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Review

A systematic review of Phonological Components Analysis therapy studies for aphasia

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ABSTRACT

Among the wide range of anomia treatments for persons with aphasia (PWA), Phonological Components Analysis (PCA) is a well-known alternative. A systematic review of PCA efficacy studies for PWA was conducted to extract treatment-related and participant-related characteristics, to synthesise immediate and long-term outcomes and to assess the methodological quality of PCA studies (PROSPERO pre-registration CRD42024552047). Experimental studies on adults with post-stroke aphasia focusing on the efficacy of PCA published in English were included. Studies combining PCA with other treatment approaches, involving people with neurodegenerative disorders, without efficacy measures, or in dissertations, theses, and conference papers were excluded. The EBSCOhost platform and citations of the original PCA paper were last searched in November 2024. In total, thirteen studies were selected involving 89 PWA. Participants were at least 6 months post-stroke, and 75 % of them presented with Broca's or anomic aphasia. The quality of PCA efficacy studies was relatively high according to the Single Case Experimental Design scale (mean 8.6 ± 1.0, range 7–10). Picture naming improved to reach at least a small effect size in 74 % of PWA (58/85) for trained items immediately after PCA and in 55 % of PWA (38/71) in the maintenance phase. Generalisation to untrained items occurred in 37 % of participants (22/59). Overall, PCA led to positive outcomes in the majority of PWA, which were often item-specific. As experimental designs were highly heterogeneous, further research is needed to better understand the optimal target population for PCA, the ideal dosage distribution, the key ingredients driving the improvement, and their neural correlates.

1. Introduction

Persons with aphasia (PWA) typically encounter word-finding difficulties, or anomia. The difficulty to find essential words can seriously affect everyday conversations and interpersonal relationships (Fama et al., 2022). The significant impact of anomia on daily life and social interactions can lead to decreased overall well-being and quality of life (Biran et al., 2024). As uttering a word stored in the mental lexicon requires retrieving both semantic and phonological features, anomia can result from impaired lexical-semantic or/and lexical-phonological processing. Therefore, two major therapeutic approaches for word-finding difficulties are often reported and compared in the speech and language therapy literature: semantically- and phonologically-based. Even if both approaches effectively treat anomia, the mechanisms underlying the improvements are still under debate. It remains unclear if the type of lexical therapy (semantic *vs.* phonological) should be strictly aligned with the level of breakdown (lexical-semantic anomia *vs.* lexical-phonological anomia), as mixed results have been found so far (e.g., Best et al., 2013; Kristinsson et al., 2021; Lorenz and Ziegler, 2009; van Hees et al., 2013; Wambaugh et al., 2001). Both therapeutic approaches might thus be a viable option for any PWA suffering from word-finding difficulties.

Semantically-based treatments for anomia recruit semantic features of the target word in order to activate its surrounding conceptual network. For instance, semantic cues can consist of a superordinate word, an associative verb, or a sentence to complete (e.g., Li and Williams, 1990). A famous semantically-based therapy consists of generating six semantic features from a picture to boost the activation of the target word: its group/category, its use, its action, its properties, its location, and a personal association (Boyle and Coelho, 1995). As such,

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the Semantic Feature Analysis (SFA) therapy has been used in numerous studies. A systematic review of SFA treatments by Efstratiadou et al. (2018), including 55 PWA from 21 studies, concluded that SFA was efficient in improving the naming accuracy of treated items in most participants (~80 %). The majority of PWA (~60 %) showed small effect sizes and maintenance of therapy gains in follow-up assessments. Limited generalisation was observed to untreated items or connected speech (~40 % of PWA).

Phonologically-based treatments are also widely used for anomia therapy (Madden et al., 2017). Such approaches employ the target word's phonological features to boost the activation of the phonological form. Typically, phonological cues consist of providing the first phoneme(s) or/and the last phoneme(s) of the target word. One of the most popular phonologically-based therapies is the Phonological Components Analysis (PCA), modelled after the SFA approach (Leonard et al., 2008). In the PCA, five phonological features are used to activate the target word from a picture: the first phoneme, a word beginning with the same phoneme, the last phoneme, a rhyming word, and the number of syllables. PCA therapy is conducted as follows:

- The PWA tries to name aloud the picture presented on a piece of paper or a computer screen.
- Whether the PWA produces a correct or incorrect response, the PWA tries to respond to the five phonological features spontaneously. In case of difficulty with any feature, the speech and language therapist provides a list of up to three responses, and the PWA tries to select the correct one from the list, with feedback concerning accuracy from the therapist. The therapist writes down the features.
- The PWA tries to name the picture again aloud.
- The therapist gives positive or negative feedback and also names the picture.
- The PWA is encouraged to repeat the target word.
- The therapist reviews the five phonological features whether the PWA produces a correct or incorrect response.

Contrary to the SFA and despite the growing popularity of the PCA, no systematic review has been conducted yet about the efficacy of PCA in treating anomia in individuals with post-stroke aphasia.

The research questions underlying the present systematic reviews were as follows:

1) What are the treatment-related and participant-related characteristics of studies assessing the efficacy of PCA for anomia therapy?

2) What is the methodological quality of PCA efficacy studies in aphasia?

3) What are the outcomes of PCA anomia therapy studies in terms of effect sizes related to immediate treatment gains for trained and untrained items and long-term maintenance for trained items?

2. Methods

The PRISMA 2020 Checklist (Page et al., 2021) served as a guideline to conduct the present systematic review (see Supplementary Material). The methodology was pre-registered in an international prospective register of systematic reviews (PROSPERO registration number CRD42024552047[1]). A systematic search of the literature was conducted to identify studies that investigated the efficacy of PCA as a primary intervention for PWA. The present method is based on the previous work of Efstratiadou et al. (2018) on the efficacy of SFA.

2.1. Eligibility criteria

Experimental studies using PCA with adults suffering from post-stroke aphasia and published in English were included. The following exclusion criteria were applied:

- Studies that combined PCA with other treatment approaches, where it was impossible to delineate the specific effects of PCA;
- Studies involving people with neurodegenerative disorders, such as primary progressive aphasia;
- Usability studies without efficacy measures;
- Master theses, PhD dissertations and conference abstracts/papers.

2.2. Information sources

Electronic searches of the following databases were conducted, with the last search in November 2024, using the EBSCOhost platform:

- Academic Search Complete
- eBook Academic Collection (EBSCOhost)
- eBook Collection (EBSCOhost)
- ERIC
- MEDLINE with Full Text
- Psychology and Behavioral Sciences Collection
- APA PsycINFO
- CINAHL Complete
- AMED - The Allied and Complementary Medicine Database

In addition to this database search, we added to the list all references that cited the original paper of Leonard et al. (2008). The last citation search also occurred in November 2024.

2.3. Search strategy

The search strategy comprised the following terms:

1. Phonological component* analysis
2. Phonological cue*
3. Phonemic cue*
4. 1 OR 2 OR 3
5. Aphasia
6. AND 5
7. Naming
8. Anomia
9. Word finding difficult*
10. 7 OR 8 OR 9
11. 6 AND 10
12. Therap*
13. Intervention*
14. Treat*
15. 12 OR 13 OR 14
16. 11 AND 15

We selected the publication date from 2008 to 2024 in reference to the first PCA report by the original authors Leonard et al. in 2008.

2.4. Selection and data collection processes

All references were imported into the automation tool Covidence,[2] which was then used for duplicate removal, study selection and data extraction processes.

To decide whether a study met the inclusion criteria, title and abstract screening was performed independently by two reviewers (MMT and GP). Covidence identified conflicts, which were further resolved by a discussion between the two reviewers. When a disagreement was flagged by Covidence (e.g., MMT excluded a reference based on the

[1] https://www.crd.york.ac.uk/PROSPERO/view/CRD42024552047

[2] Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org.

abstract, but GP independently included the same reference), the two reviewers met online and went through the abstract and discussed to reach a consensus. If in doubt, the abstract was included further for full-text analysis. The full-text review was performed similarly, and a few online meetings were needed to resolve the conflicts identified by Covidence between the two independent reviewers. The third reviewer (ED) was available to resolve conflicts in case the two reviewers could not agree, but this was not necessary. The two reviewers (MMT and GP) reached a consensus to finalise the list of included studies by going through the full texts together and discussing the differences. The full-text review resulted in two categories, as recommended by PRISMA guidelines:

1) Studies included in the review that further underwent data extraction;
2) Other reports of studies consisted of articles investigating the same group of individuals reported elsewhere. In such cases of overlap, we included as primary study the report where all PWA of the cohort were enrolled and where the behavioural efficacy of PCA was the study's main purpose.

Data extraction was performed similarly to abstract and full-text reviewing for the studies included. When raw data was missing from the original manuscript, supplementary materials or the graphs did not allow precise data reconstruction, the original authors were asked by email for the raw scores. Ten authors were contacted by email a maximum of two times. Four answered and partially or fully provided raw scores that were utilised to report data more precisely. The remaining missing data that could not be obtained (see Tables 2 and 4) was not included in the syntheses.

