			
Faroqi-Shah (2008)	Strong		Morphosemantic approach (3A)	4
Peach and Wong (2004)	Moderate	Other	Story-telling	1
Hickin et al. (2015)	Moderate		Discourse Connective	1

[a]Based on the SCED (Tate et al., 2008) and Health Evidence (2019); [b] The names come from the study or, when there was no name to a treatment, it was named after its objective by the authors of this review.; [c] The numbers and letters in parentheses refers to the groups and subgroups of treatments presented in Figure 1.

Table 2. Additional data related to participants and treatments.

References		Demographic and evaluation data				Treatments data				
								Intensity		
	Numper of participants	Time post-stroke	CVA's[a] lesion site in the LH[b]	Type of aphasia	Specific test to evaluate the SPD?	Treatments	Psycholinguistic variables	Frequency (per week)	Duration (per session)	Length of treatment
Edmonds and Babb (2011)	2	9 months and 4.1 years	MCA[c]	Broca	Yes					
Edmonds et al. (2014)	10	1.2 to 12 years	Various sites	Various types	Yes	VNeST (1B)	Non-reversible sentences	2 sessions	2 hours	10–15 weeks
Edmonds et al. (2009)	4	10 months to 8 years	MCA	TMA[d], Conduction	No					
Thompson et al. (2013)	4	1.5 to 11 years	n.r.[e]	Agrammatic aphasia	Yes	Complex Structures (1B)	Argumental structure, frequent, length of words (1–3 syllables), animate and inanimate words	2 sessions	1.5 hour	Maximum of 10 weeks
Webster et al. (2005)	1	6 years	n.r.	n.r.	Yes	Verb and Argument Retrieval (1B)	Argumental structure, functionality of the words for the participant	3 sessions	45 minutes	10 weeks

(*Continued*)

Table 2. (Continued).

References	Demographic and evaluation data					Treatments data				
								Intensity		
	Numper of participants	Time post-stroke	CVA's[a] lesion site in the LH[b]	Type of aphasia	Specific test to evaluate the SPD?	Treatments	Psycholinguistic variables	Frequency (per week)	Duration (per session)	Length of treatment
Ballard and Thompson (1999)	3	10 months to 14 years	MCA	Broca, moderate	Yes	TUF (2A)	Frequent, imageable, familiar, length of words (1–3 syllables), transitive and intransitive verbs, reversible sentences, argumental structure, sentence complexity	Generally 2 or 3 sessions	Between 1 and 2 hours	4 to 24 weeks
Dickey and Thompson (2007)	1	4 years	n.r.	Broca, non-fluent	Yes					
Jacobs and Thompson (2000)	2	2.3 to 16.5 years	n.r.	Broca	No					
Murray et al. (2004)	4	1.1 to 5.3 years	n.r.	Various types, moderately severe	No					
Thompson et al. (2010)	6	6 months to 12.2 years	Various sites	Mild to moderately severe	Yes					
Thompson et al. (2010)	6	1.1 to 16.3 years	n.r.	n.r.	Yes					
Thompson et al. (1993)	2	1.1 and 3.3 years	n.r.	Non-fluent, agrammatic	No					
Thompson et al. (1997)	2	3.5 and 10 years	MCA	Agrammatic	No					
Thompson et al. (1996)	6	1.6 and 16.5 years	MCA	n.r.	No					
Byng et al. (1994)	3	2 to 18 years	n.r.	Broca, severe	No	MTs (2B)	Reversible sentences, frequent, imageable, transitive and intransitive sentences, length of words	2 to 3 sessions	1 hour	4 to 12 weeks
Carragher et al. (2015)	9	8 months to 11 years	Various sites	Broca	No					
Marshall et al. (1993)	1	14 years	n.r.	n.r.	Yes					
Rochon et al. (2005)	3	2 to 9 years	MCA or AVM[f]	Broca	No					

(*Continued*)

Table 2. (Continued).

References	Demographic and evaluation data					Treatments data				
								Intensity		
	Numper of participants	Time post-stroke	CVA's[a] lesion site in the LH[b]	Type of aphasia	Specific test to evaluate the SPD?	Treatments	Psycholinguistic variables	Frequency (per week)	Duration (per session)	Length of treatment
Lee and Man (2017)	1	3 years	n.r.	Broca, moderate	Yes	Structural Priming (2B)	Imageable, dative verbs, animate and inanimate nouns, length of words (1–3 syllables)	3 sessions	1.5 hour	4 weeks
Fink et al. (1995)	4	2 to 14 years	Left hemisphere	Non-fluent	No	HELPSS (2C)	Active, passive, and embedded	3 sessions	n.r.	n.r.
Weinrich et al. (1997)	3	At least 3 years	Temporal and temporo-parietal regions	n.r.	No	C-VIC (3A)	Regular and irregular verbs, frequent, imageables, length (1–3 syllables)	2 sessions	1 to 2 hours	12 to 25 weeks
Boser et al. (2000)	1	15 years	Various sites	Non-fluent, severe	No					
Faroqi-Shah (2008)	4	1 to 9 years	Various sites	Different types, mainly Broca	Yes	Morphosemantic approach (3A)	Regular and irregular verbs, imageables	4–5 sessions	1 or 2 hours	Maximum of 10 weeks
Peach and Wong (2004)	1	8 months	n.r.	Broca, moderate	No	Story-telling	6 fables	n.r.	n.r.	10 weeks
Hickin et al. (2015)	1	2 years	n.r.	n.r.	No	Discourse Connective	Sentence complexity	n.r.	1 hour	n.r. (16 sessions in total)