2.5. Variables extracted

For each included study, we systematically extracted:

- the number of participants
- the country and target language
- the inclusion and exclusion criteria
- the number of treated words
- the type of PCA (grammatical class of treated words, variations to the original PCA protocol)
- the frequency (days/week), session duration, intensity (hours/week), duration (total weeks), dosage (total hours)
- the modality of delivery (individual or in group, face to face or online, and other relevant information about the location)
- the study design
- the number of assessments pre-PCA and post-PCA.

For each participant, we systematically extracted:

- the age
- the gender
- the number of education years
- the etiology of acquired brain injury (ABI)
- the time post-ABI
- the aphasia severity
- the aphasia type
- the individual number of treated words
- the individual duration of the therapy (in weeks and hours)
- the immediate results on treated items (raw picture naming accuracy pre- *vs.* post-treatment, for each treated list)
- the maintenance results on treated items (raw picture naming accuracy in the last session before follow-up *vs.* at follow-up, for each treated list)
- the immediate results on untreated items (raw picture naming accuracy pre- *vs.* post-treatment, to assess the generalisation to untrained items usually selected on an individual basis and assessed repetitively)
- the immediate results on standardised picture naming tests or language batteries (raw picture naming accuracy, to assess the generalisation to normed measures)
- the immediate results of other standardised pre- *vs.* post-behavioural measures (summarised raw data to assess across-level generalisation).

2.6. Study risk of bias/quality assessment

To assess the quality of each included study, the Single-Case Experimental Design (SCED) 10-point Scale (Tate et al., 2008) was rated independently by two reviewers (MMT and GP) in Covidence. The relevant text for each point was highlighted in each manuscript. The automation software identified conflicts, which were further resolved by discussing them with the two reviewers. If the two reviewers could not agree, the third reviewer (ED) was asked to resolve the conflict.

2.7. Effect measures

A wide range of statistical measures were used in the included studies to investigate the immediate effects on treated/untreated items and maintenance effects on treated items. Due to this heterogeneity, we decided not to report all original statistical analyses here. The most frequent measure was an adaptation of the between-subject Cohen's d, namely within-subject Busk & Serlin's d. This effect size measure has been typically used in other systematic reviews or meta-analyses in the field (e.g., Efstratiadou et al., 2018; Lee and Faroqi-Shah, 2024). As the calculation methods of the d values might differ across studies, we decided to recalculate all individual d values instead of providing the original data (see Lee and Faroqi-Shah, 2024, for a similar methodology). We used a minimum of two pre-PCA and one post-PCA score to compute a within-subject d value for each PWA. When there was no variation in pre-PCA scores, 1 was added to one of the baseline scores to induce a minimal variance. This method was used as we could not have access to each participant's individual data and experimental designs were heterogeneous across studies: it was therefore not possible to calculate a variance score in a systematic way by using the performance of another period, as suggested by Beeson and Robey (2006). When several lists were successively treated, only the first list served to compute the d value. For maintenance effects, the two pre-PCA scores were related to the last follow-up score available. Effect sizes were interpreted according to benchmarks related to anomia treatments: 4.0 for small, 7.0 for medium and 10.1 for large effects (Beeson and Robey, 2006).

For immediate generalisation effects on standardised measures and across-level generalisation, we synthesised the analyses of the original authors without recalculation.

2.8. Synthesis methods

Due to the low number of studies included, the lack of randomised controlled trials and the scope of the present systematic review, no statistical synthesis methods were used, such as pairwise meta-analysis. Sensitivity analyses were not conducted to assess the robustness of findings, but results were synthesised descriptively and qualitatively in the Discussion section. Pearson's correlations were computed to estimate the relationship between the immediate *vs.* maintained gains in treated items and between the immediate gains in treated *vs.* untreated items. The alpha criterion was set to $< .05$.

2.9. Reporting bias and certainty assessment

To assess the risk of bias in the present review, we used the Risk Of Bias In Systematic reviews tool (ROBIS; Whiting et al., 2016). The three

authors completed phases 2 and 3 of the scale until a consensus was reached. Confidence in the body of evidence was not statistically assessed due to high variability in experimental designs.

3. Results

The results of the search and selection processes are summarised in the flow diagram adapted from PRISMA guidelines (Fig. 1). After 94 duplicate removals and 197 removals based on title/abstract screening, 14 full texts were excluded for two different reasons:

1) the phonological therapy was not PCA (e.g., syllabic cueing in Monetta et al., 2021) or an overly modified version of PCA (e.g., providing only three components instead of five in Hashimoto, 2012);
2) PCA was used alongside other phonological approaches (e.g., rhyme judgments in Kristinsson et al., 2021).

Finally, thirteen studies were included in the current systematic review. Eleven reports including the same participants were not included as primary studies (see Supplementary Material for the list of primary and secondary studies). However, they will be considered in the Discussion section to interpret the results and to open the way to future perspectives.

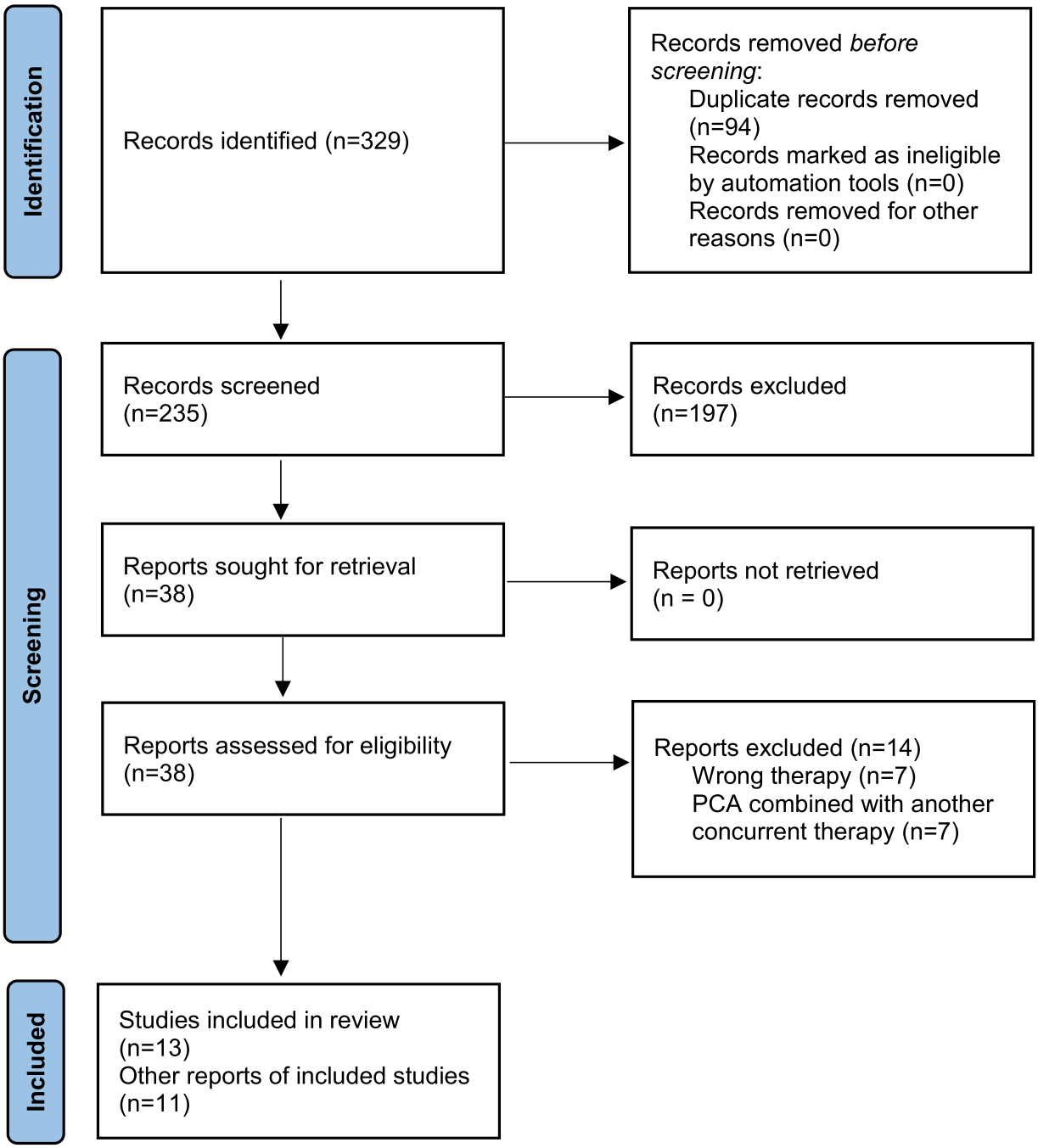

Fig. 1. Number of records in each selection phase.

3.1. Study characteristics

The data extracted from each study can be found in Table 1 for treatment-related characteristics and Table 2 for participant-related characteristics. Inclusion and exclusion criteria varied across studies, were sometimes underspecified or/and were not systematically labelled as such, but all studies targeted individuals with chronic stroke-induced aphasia (see Supplementary Material for a detailed table). The presence of aphasia was usually determined by standard batteries, such as the Boston Diagnostic Aphasia Examination (BDAE) or the Western Aphasia Battery (WAB). A few studies used the Boston Naming Test (BNT) to assess anomia and defined the accuracy range of 10–75 % as an inclusive criterion.

3.2. Treatment-related characteristics

All studies administered PCA in an individual, face-to-face setting, except for two participants in Masson-Trottier et al. (2024) who received PCA remotely due to pandemic constraints. Nine studies were conducted in English (6 in Canada, 1 in Australia, 1 in the UK, 1 in the USA), two in Persian (Iran), one in Swedish (Sweden) and one in French (Canada). Nine studies examined PCA with nouns employing the original protocol, three studies introduced a slight variation in the protocol (i.e., when the PWA gave no response or a wrong response for a phonological component, the correct response for the component was provided without presenting multiple choices), and one study used both nouns and verbs. Four studies compared PCA with SFA in the same individuals (Haentjens and Auclair-Ouellet, 2021; Neumann, 2018; Sadeghi et al., 2017; van Hees et al., 2013).

Therapy dosage ranged from 6 to 30 hours in total. The weekly intensity varied from 1 to 6 hours, except for Simic et al. (2021), who provided 12 hours per week in the high-intensity condition. In most studies, PCA therapy was administered around 3 times a week in 45–90-minute sessions, most lasting approximately 60 minutes. One study used a lower frequency of 1 session per week (Haentjens and Auclair-Ouellet, 2021), and another used a higher frequency of 5 sessions per week (Kristensson and Saldert, 2018). The number of treated items varied from 20 to 60, sometimes divided into smaller sets/lists that were trained successively.

3.3. Participant-related characteristics

In total, 89 PWA were enrolled (1–18 per study, mean 7, SD 5), 32 females and 57 males. Participants were aged 31–89 (mean 59, SD 14). They suffered from chronic aphasia at least 6 months post-stroke (mean 55 months post-stroke, SD 61, range 6–284). The severity of aphasia was reported for 75 PWA, yet it was determined by different scales throughout the studies (most often the BDAE Aphasia Severity Rating Scale (ASRS) or the WAB Aphasia Quotient (AQ)). When reported, BDAE ASRS scores ranged from 1 (severe) to 4 (mild) and WAB AQ scores from 18.66 (severe) to 91.6 (mild) in the present sample. Overall, aphasias were mild in 31 % of participants (n = 23), mild to moderate in 4 % (n = 3), moderate in 35 % (n = 26), moderate to severe in 11 % (n = 8) and severe in 20 % (n = 15). Most PWA presented with Broca's aphasia

Table 1
Treatment-related characteristics of PCA efficacy studies.

	n	Country	Language	Type of PCA	Frequency (days/ week)	Session duration (minutes)	Intensity (hours/ week)	Therapy duration (weeks)	Dosage (hours in total)	Number of treated words	Number of assessments	
											Pre-PCA	Post-PCA (timeframe)
Leonard et al., (2008)	10	Canada	English	Noun PCA	3	~60	~3	6–15	16–45	20–30 (2 or 3 lists)	3	2 (immediate, FU 4w)
Bose, (2013)	1	UK	English	Noun PCA	3	45–50	~2.5	11	27	30 (3 lists)	5	2 (immediate, FU 4w)
van Hees et al., (2013)	8	Australia	English	Noun PCA-	3	45–90	~2.5–4.5	4 *	10–18	30 (also 30 SFA and 30 untrained)	3	2 (immediate, FU 2–3w)
Leonard et al., (2015)	3	Canada	English	Noun PCA	3	60	3	10	30	30 (2 lists)	3	3 (immediate, FU 4w, FU 8w)
Sadeghi et al., (2017)	4	Iran	Persian	Noun PCA-	3–4	45	2.5–3	2 (P2&P3) 4 (P1&P4)	5.25 (P2&P3) 10.5 (P1&P4)	12 (1 list: P2&P3) 24 (2 lists: P1&P4)	3	1 (immediate)
Kristensson and Saldert, (2018)	2	Sweden	Swedish	Noun & Verb PCA	5	60	5	3–4	17 (P1) or 20 (P2)	30 (3 lists: P1) or 20 (2 lists: P2)	3	2 (immediate, FU 10w)
Neumann, (2018)	4	USA	English	Noun PCA	2–3	120	4–6	2–5	12–18	20 (also 20 SFA and 20 untrained)	2	2 (immediate, FU 4–6w)
Bose et al., (2019)	1	Canada	English	Noun PCA	3	60	3	30	30	30 (3 lists)	3	1–9
Simic et al., (2020)	10	Canada	English	Noun PCA	3	42 ± 11	~2	5	21 ± 3.4	30 (2 lists treated the same day)	3	3 (immediate, FU 4w, FU 8w)
Haentjens and Auclair-Ouellet, (2021)	4	Canada	English	Noun PCA	1	60	1	6	6	20	3	2 (immediate, FU 4w)
Simic et al., (2021)	16	Canada	English	Noun PCA	3 (ST) 4 (IT)	46 ± 13 (ST) 125 ± 10 (IT)	3 (ST) 12 (IT)	10 (ST) 2.5 (IT)	30	24–30	3	3 (immediate, FU 4w, FU 8w)
Shekari et al., (2024)	8	Iran	Persian	Noun PCA-	3	60	3	8	24	60	3	1 (immediate)
Masson-Trottier et al., (2024)	18	Canada	French	Noun PCA	3	60	3	5	15	20	3	3 (immediate, FU 12w, FU 24w)

PCA-=PCA without multiple choice; ST=Standard Treatment condition; IT=Intensive Treatment condition; FU=Follow-Up; *PCA alternated with SFA every session during these 4 weeks

Table 2
Participant-related characteristics of PCA efficacy studies.

Study	Participant	Age (years)	Gender	Education (years)	Etiology	TPO (months)	Aphasia severity (scale and score)	Aphasia type	Duration (weeks)	PCA duration (hours)	N items treated
Leonard et al., (2008)	P1	71	m	13	Left ischemic CVA	144	not reported	Broca	6	18 (List 1: 4; List 2: 14)	10
Leonard et al., (2008)	P2	57	m	8	Left CVA	36	not reported	Broca	15	45 (List 1: 15; List 2: 15; List 3: 15)	10
Leonard et al., (2008)	P3	50	f	21	Left CVA	12	not reported	Broca	14	40 (List 1: 10, List 2: 15, List 3: 15)	10
Leonard et al., (2008)	P4	65	f	14	Left CVA	168	not reported	Anomic	9	27 (List 1: 4; List 2: 8; List 3: 15)	10
Leonard et al., (2008)	P5	50	f	16	Left MCA CVA	42	not reported	Broca	14	40 (List 1: 10; List 2: 15; List 3: 15)	10
Leonard et al., (2008)	P6	73	m	12	Left MCA CVA	48	not reported	Mixed nonfluent	6	16 (List 1: 4; List 2: 6; List 3: 6)	10
Leonard et al., (2008)	P7	57	m	6	Left hemorrhagic CVA	204	not reported	Broca	10	30 (List 1: 15; List 2: 15)	10
Leonard et al., (2008)	P8	52	m	18	Left CVA	78	not reported	Broca	6	16 (List 1: 8; List 2: 4; List 3: 4)	10
Leonard et al., (2008)	P9	72	f	12	Left temporo-parietal hemorrhagic CVA	18	not reported	Wernicke	10	30 (List 1: 15; List 2: 15)	10
Leonard et al., (2008)	P10	70	m	19	Left CVA	30	not reported	Anomic	10	30 (List 1: 15; List 2: 15)	10
Bose, (2013)	P1-FF	77	m	College	Left temporo-parietal CVA	48	Severe (BDAE ASRS 1.5)	Wernicke	11	32 (List 1: 12; List 2: 9; List 3: 11)	10
van Hees et al., (2013)	P1-PS	60	f	10	Left CVA	38	Mild-moderate (WAB AQ 77.2)	Conduction	4	6–9 (6 sessions of 60–90 min)	30
van Hees et al., (2013)	P2-JV	60	m	13	Left CVA	57	Mild (WAB AQ 87.4)	Anomic	4	4.5–6 (6 sessions of 45–60 min)	30
van Hees et al., (2013)	P3-LW	41	f	14	Left CVA	170	Mild (WAB AQ 91.6)	Anomic	4	4.5–6 (6 sessions of 45–60 min)	30
van Hees et al., (2013)	P4-TW	52	f	16	Left CVA	55	Mild (WAB AQ 86.4)	Anomic	4	4.5–6 (6 sessions of 45–60 min)	30
van Hees et al., (2013)	P5-HJ	56	f	10	Left CVA	25	Moderate (WAB AQ 57.3)	Conduction	4	6–9 (6 sessions of 60–90 min)	30
van Hees et al., (2013)	P6-TK	48	f	11	Left CVA	17	Mild (WAB AQ 81.7)	Anomic	4	4.5–6 (6 sessions of 45–60 min)	30
van Hees et al., (2013)	P7-TP	69	m	10	Left CVA	36	Moderate (WAB AQ 73.4)	Anomic	4	6–9 (6 sessions of 60–90 min)	30
van Hees et al., (2013)	P8-BA	65	m	na	Left CVA	20	Mild (WAB AQ 82.9)	Anomic	4	6–9 (6 sessions of 60–90 min)	30
Leonard et al., (2015)	P1	74	m	16	Left MCA CVA	36	Severe (BDAE ASRS 2)	Broca	10	30 (Lists 1 and 2 trained in alternation)	30
Leonard et al., (2015)	P2	81	m	14	Left MCA CVA	12	Severe (BDAE ASRS 2)	Broca	10	30 (Lists 1 and 2 trained in alternation)	21
Leonard et al., (2015)	P3	89	f	15	Left MCA CVA	12	Severe (BDAE ASRS 1)	Broca	10	30 (Lists 1 and 2 trained in alternation)	30
Sadeghi et al., (2017)	P1	61	m	15	Left CVA	24	not reported	Broca	4 *	10.5 (2 blocks of 7 sessions of 45 min)	12
Sadeghi et al., (2017)	P2	52	f	9	Left CVA	17	not reported	Broca	2 * *	5.25 (1 block of 7 sessions of 45 min)	12
Sadeghi et al., (2017)	P3	45	m	12	Left CVA	67	not reported	Anomic	2 * *	5.25 (1 block of 7 sessions of 45 min)	12
Sadeghi et al., (2017)	P4	47	m	12	Left CVA	15	not reported	Broca	4 *	10.5 (2 blocks of 7 sessions of 45 min)	12
Kristensson and Saldert, (2018)	P1	76	f	11	Left ischemic CVA	24	Moderate (A-ning index 3.5)	Mixed fluent	3.5	17 (List 1: 7; List 2: 4; List 3: 6)	10