[a]Cerebrovascular accident; [b]Left hemisphere; [c]Middle cerebral artery; [d]Transcortical motor aphasia; [e]not reported; [f]Arteriovenous malformation

Table 3. Efficacy measures and strength of evidence for each treatment.

			Generalization			Transfer to other contexts			
				Inter-modality					
Groups of treatments	Treatments	Gains on trained items	To untrained items	To oral comprehension	To written production	Narrative discourse	Conversation	Maintenance of the acquired gains	Strength of evidence[a]
Verbs	VNeST	12/16[b]	11/16	–	–	9/16	1/1	12/15	Strong
	Complex Structures	4/4	4/4	–	–	–	–	–	Sufficient
	Verb retrieval	1/1	0/1	–	–	1/1	–	–	Sufficient
Sentence structure	TUF	32/32	27/32	12/18	6/6	18/23	2/2	16/18	Strong
	MTs	15/16	15/16	0/3	–	9/13	0/9	11/13	Strong
	Structural priming	1/1	1/1	–	–	1/1	–	1/1	Expert opinion
	HELPSS	4/4	4/4	–	–	4/4	–	–	Expert opinion
Morphology	C-VIC	4/4	4/4	4/4	–	–	–	1/1	Strong
	Morphosemantic approach	4/4	4/4	–	–	–	–	–	Sufficient
Other	Story-telling	1/1	1/1	–	–	–	–	1/1	Expert opinion
	Discourse connective	1/1	1/1	–	0/1	1/1	–	–	Expert opinion
Total		80/84	72/84	16/25	6/7	43/59	3/12	42/49	

[a]Based on Briss et al. (2000); [b] These fractions refer to the number of participants that showed improvements against the number of participants for which the efficacy measure was performed.

Discussion

The current study analysed the efficacy of speech and language therapy treatments that have been proposed for SPD. To do so, 11 different SPD treatments for individuals with post-stroke aphasia, presented in 25 studies, were assessed following a three-group categorization: verbs (5), sentence structures (15), and morphology (3) (Faroqi-Shah & Baker, 2017). Two other treatments that did not fit into one of the three previously established group categorizations were also included. As it was mentioned in the results, treatments targeting verbs that focused on lexical access of isolated verbs were not included in the present literature review. Some literature reviews have already been conducted on this subject in the last years (e.g., Hickin et al., 2020; Webster & Whitworth, 2012). Because our aim was to analyse the efficacy of these treatments, the following discussion was divided according to the four main efficacy measures: (a) gains on trained items, (b) generalization, (c) transfer to other contexts and (d) maintenance of the acquired gains.

Gains on trained items

Considering the results of this review, it is clear that sentence production treatments led to improvement on trained items (95.2% of participants showed an improvement). The four participants who did not show improvement on this measure received either a treatment focused on verbs (VNeST; Edmonds & Babb, 2011) or a treatment focused on sentence structures (MT; Carragher et al., 2015). On the whole, the fact that each treatment led to improvement on trained items can be associated with a publication bias because a study without positive results might not have been published. Therefore, in this case, this efficacy measure is not a deciding factor on its own to choose an optimal treatment.

Generalization

Generalization to untreated items is an important efficacy measure because it is not conceivable to train every sentence an individual needs to produce daily. In the analysed studies, it was measured with the same task as the one used to measure gains on trained items, but with different untrained items that have equivalent characteristics (e.g., number of arguments, frequency, type of sentences). A total of 72/84 participants showed generalization to untrained items (see Table 3). This is consistent with previous findings that mention that a treatment that targets a process, a semantic related item, a rule, or a strategy should lead to generalization to other items requiring the same process, rule, or strategy (Coppens & Patterson, 2018). For example, VNeST focus on the activation of the semantic features and argument structure of a specific verb, which should lead to generalization according to studies who analyzed the difference between treatments focusing on isolated verbs in comparison to treatments including the sentential complements of verbs (see Webster & Whitworth, 2012). Similarly, treatments targeting sentence structure or morphology in this study (e.g., Carragher et al., 2015; Thompson et al., 2010; Weinrich et al., 1997) trained strategies and rules, which can be applied to other stimuli requiring the same strategy or rule (Kendall et al., 1998).