(*continued on next page*)

Table 2 (*continued*)

Study	Participant	Age (years)	Gender	Education (years)	Etiology	TPO (months)	Aphasia severity (scale and score)	Aphasia type	Duration (weeks)	PCA duration (hours)	N items treated
Kristensson and Saldert, (2018)	P2	72	m	20	Left hemorrhagic CVA	60	Moderate to severe (A-ning index 2.8)	Conduction	4	20 (List 1: 15; List 2: 5)	10
Neumann, (2018)	P1	41	m	16	Left CVA	96	Moderate (BDAE ASRS 3)	Conduction	3–5°	18–20	20
Neumann, (2018)	P2	38	f	18	Left CVA	24	Mild (BDAE ASRS 4)	Anomic	2–3°°	12	20
Neumann, (2018)	P3	60	m	19	Left CVA	84	Mild (BDAE ASRS 4)	Anomic	2–3°°	12	20
Neumann, (2018)	P4	47	m	16	Left CVA	24	Severe (BDAE ASRS 2)	Anomic	2–3°°	12	20
Bose et al., (2019)	P1-AM	85	m	12	Two left CVA which occurred within a month	180	Severe (BDAE ASRS 2)	Conduction	10	30	10
Simic et al., (2020)	P1	58	m	16	Left MCA ischemic CVA	13	Moderate (WAB AQ 61.8)	Broca	5	23	30
Simic et al., (2020)	P2	35	m	17	Left MCA ischemic CVA & cortical petechial hemorrhage	8	Moderate (WAB AQ 58.1)	Broca	5	21.9	30
Simic et al., (2020)	P3	75	m	20	Left MCA ischemic CVA	12	Mild (WAB AQ 77.2)	Anomic	5	21.4	30
Simic et al., (2020)	P4	35	f	15	Left MCA CVA (subarachnoid hemorrhage)	18	Severe (WAB AQ 39.6)	Broca	5	23.7	30
Simic et al., (2020)	P5	56	m	17	Left MCA ischemic CVA	12	Moderate (WAB AQ 64.9)	Broca	5	19.2	30
Simic et al., (2020)	P6	64	m	18	Left MCA ischemic CVA	6	Mild (WAB AQ 78.6)	Conduction	5	15	30
Simic et al., (2020)	P7	55	m	14	Left hemorrhagic CVA	10	Moderate (WAB AQ 66.8)	Broca	5	18.5	30
Simic et al., (2020)	P8	42	m	19	Left MCA & ACA ischemic CVA with hemorrhagic transformation	9	Moderate (WAB AQ 62.1)	Broca	5	26.8	30
Simic et al., (2020)	P9	79	m	13	Left hemorrhagic CVA	74	Mild (WAB AQ 84.1)	Anomic	5	22.7	30
Simic et al., (2020)	P10	56	m	18	Left ischemic MCA CVA & cortical petechial hemorrhage	19	Mild (WAB AQ 85.2)	Anomic	5	18.2	30
Haentjens and Auclair-Ouellet, (2021)	P1	63	m	17	Left ischemic CVA	153	Mild (WAB AQ 85.8)	Anomic	6	6	20
Haentjens and Auclair-Ouellet, (2021)	P2	67	m	17	Left ischemic CVA	105	Moderate (WAB AQ 56.1)	Broca	6	6	20
Haentjens and Auclair-Ouellet, (2021)	P3	50	f	13	Left ischemic CVA	50	Severe (WAB AQ 42.6)	Broca	6	6	20
Haentjens and Auclair-Ouellet, (2021)	P4	43	f	18	Left hemorrhagic CVA	18	Mild (WAB AQ 91.6)	Anomic	6	6	20
Simic et al., (2021)	P1	44	m	17	Left frontal, temporal, parietal CVA	105	Moderate (WAB AQ 66.0)	Broca	10	30	30
Simic et al., (2021)	P2	50	f	15	Left MCA CVA	24	Moderate (WAB AQ 63.2)	Broca	10	30	24
Simic et al., (2021)	P3	64	f	14	Subarachnoid hemorrhage	204	Moderate (WAB AQ 53.9)	Broca	10	30	30
Simic et al., (2021)	P4	33	f	13	Left CVA	18	Moderate (WAB AQ 68.4)	Conduction	10	30	30
Simic et al., (2021)	P5	59	m	13	Left MCA CVA	18	Severe (WAB AQ 47.9)	Broca	10	30	30
Simic et al., (2021)	P6	56	f	14	Left MCA CVA	36	Moderate (WAB AQ 53.9)	Broca	10	30	30
Simic et al., (2021)	P7	46	f	17	Left intraparenchymal hemorrhagic CVA	54	Mild (WAB AQ 85.8)	Anomic	10	30	25
Simic et al., (2021)	P8	58	m	13	Left MCA CVA	12	Moderate (WAB AQ 61.8)	Broca	10	30	30
Simic et al., (2021)	P9	57	m	12	Left MCA hemorrhagic CVA	24	Severe (WAB AQ 40.2)	Broca	2.5	30	30
Simic et al., (2021)	P10	53	f	16	Left MCA CVA	18	Mild (WAB AQ 82.0)	Anomic	2.5	30	30

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Table 2 (*continued*)

Study	Participant	Age (years)	Gender	Education (years)	Etiology	TPO (months)	Aphasia severity (scale and score)	Aphasia type	Duration (weeks)	PCA duration (hours)	N items treated
Simic et al., (2021)	P11	66	f	12	Left CVA	57	Moderate (WAB AQ 74.0)	Anomic	2.5	30	26
Simic et al., (2021)	P12	46	m	15	Left CVA due to AVM	222	Moderate (WAB AQ 60.4)	Broca	2.5	30	30
Simic et al., (2021)	P13	41	f	18	Left intracerebral hemorrhagic CVA	18	Severe (WAB AQ 40.4)	Wernicke	2.5	30	30
Simic et al., (2021)	P14	59	f	14	Left MCA CVA	36	Moderate (WAB AQ 65.6)	Broca	2.5	30	30
Simic et al., (2021)	P15	35	m	17	Left MCA CVA	9	Moderate (WAB AQ 58.1)	Broca	2.5	30	30
Simic et al., (2021)	P16	75	m	20	Left MCA CVA	12	Mild (WAB AQ 77.2)	Anomic	2.5	30	30
Shekari et al., (2024)	P8	56	m	14	Left CVA	24	Moderate (P-WAB AQ 78.66)	Broca	8	24	60
Shekari et al., (2024)	P9	50	f	8	Left CVA	96	Mild (P-WAB AQ 56)	Anomic	8	24	60
Shekari et al., (2024)	P10	31	m	9	Left CVA	14	Moderate (P-WAB AQ 18.66)	Broca	8	24	60
Shekari et al., (2024)	P11	48	f	8	Left CVA	34	Severe (P-WAB AQ 29.83)	Global	8	24	60
Shekari et al., (2024)	P12	61	m	14	Left CVA	36	Moderate to severe (P-WAB AQ 90.6)	Broca	8	24	60
Shekari et al., (2024)	P13	48	m	9	Left CVA	13	Mild (P-WAB AQ 23.83)	Anomic	8	24	60
Shekari et al., (2024)	P14	46	m	14	Left CVA	30	Severe (P-WAB AQ 16.83)	Global	8	24	60
Shekari et al., (2024)	P15	32	m	14	Left CVA	60	Mild to moderate (P-WAB AQ 71.5)	Anomic	8	24	60
Masson-Trottier et al., (2024)	P1-PA02	58	m	12	Left CVA	57	Moderate to severe (BDAE ASRS 2)	Broca	5	15	20
Masson-Trottier et al., (2024)	P2-PA05	73	m	6	Left CVA	36	Mild to moderate (BDAE ASRS 4)	Transcortical motor	5	15	20
Masson-Trottier et al., (2024)	P3-PA08	82	m	15	Left CVA	24	Moderate to severe (BDAE ASRS 2)	Transcortical mixed	5	15	20
Masson-Trottier et al., (2024)	P4-PA11	48	m	15	Left CVA	22	Moderate (BDAE ASRS 3)	Transcortical motor	5	15	20
Masson-Trottier et al., (2024)	P5-PA12	70	f	15	Left CVA	41	Severe (BDAE ASRS 1)	Global	5	15	20
Masson-Trottier et al., (2024)	P6-PA13	75	m	15	Left CVA	284	Mild (BDAE ASRS 4)	Conduction	5	15	20
Masson-Trottier et al., (2024)	P7-PA15	60	m	12	Left CVA	172	Mild (BDAE ASRS 4)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P8-PA16	69	m	12	Left CVA	268	Moderate to severe (BDAE ASRS 2)	Transcortical mixed	5	15	20
Masson-Trottier et al., (2024)	P9-PA17	72	f	12	Left CVA	47	Moderate to severe (BDAE ASRS 2)	Broca	5	15	20
Masson-Trottier et al., (2024)	P10-PA19	65	m	15	Left CVA	57	Moderate to severe (BDAE ASRS 2)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P11-PA20	73	m	20	Left CVA	74	Mild (BDAE ASRS 4)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P12-PA22	63	f	18	Left CVA	11	Moderate to severe (BDAE ASRS 2)	Broca	5	15	20
Masson-Trottier et al., (2024)	P13-PA25	79	m	20	Left CVA	12	Severe (BDAE ASRS 1)	Global	5	15	20
Masson-Trottier et al., (2024)	P14-PA26	48	f	15	Left CVA	12	Moderate (BDAE ASRS 3)	Transcortical mixed	5	15	20

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Table 2 (*continued*)

Study	Participant	Age (years)	Gender	Education (years)	Etiology	TPO (months)	Aphasia severity (scale and score)	Aphasia type	Duration (weeks)	PCA duration (hours)	N items treated
Masson-Trottier et al., (2024)	P15-PA27	77	m	17	Left CVA	11	Moderate (BDAE ASRS 3)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P16-PA28	70	m	13	Left CVA	56	Mild (BDAE ASRS 4)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P17-PA29	46	f	15	Left CVA	38	Mild (BDAE ASRS 4)	Anomic	5	15	20
Masson-Trottier et al., (2024)	P18-PA30	82	m	15	Left CVA	34	Moderate (BDAE ASRS 3)	Transcortical mixed	5	15	20

*interrupted by 2 weeks of SFA; * *inserted in 4 weeks of SFA; °estimation based on the number of probes: 3, meaning 9 or 10 sessions of 2 h 2–3x/week; °°estimation based on the number of probes: 2, meaning 6 sessions of 2 h 2–3x/week BDAE ASRS: Boston Diagnostic Aphasia Examination Aphasia Severity Rating Scale, CVA: Cerebro-Vascular Accident, MCA: Middle Cerebral Artery, WAB AQ: Western Aphasia Battery Aphasia Quotient

(40 %, n = 36) or anomic aphasia (34 %, n = 30). The remaining PWA received a diagnosis of conduction aphasia (9 %, n = 8), global aphasia (4 %, n = 4), transcortical mixed aphasia (4 %, n = 4), Wernicke's aphasia (3 %, n = 3), transcortical motor aphasia (2 %, n = 2), mixed fluent aphasia (1 %, n = 1) or mixed nonfluent aphasia (1 %, n = 1).

3.4. Quality assessment

The results from the SCED scale (Tate et al., 2008) for each study can be found in Table 3. Although the scale consists of 11 points, only ten were retained to assess the methodological quality and to calculate the total score as recommended. All studies reached at least 7 points (out of 10), with the majority reaching 8 points (on average 8.6, SD 1.0).

3.5. Effect measures

The effect sizes recalculated for each participant can be found in Table 4. Out of the 89 participants, it was possible to recalculate effect sizes for 85 participants on immediate effects for treated items, for 71 on maintenance effects for treated items and for 59 on generalisation effects to untreated items.

Immediate effect sizes for treated items were medium-large on average (8.96 ± 6.67), with a wide variability from null effect sizes (-0.58) to very large effect sizes (25.40). While about one-third of participants (27/85, 31.8 %) showed large effect sizes above 10.1, one-quarter of participants (22/85, 25.9 %) showed an effect size below 4.0 (i.e., less than small). The remaining participants equally showed small to medium effect sizes between 4.0 and 7.0 (18/85, 21.2 %) or medium to large effect sizes between 7.0 and 10.1 (18/85, 21.2 %).

Effect sizes related to the maintenance of treated items were small on average (4.96 ± 5.07), again with a similar wide variability (from −2.60–23.00). Half of the participants showed effect sizes below 4.0 (33/71, 46.5 %), 26.8 % (19/71) showed small to medium effect sizes, 14.1 % (10/71) showed medium to large effect sizes, and 12.7 % (9/71) showed large effect sizes above 10.1.

For generalisation to untreated items, effect sizes were also small on average (4.52 ± 5.28) and greatly variable (from −3.46–24.25). The majority of participants (62.7 %, 37/59) showed effect sizes below 4.0, 15.3 % (9/59) of them showed small to medium effect sizes, 8.5 % (5/59) medium to large effect sizes and 13.6 % (8/59) large effect sizes above 10.1.

There were significant correlations between the effect sizes for immediate *vs.* maintained gains for treated items ($r = .55$, $p < .001$) and between the effect sizes for immediate gains on treated *vs.* untreated items ($r = .36$, $p = .005$).

Generalisation to standardised measures was assessed in 8 out of 13 studies, usually through normed picture naming tests (Table 4). Among the 61 participants who underwent standardised picture naming tests pre- *vs* post-PCA, 57 % (35/61) demonstrated generalisation effects to normed measures. Across-level generalisation was assessed in half of the studies (6/13) using discourse tasks (picture description or/and narrative), semantic tasks or quality of life or/and communication scales. Among 18 participants tested on discourse tasks, 44 % (8/18) demonstrated generalisation effects in terms of total number of utterances (or words per minute), mean length of utterances or total number of main concepts. In participants tested on semantic tasks by Shekari et al. (2024), 6/8 demonstrated improvements on the Persian word-to-word matching version of the Pyramids and Palm Trees test (PPTT; Howard and Patterson, 1992). Among the 38 participants tested on quality of life or communication scales, the only significant transfer was reported in Masson-Trottier et al. (2024) for 7 out of 16 participants on the communicative effectiveness index (CETI; Lomas et al., 1989) filled in by proxies. Importantly, note that other studies reporting non-significant changes used different scales such as the Communication Outcome After STroke scale (COAST; Long et al., 2009) filled in both by the PWA and a relative, or the self-reported Quality of Communication

Table 3
Methodological quality of included studies according to the SCED Scale.

	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	SCED total (out of 10)
Leonard et al., (2008)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	9
Bose, (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	8
van Hees et al., (2013)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	8
Leonard et al., (2015)	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8
Sadeghi et al., (2017)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	8
Kristensson and Saldert, (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Neumann, (2018)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	8
Bose et al., (2019)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	7
Simic et al., (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Haentjens and Auclair-Ouellet, (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	9
Simic et al., (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Shekari et al., (2024)	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	8
Masson-Trottier et al., (2024)	Not a single-case study, but a non-randomised experimental group study											

SCED Quality Criteria: 0.=Clinical history, 1.=Target behaviours, 2.=Study design, 3.=Baseline, 4.=Sampling behaviour during treatment, 5.=Raw data record, 6.=Inter-rater reliability, 7.= Independance of assessors, 8.=Statistical analyses, 9.=Replication, 10.=Generalisation

Life scale from the American Speech-Language-Hearing Association (ASHA-QCL; Paul et al., 2004).

3.6. Risk of bias in the current review

Upon completing the ROBIS assessment, we identified no major consequential concern regarding the risk of bias in the present systematic review. Among the potential concerns, eligibility criteria excluded theses, dissertations, conference proceedings, and studies published in non-English languages, which may have restricted the studies included. Furthermore, one study could not be evaluated for its methodological quality with the SCED scale due to its group design. Finally, effect sizes could only be calculated for studies that made detailed raw data available, and comprehensive statistical analyses were hampered by methodological heterogeneity. Nevertheless, most studies demonstrated sufficient rigor, and all eligible studies were included in the synthesis where data allowed. Despite these minor concerns, the overall risk of bias was estimated as low, and the findings of this review can be considered reliable.

4. Discussion

The purpose of the present review was to assess the methodological quality of PCA efficacy studies, summarise their characteristics and synthesise their outcomes. In total, 13 studies were reviewed, including 89 PWA.

The methodological quality of the included studies was generally high according to the SCED rating scale (8.6/10 on average). Only a minority of studies (n = 4) used independent assessors. Overall, the included studies were highly heterogeneous in terms of participant-related characteristics (time post-stroke, aphasia severity and type) and treatment-related characteristics (dosage, number of treated items and number of consecutive lists, number of assessments during therapy, generalisation and control measures, …).

The proportion of participants showing improvements post-PCA (i.e., at least a small effect size) is quite similar to the proportions reported by Efstratiadou et al. (2018) post-SFA, despite having a larger number participants in this review: PCA therapy was efficient in improving the naming accuracy of treated items in the majority of participants immediately (74 % here *vs.* 82 % for the SFA review) and in the long-term (55 % here *vs.* 62 % for SFA), whereas generalisation to untreated items or connected speech was more limited (37–44 % here *vs.* 40 % for SFA). Generalisation to communication, assessed by questionnaires, showed less evident transfer (29 %, i.e., 11/38 PWA).