Another interesting measure of generalization is inter-modality generalization. Because sentence production can be preserved in an individual whose sentence comprehension skills are impaired and vice versa, it has been said that these two abilities necessitate distinct processing systems (see Nickels et al., 2015). However, numerous studies have also observed inter-modality generalization, which suggests a relationship between these two systems (see Madden et al., 2020; Mitchum et al., 1995). While several studies showed that training sentence production does not improve sentence comprehension (see Adelt et al., 2018; Murray et al., 2004), others have results demonstrating that training sentence comprehension improves sentence production (see Byng, 1988; Rochon & Reichman, 2004). In the present review, generalization from oral sentence production to oral sentence comprehension was observed for most of the participants for whom it was measured (16/25). Most of the participants who improved their comprehension received TUF and a few received C-VIC, which means that it was not specific to a group of treatments. It is not surprising that training sentence production with TUF led to inter-modality generalization to sentence comprehension because this treatment has been developed to improve both these modalities simultaneously (Thompson & Shapiro, 2005). Also, inter-modality generalization from oral sentence production to written sentence production was improved for almost every participant for whom it was measured (6/7). The six participants who improved all received TUF, which uses the written form of the sentences during treatment. This could have supported this generalization to written production.

On the whole, while generalization to untrained items has been analyzed and reported in many studies, the evaluation of inter-modality generalization and across-level generalization (i.e., tranfer from sentence-level treatment to discourse level or from word-level treatment to sentence level, see section below) is not systematically included. The use of a generalization framework like the one developed by Webster et al. (2015) could help researchers to better describe both generalization within level (i.e., to untreated items) and across level (i.e., transfer).

Transfer to other contexts

Because speech-language therapy aims to improve daily communicational skills, transfer to discourse is an important measure of treatment efficacy. In this review, transfer to the narrative context was mainly evaluated through the telling of the Cinderella or the Little Red Riding Hood story. The analysed variables were mainly mean length of utterances, number of grammatically correct sentences, number of correct information units, complexity of sentences, and number of open- and closed-class words. Narrative discourse was improved for most of the participants for whom it was measured (43/59). The participants who did not transfer their improvements to a narrative context were from different studies and received different treatment: VNeST, TUF, or MT.

A few studies also measured transfer to an ecological context (conversation with a family member or friend), but the results were not as positive as those for the other efficacy measures. The three participants for which it was improved received VNeST or TUF. However, it is important to be cautious when interpreting very small samples of data. In Carragher et al. (2015), transfer to an ecological context was measured, but none of the nine participants improved after treatment. These authors explain that it could be due to the lack of constraint in conversation (e.g., frequency of verbs, types of sentences, non-adjusted conversation partners, etc.), which makes it harder for IWA to construct complete sentences. In future studies, it would be important to consider this efficacy measure to lead to a better daily improvement in communication.

Maintenance of the acquired gains

Maintenance of the acquired gains is also an important efficacy measure because the goal of therapy is that the patient does not lose progression once the treatment is over. In the case of post-stroke deficits, long-term maintenance of progression can be achieved because it is not a degenerative condition. In this review, maintenance of the acquired gains was present for the majority of the participants for which it was measured (42/49). Studies that have examined SPD maintenance have reported similar results. However, for most of them, the retention interval typically has been relatively short (between 2 and 6 weeks). Other than the single case study of C-VIC that showed a 1-year maintenance (Boser et al., 2000), none of the other analyzed studies of SPD treatment in IWA have tested maintenance beyond 5 months of post-treatment.

Other variables influencing efficacy

Other variables that are not specifically related to syntax could have influenced the efficacy of treatments: demographic variables concerning the participants and variables concerning treatments (in terms of intensity, administration, number of stimuli, etc.). Concerning the participants, the time that has passed since they had their cerebrovascular accident (CVA) has an effect on cerebral plasticity (Teasell et al., 2012), whereas the lesion's site and the type of aphasia can lead to different deficits in addition to the SPD (see Marková, 2010; Mirman et al., 2019). In this review, these data varied greatly from one participant to another and did not seem to have a clear impact on efficacy (see Table 2). Nevertheless, severity of aphasia seems to have had an impact on treatment efficacy, which was reported by authors from the different studies reviewed. This is consistent with precedent studies, which demonstrated that the initial severity of aphasia is a contributing factor to the prognosis (e.g., Laska et al., 2001; Pedersen et al., 2004). However, with small sample sizes, it is hard to draw general conclusion about the impact of these variables on efficacy measures.

Concerning the frequency of sessions per week and their duration, this was similar for every study (mainly two times a week for 1 h 30 min to 2 h sessions), but the length of treatments varied. This could have had an impact on efficacy given that a greater intensity has been shown to be beneficial (Brady et al., 2016). Regarding the stimuli, treatments targeting verbs used non-reversible sentences only, whereas treatments targeting sentence structures used reversible sentences. This could have influenced efficacy because canonical non-reversible sentences (i.e., sentences where the agent and patient are not interchangeable; e.g., "The man walks the dog") are less complex than reversible sentences (e.g., "The woman punches the man"; Sherman & Schweickert, 1989). However, treatments targeting verbs were not more effective than the others.

Even if all of these variables do not reveal their specific role on efficacy in the treatments analysed, they are important to ensure the study's replicability and to obtain a sufficient homogeneity to be able to compare different treatments. Moreover, the fact that participants under the same experimental conditions showed different patterns of improvement suggests that the initial characteristics of the participants have greater effect on the outcomes of the treatment than the treatment itself. It is possible that with a higher number of participants, some tendencies regarding the effect of these variables on efficacy could have been found.

Another important aspect to consider is the way the initial deficit was measured. As mentioned earlier, about half of the studies used tests designed to identify the level of production on which there is a deficit. However, it is essential to establish the origin of the SPD and choose which treatment to use because each group of treatment targets a different level.

Limitations

Some methodological limitations from the included studies impact the conclusions that have been drawn in this review; the prominent ones being that the participants' characteristics varied extensively across studies (e.g., lesion site, time post-stroke) that some efficacy measures were not measured for most of the participants, neither were they reported nor measured in an homogenous way through the treatments. Also, almost half of the studies were from the same group of researchers. Moreover, as in most treatment studies, a selection bias (the participation of motivated participants) and a publication bias (the studies with positive results are published more easily) could affect the available results. Finally, it would have been interesting to analyse the magnitude of improvements for the different efficacy measures. However, effect sizes were not reported for most of the studies, limiting the interpretation to the available data, which were mostly percentage of improvement and significance levels.

It is important to remember that each of the 11 treatments reported in this review did not have the same strength of evidence (see Table 1). Among the treatments targeting verbs or sentence structures, only VNeST, TUF, MTs, and C-VIC had a strong strength of evidence. The other treatments either did not have enough studies replicating the same treatment or the studies applying these treatments had a moderate methodological quality. Thus, their strength of evidence has been deemed *sufficient* or *expert opinion*. Another important fact is that it is often the same group of researchers that replicate a treatment through numerous studies (e.g., VNeST and TUF). To demonstrate experimental control, the replication of a study is essential, but it is more meaningful if at least three different groups of researchers have done it (Horner et al., 2005), which is only the case for MTs in this review. However, studies that were not found in this review might exist and reinforce strength of evidence of treatments.

Future perspectives

The present review adds to the aphasia literature by analyzing the four efficacy measures of different types of treatments. This provides a more global view of efficacy because it is not centered on one efficacy measure for many treatments nor on various measures for one type of treatment. In the future, to allow for a better demonstration of the efficacy of a treatment, it would be important to include the efficacy measures mentioned in this review, particularly inter-modality generalization and transfer to an ecological context (see Webster et al., 2015 framework proposition), which was only measured in a few studies. A study using TUF mentioned that this treatment is tricky to apply for a clinician without an in-depth knowledge of linguistics. They addressed this difficulty by developing a computerized version of TUF provided by a virtual clinician four times a week (Thompson et al., 2010), which compensates for the complexity of the procedure and allows for a greater intensity of treatment. It is an interesting modality to consider in the future to compensate for the complexity of some procedures, or to make treatments accessible for more individuals by counterbalancing the restrictions resulting from geographical distance or the lack of time that a clinician has to see the same patient multiple times a week.

Disclosure statement

The authors report no conflicts of interest.

Funding

This review is an independent research from a Master's Research Fellowship to SEP supported by the Fonds de recherche du Québec – Santé (FRQS). The views expressed in this publication are those of the authors and not necessarily those of the FRQS; Fonds de Recherche du Québec - Santé;

References

Adelt, A., Hanne, S., & Nicole, S. (2018). Treatment of sentence comprehension and production in aphasia: Is there cross-modal generalisation? *Neuropsychological Rehabilitation*, *28*(6), 937–965. https://doi.org/10.1080/09602011.2016.1213176

Ballard, K. J., & Thompson, C. K. (1999). Treatment and generalization of complex sentence production in agrammatism. *Journal of Speech, Language, and Hearing Research*, *42*(3), 690–707. https://doi.org/10.1044/jslhr.4203.690

Bastiaanse, R., Edwards, S., Mass, E., & Rispens, J. (2003) Assessing comprehension and production of verbs and sentences: The Verb and Sentence Test (VAST). *Aphasiology*, *17*(1), 49–73. doi:10.1080/729254890

Bastiaanse, R., Hurkmans, J., & Links, P. (2006). The training of verb production in Broca's aphasia: A multiple-baseline across-behaviours study. *Aphasiology*, *20*(2–4), 298–311. https://doi.org/10.1080/02687030500474922

Bock, K., & Levelt, W. (1994). Language production: Grammatical encoding. In *Handbook of psycholinguistics* (pp. 945–984). Academic Press.