A few issues will be detailed below to synthesise available evidence and current limitations and to put results in the context of other relevant studies (for instance, using variants/combinations of PCA or involving the same set of participants).

4.1. The target population for PCA

The present review highlights that some PWA were good responders to PCA, but others were not. Overall, PWA that responded well to the PCA therapy for immediate effects on treated items showed strong maintenance of therapy gains and a generalisation to untreated items, as significant correlations were found. Due to the extreme variability across studies in terms of experimental design inducing numerous potential biases, it seems premature to compute meta-analytic links between participant-related variables and treatment outcomes. The study with the most significant sample (Masson-Trottier et al., 2024) investigated the influence of participant-related variables on treatment outcomes. Gender, years of education and time post-stroke did not significantly modulate treatment gains, whereas age was a significant variable: older participants showed less improvement than younger participants. In a subsample of participants, it was suggested that bilingual PWA could show greater PCA outcomes than monolingual PWA (Masson-Trottier et al., 2022). Other significant predictors of PCA outcomes were reported by Simic, Chambers, et al. (2020), namely the responsiveness to cueing and naming improvements made during the first therapy sessions.

Some other features possibly explaining the variability in outcomes will be discussed below: anomia severity, anomia subtype and associated motor/cognitive disorders (apraxia of speech, metaphonological and/or executive impairment).

In terms of anomia severity, the two studies with the largest samples of participants both reported that individuals with milder anomias showed greater benefits for treated items (and untreated items to a lesser extent) after PCA than individuals with more severe anomias (Masson-Trottier et al., 2024; Simic et al., 2021). This observation is consistent with case reports of severe jargon aphasia where PCA failed to induce a small effect size (Bose, 2013; Bose et al., 2019).

Regarding the anomia subtype, most participants suffered from semantic processing impairments rather than phonological processing impairments in the original study by Leonard et al. (2008). Although PCA has a strong phonological emphasis/focus, it is not purely phonological, as it also requires access to semantics from the picture (Leonard et al., 2008). A study controlling for the type of anomia showed that PCA was efficient for both lexical-semantic and lexical-phonological impairments (van Hees et al., 2013). The severity and the type of anomia might also interact, as a phonological treatment (including PCA) in a large randomised controlled trial was found to be more effective for PWA with severe lexical-semantic anomia, but less effective for PWA with severe lexical-phonological anomia (Kristinsson et al., 2021).

In terms of associated apraxia of speech, individuals with motor speech disorders were sometimes excluded (e.g., in the first study by Leonard et al., 2008). The studies including participants with apraxia of speech showed that they could benefit from PCA (Simic et al., 2021) but

Table 4
Effect sizes recalculated for every participant, generalisation to standardised measures and across levels.

Study	Participant	d Treated Pre vs Post	d Treated Pre vs Follow-up	d Untreated Pre vs Post	Generalization to standardized measures	Across-level generalization
Leonard et al., (2008)	P1	13.28	11.55	na	NO* (PNT 72 % -> 77 %)	not assessed
Leonard et al., (2008)	P2	13.28	13.28	na	YES* (PNT 47 % -> 59 %)	not assessed
Leonard et al., (2008)	P3	13.28	13.28	na	YES* (PNT 23 % -> 61 %)	not assessed
Leonard et al., (2008)	P4	15.01	8.08	na	YES* (PNT 52 % -> 63 %)	not assessed
Leonard et al., (2008)	P5	13.28	9.81	na	NO* (PNT 49 % -> 54 %)	not assessed
Leonard et al., (2008)	P6	5.2	5.20	na	NO* (PNT 64 % -> 69 %)	not assessed
Leonard et al., (2008)	P7	4.62	−0.58	na	NO* (PNT 9 % -> 10 %)	not assessed
Leonard et al., (2008)	P8	2.00	4.00	na	NO* (PNT 69 % -> 73 %)	not assessed
Leonard et al., (2008)	P9	−0.58	−0.58	na	NO* (PNT 9 % -> 8 %)	not assessed
Leonard et al., (2008)	P10	−0.58	−0.58	na	YES* (PNT 1 % -> 9 %)	not assessed
Bose, (2013)	P1-FF	1.48	1.09	na	NO* (PNT 76/175 -> 75/175)	not assessed
van Hees et al., (2013)	P1-PS	9.45	5.67	1.51	NO* (BNT 35/60 -> no score post ttt provided)	YES (number of utterances or MLU in 5 discourse tasks)
van Hees et al., (2013)	P2-JV	3.05	−2.60	0.84	NO* (BNT 57/60 -> no score post ttt provided)	NO (five discourse tasks)
van Hees et al., (2013)	P3-LW	5.33	5.00	1.33	NO* (BNT 44/60 -> no score post ttt provided)	NO (five discourse tasks)
van Hees et al., (2013)	P4-TW	3.93	3.71	2.76	NO* (BNT 57/60 -> no score post ttt provided)	NO (five discourse tasks)
van Hees et al., (2013)	P5-HJ	5.48	3.18	1.15	NO* (BNT 9/60 -> no score post ttt provided)	YES (number of utterances or MLU in 5 discourse tasks)
van Hees et al., (2013)	P6-TK	2.89	2.62	0.63	YES* (BNT 40/60 -> no score post ttt provided)	NO (five discourse tasks)
van Hees et al., (2013)	P7-TP	3.27	2.89	0.83	NO* (BNT 31/60 -> no score post ttt provided)	YES (number of utterances or MLU in 5 discourse tasks)
van Hees et al., (2013)	P8-BA	3.44	2.86	0.32	NO* (BNT 35/60 -> no score post ttt provided)	YES (number of utterances or MLU in 5 discourse tasks)
Leonard et al., (2015)	P1	na	na	na	NO* (PNT 67 % -> 63 %)	na
Leonard et al., (2015)	P2	na	na	na	YES* (PNT 63 % -> 75 %)	na
Leonard et al., (2015)	P3	na	na	na	YES* (PNT 7 % -> 26 %)	na
Sadeghi et al., (2017)	P1	6.35	−0.58	2.69	not assessed	not assessed
Sadeghi et al., (2017)	P2	20.21	−0.58	14.43	not assessed	not assessed
Sadeghi et al., (2017)	P3	20.21	−0.58	5.77	not assessed	not assessed
Sadeghi et al., (2017)	P4	18.48	−0.58	0.00	not assessed	not assessed
Kristensson and Saldert, (2018)	P1	10.16	8.08	na	not assessed	YES (wpm and CIU in picture description); NO (COAST & Carer-COAST)
Kristensson and Saldert, (2018)	P2	2.74	2.89	na	not assessed	NO (Cookie Theft picture description); NO (COAST & Carer-COAST)
Neumann, (2018)	P1	3.06	−1.41	na	not assessed	not assessed
Neumann, (2018)	P2	1.16	−1.03	na	not assessed	not assessed
Neumann, (2018)	P3	3.82	−1.56	na	not assessed	not assessed
Neumann, (2018)	P4	1.80	2.32	na	not assessed	not assessed
Bose et al., (2019)	P1-AM	1.48	−1.53	0.22	NO* (PNT 35/175 -> 18/175)	not assessed
Simic et al., (2020)	P1	4.18	4.75	1.04	na	not assessed
Simic et al., (2020)	P2	8.00	8.00	4.33	YES* (PNT 110/175 -> 121/175)	not assessed
Simic et al., (2020)	P3	8.95	4.36	3.49	YES* (PNT 56/175 -> 67/175)	not assessed
Simic et al., (2020)	P4	10.10	1.44	0.00	YES* (PNT 51/175 -> 56/175)	not assessed
Simic et al., (2020)	P5	11.00	15.00	6.67	YES* (PNT 65/175 -> 91/175)	not assessed
Simic et al., (2020)	P6	23.00	23.00	8.00	NO* (PNT 123/175 -> 123/175)	not assessed
Simic et al., (2020)	P7	24.00	18.00	5.00	YES* (PNT 87/175 -> 99/175)	not assessed
Simic et al., (2020)	P8	2.18	1.90	1.71	YES* (PNT 31/175 -> 67/175)	not assessed
Simic et al., (2020)	P9	9.60	5.67	2.18	NO* (PNT 115/175 -> 113/175)	not assessed
Simic et al., (2020)	P10	10.68	5.48	1.73	YES* (PNT 97/175 ->104/175)	not assessed
Haentjens and Auclair-Ouellet, (2021)	P1	7.65	7.22	3.18	NO° (WAB AQ 85.8 -> 87.5); YES° (BNT 44/60 -> 49/60); NO (Fluency)	NO (QCL, SAQOL−39)
Haentjens and Auclair-Ouellet, (2021)	P2	6.00	−1.00	0.00	YES° (WAB AQ 56.1 -> 61.4); NO° (BNT 10 /60 -> 15/60); NO (Fluency)	NO (QCL, SAQOL−39)
Haentjens and Auclair-Ouellet, (2021)	P3	0.44	−0.87	1.75	YES° (WAB AQ 42.6 -> 52.7); NO° (BNT 2/ 60 -> 4/60); NO (Fluency)	NO (QCL, SAQOL−39)
Haentjens and Auclair-Ouellet, (2021)	P4	3.68	2.72	2.24	NO° (WAB AQ 91.6 -> 90.6); NO° (BNT 24/60 -> 27/60); NO (Fluency)	NO (QCL, SAQOL−39)
Simic et al., (2021)	P1	5.35	6.00	0.87	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P2	6.81	6.81	3.46	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P3	5.48	0.29	0.29	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P4	3.00	2.66	−0.23	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P5	6.00	7.00	4.67	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P6	5.50	2.50	2.67	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P7	7.50	5.00	2.67	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P8	4.18	4.75	1.04	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P9	7.94	4.91	na	not assessed	^NO (ASHA-QCL)