Boo, M., & Rose, M. L. (2011). The efficacy of repetition, semantic, and gesture treatments for verb retrieval and use in Broca's aphasia. *Aphasiology*, *25*(2), 154–175. https://doi.org/10.1080/02687031003743789

Boser, K. I., & Weinrich, M. (1998). Functional categories in agrammatic production: Evidence for access to tense projections. *Brain and Language*, *65*, 207–210. https://www-ncbi-nlm-nih-gov.acces.bibl.ulaval.ca/pmc/articles/PMC3092593/

Boser, K. I., Weinrich, M., & Mccall, D. (2000). Maintenance of Oral Production in Agrammatic Aphasia: Verb Tense Morphology Training. *Neurorehabilitation and Neural Repair*, *14*(2), 105–118. https://doi.org/10.1177/154596830001400203

Brady, M. C., Kelly, H., Godwin, J., Enderby, P., & Campbell, P. (2016). Speech and language therapy for aphasia following stroke. *Cochrane Database of Systematic Reviews*, (6). https://doi.org/10.1002/14651858.CD000425.pub4

Briss, P. A., Zaza, S., Pappaioanou, M., Fielding, J., Wright-De Agüero, L., Truman, B. I., Hopkins, D. P., Mullen, P. D., Thompson, R. S., Woolf, S. H., Carande-Kulis, V. G., Anderson, L., Hinman, A. R., McQueen, D. V., Teutsch, S. M., & Harris, J. R. (2000). Developing an evidence-based Guide to Community Preventive Services-Methods. *American Journal of Preventive Medicine*, *18*(1), 35–43. https://doi.org/10.1016/S0749-3797(99)00119-1

Byng, S. (1988). Sentence processing deficits: Theory and therapy. *Cognitive Neuropsychology*, *5*(6), 629–676. https://doi.org/10.1080/02643298808253277

Byng, S., Nickels, L., & Black, M. (1994). Replicating therapy for mapping deficits in agrammatism: Remapping the deficit? *Aphasiology*, *8*(4), 315–341. https://doi.org/10.1080/02687039408248663

Carragher, M., Sage, K., & Conroy, P. (2015). Outcomes of treatment targeting syntax production in people with Broca's-type aphasia: Evidence from psycholinguistic assessment tasks and everyday conversation. *International Journal of Language and Communication Disorders*, *50*(3), 322–336. https://doi.org/10.1111/1460-6984.12135

Chomsky, N. (1995). Categories and transformations. In N. Chomsky (Ed.), *The minimalist program* (pp. 219–394). MIT Press.

Conroy, P., Sage, K., & Lambon Ralph, M. A. (2009). Errorless and errorful therapy for verb and noun naming in aphasia. *Aphasiology*, *23*(11), 1311–1337. https://doi.org/10.1080/02687030902756439

Coppens, P., & Patterson, J. (2018). Generalisation in aphasiology : What are the best strategies? In I. Coppens & Patterson (Eds.), *Aphasia Rehabilitation: Clinical Challenges* (pp. 205–248). Jones & Bartlett Leaning.

Coulombe, V., Fossard, M., & Monetta, L. (2019). BEPS: Development, validation, and normative data of a sentence production test in French. *Applied Neuropsychology:Adult*, *19*(1), 1–13. https://doi.org/10.1080/23279095.2019.1640699

de Ruiter, J. P. (2006). Can gesticulation help aphasic people speak, or rather, communicate? *Advances in Speech Language Pathology*, *8*(2), 124–127. https://doi.org/10.1080/14417040600667285

Dickey, L., Kagan, A., Lindsay, M. P., Fang, J., Rowland, A., & Black, S. (2010). Incidence and Profile of Inpatient Stroke-Induced Aphasia in Ontario, Canada. *Archives of Physical Medicine and Rehabilitation*, *91*(2), 196–202. https://doi.org/10.1016/j.apmr.2009.09.020

Dickey, M. W., & Thompson, C. K. (2007). The relation between syntactic and morphological recovery in agrammatic aphasia: A case study. *Aphasiology*, *21*(6–8), 604–616. https://doi.org/10.1080/02687030701192059

Edmonds, L. A., & Babb, M. (2011). Effect of verb network strengthening treatment in moderate-to-severe aphasia. *American Journal of Speech-Language Pathology*, *20*(2), 131–145. https://doi.org/10.1044/1058-0360(2011/10-0036

Edmonds, L. A., Mammino, K., & Ojeda, J. (2014). Effect of verb network strengthening treatment (VNeST) in persons with aphasia: Extension and replication of previous findings. *American Journal of Speech-Language Pathology*, *23*(2), 312–329. doi:10.1044/2014_AJSLP-13-0098.