(*continued on next page*)

Table 4 (*continued*)

Study	Participant	d Treated Pre vs Post	d Treated Pre vs Follow-up	d Untreated Pre vs Post	Generalization to standardized measures	Across-level generalization
Simic et al., (2021)	P10	9.77	7.85	7.21	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P11	2.95	2.95	1.30	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P12	na	na	na	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P13	9.6	8.95	5.46	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P14	5.92	6.35	2.17	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P15	8.00	8.00	4.33	not assessed	^NO (ASHA-QCL)
Simic et al., (2021)	P16	10.26	4.36	4.15	not assessed	^NO (ASHA-QCL)
Shekari et al., (2024)	P8	23.67	na	na	YES° (PNB 36/60 -> 48/60); YES° (P-WAB 78.66 -> 89.83)	^NO (PPTT 96/104 -> 96/104)
Shekari et al., (2024)	P9	17.90	na	na	YES° (PNB 17/60 -> 38/60); YES° (P-WAB 56 -> 68.33)	^YES (PPTT 84/104 -> 86/104)
Shekari et al., (2024)	P10	17.90	na	na	YES° (PNB 12/60 -> 36/60); YES° (P-WAB 18.66 -> 33.33)	^YES (PPTT 88/104 -> 92/104)
Shekari et al., (2024)	P11	16.17	na	na	YES° (PNB 2/60 -> 30/60); YES° (P-WAB 29.83 -> 47.83)	^YES (PPTT 60/104 -> 76/104)
Shekari et al., (2024)	P12	23.67	na	na	YES° (PNB 37/60 -> 48/60); YES° (P-WAB 90.6 -> 97.33)	^NO (PPTT 96/104 -> 96/104)
Shekari et al., (2024)	P13	8.00	na	na	YES° (PNB 10/60 -> 35/60); YES° (P-WAB 23.83 -> 56.6)	^YES (PPTT 68/104 -> 82/104)
Shekari et al., (2024)	P14	18.48	na	na	YES° (PNB 1/60 -> 14/60); YES° (P-WAB 16.83 -> 44.5)	^YES (PPTT 60/104 -> 80/104)
Shekari et al., (2024)	P15	21.36	na	na	YES° (PNB 34/60 -> 50/60); YES° (P-WAB 71.5 -> 90)	^YES (PPTT 96/104 -> 98/104)
Masson-Trottier et al., (2024)	P1-PA02	2.89	15.01	10.39	NO (TDQ 36/60 -> 33/60)	YES (CETI 54 -> 65)
Masson-Trottier et al., (2024)	P2-PA05	25.40	4.62	−3.46	YES (TDQ60 24/60 -> 42/60); NO (DVL38 99/114 -> 100/114)	NO (CETI 78 -> 76)
Masson-Trottier et al., (2024)	P3-PA08	6.35	2.89	1.73	YES (TDQ60 16/60, 22/60); YES (DVL38 40/114 -> 52/114)	na
Masson-Trottier et al., (2024)	P4-PA11	14.00	9.00	13.67	YES (TDQ60 43/60 -> 49/60); NO (DVL38 107/114 -> 108/114)	YES (Main concepts in narrative discourse) & NO° (CETI 62 -> 71)
Masson-Trottier et al., (2024)	P5-PA12	4.00	4.00	3.00	YES (TDQ60 1/60 -> 18/60); YES (DVL38 43/114 -> 71/114)	NO (Main concepts in narrative discourse) & YES (CETI 53 -> 64)
Masson-Trottier et al., (2024)	P6-PA13	5.00	3.00	2.83	YES (TDQ60 53/60 -> 59/60); NO (DVL38 95/114 -> 98/114)	YES (CETI 61 -> 71)
Masson-Trottier et al., (2024)	P7-PA15	1.31	1.09	1.24	NO (TDQ60 60/60 -> 60/60); NO (DVL38 103/114 -> 109/114)	NO (Main concepts in narrative discourse) & NO° (CETI 79 -> 87)
Masson-Trottier et al., (2024)	P8-PA16	21.36	14.43	17.32	NO (TDQ60 32/60 -> 33/60); YES (DVL38 40/114 -> 59/114)	NO (CETI 41 -> 41)
Masson-Trottier et al., (2024)	P9-PA17	9.81	9.81	24.25	YES (TDQ60 18/60 -> 40/60); YES (DVL38 15/114 -> 33/114)	NO (Main concepts in narrative discourse) & YES (CETI 37 -> 51)
Masson-Trottier et al., (2024)	P10-PA19	8.95	6.35	9.81	NO (TDQ60 57/60 -> 58/60); YES (DVL38 91/114 -> 106/114)	NO (Main concepts in narrative discourse) & NO° (CETI 92 -> 97)
Masson-Trottier et al., (2024)	P11-PA20	7.22	2.89	8.95	YES (TDQ60 24/60 -> 42/60); NO (DVL38 99/114 -> 100/114)	YES (Main concepts in narrative discourse) & NO° (CETI 45 -> 53)
Masson-Trottier et al., (2024)	P12-PA22	13.28	na	9.81	YES (TDQ60 57/60 -> 60/60); NO (DVL38 105/114 -> 105/114)	NO (Main concepts in narrative discourse) & YES (CETI 58 -> 69)
Masson-Trottier et al., (2024)	P13-PA25	9.81	na	19.05	NO (TDQ60 9/60 -> 10/60); YES (DVL38 31/114 -> 52/114)	NO° (CETI 43 -> 46)
Masson-Trottier et al., (2024)	P14-PA26	7.42	11.35	13.53	YES (TDQ60 43/60 -> 57/60); YES (DVL38 22/114 -> 31/114)	NO° (CETI 82 -> 86)
Masson-Trottier et al., (2024)	P15-PA27	13.57	na	6.06	YES (TDQ60 36/60 -> 47/60); NO (DVL38 95/114 -> 102/114)	YES (Main concepts in narrative discourse) & YES° (CETI 64 -> 85)
Masson-Trottier et al., (2024)	P16-PA28	9.24	na	1.44	YES (TDQ60 55/60 -> 58/60); NO (DVL38 102/114 -> 105/114)	YES (CETI 63 -> 74)
Masson-Trottier et al., (2024)	P17-PA29	4.19	na	2.89	YES (TDQ60 57/60 -> 60/60); NO (DVL38 111/114 -> 105/114)	NO° (CETI 68 -> 76)
Masson-Trottier et al., (2024)	P18-PA30	16.74	na	10.39	na	na

YES/NO refer to numerical observations except (*) when statistical validation was provided by the original authors, (°) when the use of benchmarks of Gilmore et al., (2019) was possible (i.e., min. +5.03 for WAB-AQ; min. +3.3 for BNT; min. +10.37 for CETI) or (^) when group analyses were conducted

that individuals with severe apraxia of speech showed less benefit than participants with milder or no apraxia of speech (Masson-Trottier et al., 2024). Nevertheless, potential participants showing very reduced voluntary speech due to severe apraxia of speech had to be excluded in Masson-Trottier et al. (2024).

In terms of associated cognitive skills, PCA requires and trains a certain amount of metaphonological abilities to segment and manipulate phonemes/syllables. Such abilities might be particularly impaired in aphasia (Meier et al., 2016). Whereas executive skills did not predict immediate treatment effects for treated items or long-term generalisation to untreated items in PCA, better executive functioning was related to better delayed gains for treated items and better immediate generalisation to untreated items (Simic, Bitan, et al., 2020).

4.2. The mode of delivery of PCA

PCA was typically delivered in-person in an individual face-to-face therapeutic setting. However, one usability study showed favorable

results of PCA provided remotely in telerehabilitation (Simic et al., 2016). In addition, two participants in Masson-Trottier et al. (2024) had to receive PCA remotely due to pandemic constraints, yet they achieved similar improvements as PWA receiving in-person PCA. Therefore, it is likely that PCA could also be an appropriate online treatment in certain cases to provide evidence-based intensive and long-term therapy (Cetinkaya et al., 2024).

4.3. The dosage of PCA

Even if the number and the distribution of therapy sessions/hours were very variable across studies, on average PWA received PCA for 3 one-hour sessions per week, during a few weeks. When comparing two schedules distributing 30 hours of PCA sessions either 12 hours/week for 2.5 weeks or 3 hours/week for 10 weeks, no difference was found for long-term effects (Simic et al., 2021). Improvements for treated items were reported after a variety of schedules distributing sessions from 1 per week over 6 weeks (Haentjens and Auclair-Ouellet, 2021) to 5 per week over 4 weeks (Kristensson and Saldert, 2018). The optimal dosage of PCA therapy thus remains vague, but it seems adaptable to actual clinical constraints in a positive way. Future PCA research should aim at providing gain estimates according to therapy dosage, as it has been proposed for SFA (Quique et al., 2019).