Edmonds, L. A., Nadeau, S. E., & Kiran, S. (2009). Effect of Verb Network Strengthening Treatment (VNeST) on lexical retrieval of content words in sentences in persons with aphasia. *Aphasiology*, *23*(3), 402–424. https://doi.org/10.1080/02687030802291339

Faroqi-Shah, Y. (2008). A comparison of two theoretically driven treatments for verb inflection deficits in aphasia. *Neuropsychologia*, *46*(13), 3088–3100. https://doi.org/10.1016/j.neuropsychologia.2008.06.018

Faroqi-Shah, Y., & Baker, A. L. (2017). Agrammatic aphasia. In P. Coppens (Ed.) *Aphasia Rehabilitation: Clinical Challenges* (pp. 101–141). Jones & Bartlett Learning.

Fink, R. B., Schwartz, M. F., Rochon, E., Myers, J. L., Socolof, G. S., & Bluestone, R. (1995). Syntax Stimulation Revisited. *American Journal of Speech-Language Pathology*, *4*(4), 99–104. https://doi.org/10.1044/1058-0360.0404.99

Friedmann, N., & Grodzinsky, Y. (1997). Tense and agreement in agrammatic production: Pruning the syntactic tree. *Brain and Language*, *56*(3), 397–425. https://doi.org/10.1006/brln.1997.1795

Goodglass, H., Kaplan, E., & Barrese, B. (2001). *The Assessment of Aphasia and Related Disorders. Lippincott*. Williams, & Wilkins.

Hagiwara, H. (1995). The breakdown of functional categories and the economy of derivation. *Brain and Language*, *50*(1), 92–116. https://doi.org/10.1006/brln.1995.1041

Health Evidence. (2019). McMaster University. https://healthevidence.org/our-appraisal-tools.aspx

Helm-Estabrooks, N. (1981). *Helm Elicited Language Production Program for Aphasia*. Exceptional Resources Inc.

Herbert, R., Gregory, E., & Best, W. (2014). Syntactic versus lexical therapy for anomia in acquired aphasia: Differential effects on narrative and conversation. *International Journal of Language and Communication Disorders*, *49*(2), 162–173. https://doi.org/10.1111/1460-6984.12054

Hickin, J., Cruice, M., & Dipper, L. (2020). A Systematically Conducted Scoping Review of the Evidence and Fidelity of Treatments for Verb Deficits in Aphasia: Verb-in-Isolation Treatments. *American Journal of Speech-Language Pathology*, *29*(1S), 530–559. https://doi.org/10.1044/2019_AJSLP-CAC48-18-0234

Hickin, J., Mehta, B., & Dipper, L. (2015). To the sentence and beyond: A single case therapy report for mild aphasia. *Aphasiology*, *29*(9), 1038–1061. https://doi.org/10.1080/02687038.2015.1010474

Horner, R. H., Carr, E. G., Halle, J., Mcgee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*(2), 165. https://doi.org/10.1177/001440290507100203

Jacobs, B. J., & Thompson, C. K. (2000). Cross-Modal Generalization Effects of Training Noncanonical Sentence Comprehension and Production in Agrammatic Aphasia. *Journal of Speech, Language, and Hearing Research*, *43*(1), 5–20. https://doi.org/10.1044/jslhr.4301.05

Kendall, D. L., McNelil, M. R., & Small, S. L. (1998). Rule-based treatment for acquired phonological dyslexia. *Aphasiology*, *12*(7–8), 587–600. https://doi.org/10.1080/02687039808249560

Laska, A. C., Hellblom, A., Murray, V., Kahan, T., & Von Arbin, M. (2001). Aphasia in acute stroke and relation to outcome. *Journal of Internal Medicine*, *249*(5), 413–422. https://doi.org/10.1046/j.1365-2796.2001.00812.x

Lavoie, M., & Macoir, J. (2018). Généralisation des effets du traitement de l'anomie post-AVC: Synthèse des écrits scientifiques et enjeux actuels. *Rééducation Orthophonique*, *275*, 153–170.

Lee, J., & Man, G. (2017). Language recovery in aphasia following implicit structural priming training: A case study. *Aphasiology*, *31*(12), 1441–1458. https://doi.org/10.1080/02687038.2017.1306638

Madden, E. B., Torrence, J., & Kendall, D. L. (2020). Cross-modal generalization of anomia treatment to reading in aphasia. In *Aphasiology*, *35*(7), 875–899. https://doi-org.acces.bibl.ulaval.ca/10.1080/02687038.2020.1734529

Marková, J. (2010). Morphological-syntactic deficits in the production of Slovak-speaking aphasic patients. *Aphasiology*, *24*(10), 1197–1222. https://doi.org/10.1080/02687030903422452

Marshall, J., Pring, T., & Chiat, S. (1993). Sentence processing therapy: Working at the level of the event. *Aphasiology*, *7*(2), 177–199. https://doi.org/10.1080/02687039308249505

Mirman, D., Kraft, A. E., Harvey, D. Y., Brecher, A. R., & Schwartz, M. F. (2019). Mapping articulatory and grammatical subcomponents of fluency deficits in post-stroke aphasia. *Cognitive, Affective & Behavioral Neuroscience*, *19*(5), 1286–1298. https://doi.org/10.3758/s13415-019-00729-9

Mitchum, C. C., Haendiges, A. N., & Berndt, R. S. (1993). Model-guided treatment to improve written sentence production: A case study. *Aphasiology*, *7*(1), 71–109. https://doi.org/10.1080/02687039308249500

Mitchum, C. C., Haendiges, A. N., & Berndt, R. S. (1995). Treatment of thematic mapping in sentence comprehension: Implications for normal processing. *Cognitive Neuropsychology*, *12*(5), 503–547. https://doi.org/10.1080/02643299508252006

Murray, L., Ballard, K. J., & Karcher, L. (2004). Linguistic specific treatment: Just for Broca's aphasia? *Aphasiology*, *18*(9), 785–809. https://doi.org/10.1080/02687030444000273

Nickels, L., Rapp, B., & Kohnen, S. (2015). Challenges in the use of treatment to investigate cognition. *Cognitive Neuropsychology*, *32*(3–4), 91–103. https://doi.org/10.1080/02643294.2015.1056652

OCEBM Levels of Evidence. (2011). Oxford Centre for Evidence-Based Medicine.

Peach, R. K., & Reuter, K. A. (2010). A discourse-based approach to semantic feature analysis for the treatment of aphasic word retrieval failures. *Aphasiology*, *24*(9), 971–990. https://doi.org/10.1080/02687030903058629

Peach, R. K., & Wong, P. C. M. (2004). Integrating the message level into treatment for agrammatism using story retelling. *Aphasiology*, *18*(5–7), 429–441. https://doi.org/10.1080/02687030444000147

Pedersen, P. M., Vinter, K., & Olsen, T. S. (2004). Aphasia after stroke: Type, severity and prognosis. The Copenhagen aphasia study. *Journal of Stroke and Cerebrovascular Diseases*, *17*(1), 35–45. doi: 10.1159/000073896.

Pillon, A. (2016). Réhabilitation de la production et de la compréhension des phrases dans l'aphasie. In X. Seron & M. Van Der Linden (Eds.), *Traité de neuropsychologie clinique de l'adulte - Tome 2-Revalidation* (pp. 214–289). De Boeck Supérieur.

Pulvermuller, F., & Berthier, M. (2008). Aphasia therapy on a neuroscience basis. *Aphasiology*, *22*(6), 563–599. https://doi.org/10.1080/02687030701612213

Rochon, E., Laird, L., Bose, A., & Scofield, J. (2005). Mapping therapy for sentence production impairments in nonfluent aphasia. *Neuropsychological Rehabilitation*, *15*(1), 1–36. https://doi.org/10.1080/09602010343000327

Rochon, E., & Reichman, S. (2004). A modular treatment for sentence processing impairments: Sentence comprehension. *Journal of Speech-Language Pathology & Audiology*, *28*(1), 25–33.

Rose, M., Anastasia, M. R., Lanyon, L. E., & Attard, M. C. (2013). A systematic review of gesture treatments for post-stroke aphasia. *Aphasiology*, *27*(9), 1090–1127. https://doi.org/10.1080/02687038.2013.805726

Saffran, E. M., Schwartz, M. F., Linebarger, M., Martin, N., & Bochetto, P. (1988). *The Philadelphia Comprehension Battery for Aphasia*. Unpublished manuscript.

Schwartz, M. F., Saffran, E. M., Fink, R. B., Myers, J. L., & Martind, N. (1994). Mapping therapy : A treatment programme for agrammatism. *Aphasiology*, *8*(1), 19–54. https://doi.org/10.1080/02687039408248639

Segaert, K., Menenti, L., Weber, K., Petersson, K. M., & Hagoort, P. (2012). Shared syntax in language production and language comprehension: An fMRI study. *Cerebral Cortex*, *22*(7), 1662–1670. https://doi.org/10.1093/cercor/bhr249

Sherman, J. C., & Schweickert, J. (1989). Syntactic and semantic contributions to sentence comprehension in agrammatism. *Brain and Language*, *37*(3), 419–439. https://doi.org/10.1016/0093-934X(89)90029-1

Springer, L. (2008). Therapeutic Approaches in Aphasia Rehabilitation. *Handbook of the Neuroscience of Language*, 397–406. Academic Press. https://doi.org/10.1016/B978-008045352-1.00039-2