4.4. The content of PCA

In PCA, multiple mechanisms are integrated within a framework that remains largely opaque. Exploring PCA through the lens of the Rehabilitation Treatment Specification System (RTSS) allows to identify several ingredients that might lead to the observed therapeutic goal (Hart et al., 2019). In the context of PCA, the goal is to improve naming abilities in PWA. The overarching goal can further be decomposed into several measurable targets, namely increased naming accuracy, reduced response time, increased independence in generating the cues, use of self-cueing to initiate word-finding, *etc*. In terms of ingredients, on top of the phonological activation of the target word through the generation of associated phonological properties and cues, stimuli are presented in image format (likely leading to semantic activation), target words are repeated multiple times within or/and across sessions (likely inducing repetition priming or/and spaced retrieval practice), cues are visible in the written form (likely inducing orthographic on top of phonological activation), *etc*. As the PCA technique was modelled after SFA (Leonard et al., 2008), it did not emerge from a strong theoretical background justifying the active ingredients and underlying mechanisms of the therapy. For instance, the original authors suggested in 2008 to refine the number and the type of components in future studies. Such refinements would allow clinicians to specify how many components would be necessary and which ones would be the most helpful.

Some treatment protocols did not strictly follow the original PCA therapy described by the original authors. For instance, the order in which the five phonological components should be generated varied across studies. An additional variation pertains to the method of cue presentation. In the original PCA protocol, when a phonological component could not be identified spontaneously, PWA were offered three multiple-choice options in both oral and written formats. However, a few studies introduced a slight variation to the protocol and provided the response without multiple choices when a component could not be retrieved (Sadeghi et al., 2017; Shekari et al., 2024; van Hees et al., 2013). Given that participants in these three studies did not exhibit drastically different effect sizes compared to other studies, it is plausible that selecting the correct response from a set of three alternatives is not a critical component of PCA. One study directly compared if letting first the PWA actively search for the components (3 participants) was better than providing the components directly to the PWA, thus approaching a more traditional phonological and orthographical cueing technique (2 other participants) (Leonard et al., 2015). The results suggested that the active search for phonological components, referred to as the "choice" element, did not particularly influence behavioural outcomes. However, a study with a larger sample (Simic et al., 2021) found that the number of self-generated phonological components correlated with greater improvements in treated and untreated words. Notably, this predictor lost significance after controlling for anomia severity. Given the multicomponent and multimodal nature of PCA, identifying the key ingredients driving behavioural changes remains challenging. Future studies should therefore try to determine which aspects of PCA are most critical and effective to enhance the theory of therapy. Note that similar questions about the underlying mechanisms of anomia therapy are currently raised for SFA (Evans et al., 2021; Lyalka et al., 2023; Shenoy et al., 2024).

4.5. The specificity of PCA

PCA studies primarily investigated the specificity of the intervention by comparing the performance on a treated *vs.* an untreated list of pictures to name. Whereas a few studies compared PCA to SFA (Hashimoto, 2012; Neumann, 2018; Sadeghi et al., 2017; van Hees et al., 2013), no study compared PCA with another type of therapy (for instance a less complex phonological therapy, another type of anomia therapy such as Repeated Increasingly-Speeded Production (Conroy et al., 2018), an attentional therapy, …). Comparing PCA to other phonological therapies would also be extremely useful to establish the superiority of PCA over potentially less time-consuming phonological therapies (Best et al., 2013). In self-administration, orthographic cues can be delivered automatically by a tablet/computer (Lavoie et al., 2016) and it has been shown that increasing the number of trained items was beneficial in computer-assisted anomia therapies (Laganaro et al., 2006). To optimise anomia treatment for PWA, it is crucial to better define which therapeutic approach achieves the optimal balance between effort and outcomes, considering immediate gains, maintenance, generalisation to untreated items, and transfer to everyday communication. A meta-analysis of anomia treatments identified key ingredients driving the most success in anomia therapies for treated items (in the short- and long-term): feedback about naming accuracy and provision of orthographic cues (letters or whole word) (Sze et al., 2021). In PCA, feedback is always given, orthographic cues can be provided in multiple choice or/and the phonological components are written down. Therefore, it is possible that these factors are the most active ingredients of PCA predominantly driving the behavioural changes. Future studies comparing PCA with other anomia treatments are warranted to conclude about the advantage of PCA, especially since PCA is a technique specifically targeting self-cueing, either to reach the threshold of lexical activation/selection, or to optimise communication by providing phonological features of the missing word to the partner.

4.6. The neural signature of PCA

A few studies investigated the neurofunctional reorganisation following PCA. In a resting state functional connectivity analysis, an increased connectivity was found after PCA in networks known to support language and visual processing in the left hemisphere, whereas decreased activation was reported in controlateral right hemispheric networks (Masson-Trottier et al., 2021). However, these neural changes did not correlate significantly with behavioural improvements. In fMRI with overt picture naming tasks, complex patterns were reported with both increased activation bilaterally and decreased activation bilaterally interpreted as more efficient processing (Marcotte et al., 2018). In fMRI with silent picture naming tasks, simultaneous patterns of normalisation (rejoining neurotypical activation) as well as compensatory reorganisation (deviating from neurotypical activation) were reported in the right hemisphere (Truzman et al., 2021). In fMRI with phonological and semantic judgments tasks, neural changes were more evident for semantic than phonological processing after PCA and it was concluded

that behavioural improvements were related to greater left than right hemisphere processing (Rochon et al., 2010). In subsets of participants from the study of van Hees et al. (2013), several other findings were reported:

- PCA gains correlated with the recruitment of the left supramarginal gyrus and right precuneus post-treatment (van Hees et al., 2014b);
- greater gains correlated with pre-treatment amplitude of low frequency fluctuations in the right middle temporal gyrus, with a post-treatment shift to the left homolog area as well as the right inferior frontal gyrus (van Hees et al., 2014c);
- maintenance of PCA gains correlated with the mean generalised fractional anisotropy in the left arcuate fasciculus pre- and post-treatment (van Hees et al., 2014a);
- PCA gains were further predicted by the alteration of cortical responses recorded bilaterally in a dynamic causal electroencephalographic model (Iyer et al., 2020).

In addition, comparisons of single cases found diverging activation patterns related to treatment intensity (Marcotte et al., 2018) or to the active generation of components (Leonard et al., 2015). Further integrated analyses of behavioural and neuroimaging data, ideally using the same event-related tasks and larger sample sizes, are essential to more reliably characterise the neuroplasticity mechanisms underlying PCA-induced changes.

4.7. Limitations of the present review

The experimental designs of the PCA studies included in the present review were of good quality, but extremely heterogeneous. This heterogeneity makes it difficult to aggregate the data without generating serious biases. Treatment sessions varied in length and were distributed in dissimilar ways in terms of dosage (total hours of therapy, duration (number of weeks), frequency (days per week), and intensity (hours per week)). Some studies adapted the number and duration of sessions individually according to the severity of the impairment or an accuracy threshold to reach. While such an adaptive setting is clinically highly relevant, it complexifies interindividual comparisons and data compilation. Furthermore, the trained items were sometimes split into different lists that were assessed multiple times before and after the actual intervention. This procedure led to potential learning, generalisation and maintenance effects that can hardly be disentangled. In addition, a list of items was sometimes trained by PCA whereas another list of items was trained by SFA in parallel. This procedure led to potential confounds between direct treatment gains induced by PCA or indirect treatment gains induced by SFA (for instance on related items). Crucially, the substantial variability in experimental designs prevented the use of statistical synthesis methods yet, and also influenced the recalculation possibilities of effect sizes.

5. Conclusion

Given the limitations mentioned above, it seems difficult to provide robust clinical recommendations regarding PCA at this time. Concerning the target population, PCA has been administered mainly to persons suffering from Broca's or anomic aphasia (74 % of the PWA included in the present review). However, this observation does not indicate that PCA is more efficient for these aphasia types as compared to other types. The preliminary evidence here is in line with previous anomia therapy literature, as PCA seems to induce greater improvements in PWA with mild anomia and mild associated deficits (such as apraxia of speech or executive functioning), while the role of anomia subtype (lexical-phonological or lexical-semantic deficit) appears to be minor. All studies were conducted on PWA in the chronic phase of recovery ($\geq$6 months post-stroke) and it is likely that similar outcomes (or even greater effects additionally boosted by spontaneous recovery) could be observed in the post-acute phase of recovery. In most studies, PCA was delivered in-person in an individual face-to-face setting. Again, this does not indicate a superiority of this mode of delivery over other settings (online, in a group, …) that remain to be formally tested. The optimal dosage of PCA remains an open question, but there does not seem to be just one possible intensity to generate significant improvements. Finally, future studies should also seek to better understand the active and essential ingredients of PCA.

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CRediT authorship contribution statement

Python Gregoire: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Masson-Trottier Michèle:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Durand Edith:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors report no known conflict of interest.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.brainresbull.2025.111269.

Data availability

See Supplementary Material

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