Springer, L., Huber, W., Schlenck, K. J., & Schlenck, C. (2000). Agrammatism: Deficit or compensation? Consequences for aphasia therapy. *Neuropsychological Rehabilitation*, *10*(3), 279–309. https://doi.org/10.1080/096020100389165

Tate, R. L., McDonald, S., Perdices, M., Togher, L., Schultz, R., & Savage, S. (2008). Rating the methodological quality of single-subject designs and n-of-1 trials: Introducing the single-case experimental design (SCED) scale. *Neuropsychological Rehabilitation*, *18*(4), 385–401. https://doi.org/10.1080/09602010802009201

Teasell, R., Mehta, S., Pereira, S., McIntyre, A., Janzen, S., Allen, L., Lobo, L., & Viana, R. (2012). Time to rethink long-term rehabilitation management of stroke patients. *Topics in Stroke Rehabilitation*, *19*(6), 457–462. https://doi.org/10.1310/tsr1906-457

Thompson, C. K. (2008). Treatment of syntactic and morphological deficits in agrammatic aphasia: Treatment of underlying forms. In R. Chapey (Ed.), *Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders* (*Fifth Edition* ed., pp. 735–753). Williams & Wilkins.

Thompson, C. K. (2012). *Northwestern Assessment of Verbs and Sentences (NAVS)*. Northwestern University.

Thompson, C. K., den Ouden, D. B., Bonakdarpour, B., Garibaldi, K., & Parrish, T. B. (2010). Neural plasticity and treatment-induced recovery of sentence processing in agrammatism. *Neuropsychologia*, *48*(11), 3211–3227. https://doi.org/10.1016/j.neuropsychologia.2010.06.036

Thompson, C. K., Lange, K. L., Schneider, S. L., & Shapiro, L. P. (1997). Agrammatic and non-brain-damaged subjects' verb and verb argument structure production. *Aphasiology*, *11*(4–5), 473–490. https://doi.org/10.1080/02687039708248485

Thompson, C. K., Riley, E. A., den Ouden, D. B., Meltzer-Asscher, A., & Lukic, S. (2013). Training verb argument structure production in agrammatic aphasia: Behavioral and neural recovery patterns. *Cortex*, *49*(9), 2358–2376. https://doi.org/10.1016/j.cortex.2013.02.003

Thompson, C. K., & Shapiro, L. P. (2005). Treating agrammatic aphasia within a linguistic framework: Treatment of Underlying Forms. *Aphasiology*, *19*(10–11), 1021–1036. https://doi.org/10.1080/02687030544000227

Thompson, C. K., Shapiro, L. P., & Roberts, M. M. (1993). Treatment of sentence production deficits in aphasia: A linguistic-specific approach to wh-interrogative training and generalization. *Aphasiology*, *7*(1), 111–133. https://doi.org/10.1080/02687039308249501

Thompson, C. K., Shapiro, L. P., Tait, M. E., Jacobs, B. J., & Schneider, S. L. (1996). Training wh-question production in agrammatic aphasia: Analysis of argument and adjunct movement. *Brain and Language*, *52*(1), 175–228. https://doi.org/10.1006/brln.1996.0009

Wambaugh, J. L., Doyle, P. J., Martinez, A. L., & Kalinyak-Fliszar, M. (2002). Effects of two lexical retrieval cueing treatments on action naming in aphasia. *Journal of Rehabilitation Research and Development*, *39*(4), 455–466.

Webster, J., Morris, J., & Franklin, S. (2005). Effects of therapy targeted at verb retrieval and the realisation of the predicate argument structure: A case study. *Aphasiology*, *19*(8), 748–764. https://doi.org/10.1080/02687030500166957

Webster, J., & Whitworth, A. (2012). Treating verbs in aphasia: Exploring the impact of therapy at the single word and sentence levels. *International Journal of Language and Communication Disorders*, *47*(6), 619–636. https://doi.org/10.1111/j.1460-6984.2012.00174.x

Webster, J., Whitworth, A., & Morris, J. (2015). Is it time to stop "fishing"? a review of generalisation following aphasia intervention. *Aphasiology*, *29*(11), 1240–1264. https://doi.org/10.1080/02687038.2015.1027169

Weinrich, M., Shelton, J. R., Cox, D. M., & McCall, D. (1997). Remediating production of tense morphology improves verb retrieval in chronic aphasia. *Brain and Language*, *58*(1), 23–45. https://doi.org/10.1006/brln.1997.1757

Willmes, K., & Poeck, K. (1984). Ergebnisse einer multizentrischen Untersuchung über die Spontanprognose von aphasicn vaskulärer Ätiologie. *Nervenarzt*, *55*, 62–71.

Wisenburn, B., & Mahoney, K. (2009). A meta-analysis of word-finding treatments for aphasia. *Aphasiology*, *23*(11), 1338–1352. https://doi.org/10.1080/02687030902732745