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An exploration of anomia rehabilitation in drug-resistant temporal lobe epilepsy☆

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ABSTRACT

Around 40% of patients who undergo a left temporal lobe epilepsy (LTLE) surgery suffer from anomia (word-finding difficulties), a condition that negatively impacts quality of life. Despite these observations, language rehabilitation is still understudied in LTLE. We assessed the effect of a four-week rehabilitation on four drug-resistant LTLE patients after their surgery. The anomia rehabilitation was based on cognitive descriptions of word finding deficits in LTLE. Its primary ingredients were psycholinguistic tasks and a psychoeducation approach to help patients cope with daily communication issues. We repeatedly assessed naming skills for trained and untrained words, before and during the therapy using an A-B design with follow-up and replication. Subjective anomia complaint and standardized language assessments were also collected. We demonstrated the effectiveness of the rehabilitation program for trained words despite the persistence of seizures. Furthermore, encouraging results were observed for untrained items. Variable changes in anomia complaint were observed. One patient who conducted the protocol as self-rehabilitation responded similarly to the others, despite the different manner of intervention. These results open promising avenues for helping epileptic patients suffering from anomia. For example, this post-operative program could easily be adapted to be conducted preoperatively.

1. Introduction

Left temporal lobe epilepsy patients (hereafter LTLE patients) often complain about cognitive deficits such as language or memory impairments that have lasting impacts on their personal, social, and occupational activities [1–4]. Memory impairments, especially verbal episodic memory difficulties, have been documented in left temporal lobe epilepsy as being associated with language disorders [5,6].These cognitive deficits can increase after neurosurgery for LTLE [7,8] and their impact on the patients' quality of life can be higher than that of epileptic seizures [9]. Despite these facts, language rehabilitation remains under investigated in this population (more details below). In this study, we explored the effect of a language rehabilitation protocol in four left hemisphere language dominant LTLE patients.

1.1. *Language deficits in left temporal lobe epilepsy*

A review by Bartha-Doering & Trinka [10] revealed that word finding difficulties or "anomia" was the inter-ictal language difficulty most frequently reported by epileptic patients, with an estimated 55 % of LTLE patients having significant deficits, compared to normative data, on a naming task. Drane and Pedersen [11] raised that naming is not "a homogeneous, unitary phenomenon, but rather a complex, multistep process that involves multiple brain regions". Two cognitive hypotheses account for anomia in LTLE. They are both framed within the standard models of processing in lexical access [e.g., [12–14]]. The first account is derived from the observation of patients who experience naming difficulties despite preserved meaning, suggesting a lexical retrieval perturbation [15–17]. The second account is based on the difficulties experienced by some patients with certain semantic categories or in tasks requiring identification of objects, suggesting a deficit at the

Abbreviations: LTLE, Left Temporal Lobe Epilepsy; BETL, Batterie d'Evaluation des Troubles Lexicaux; RCI, Reliable Change index; SE_{diff}, Standard Error of Difference.

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semantic processing level [18–20].

Language deficits in LTLE patients have been mostly investigated in the context of epilepsy surgery. While a surgical treatment can be the main option to manage seizures in drug-resistant epilepsy, it carries a risk of post–operative neurocognitive problems. Busch et al. [8] reported post-surgical language outcomes for 875 adults from a 29–year cohort of drug–resistant epilepsy patients. In the case of LTLE surgery, naming decline occurred for 41 % of patients. The age at seizure onset, age at surgery and naming performance before surgery was predictive of presence and degree of severity of naming decline following neurosurgery. The post-surgical persistence of seizures has also been linked to naming deterioration [21].

1.2. Limited evidence for anomia rehabilitation for left temporal lobe epilepsy patients

In epilepsy, cognitive rehabilitation programs have targeted cognitive functions such as verbal memory or attention, and LTLE patients have been the primary population of interest, compared to other forms of epilepsy as it was pointed by several reviews. They conclude that cognitive rehabilitation programs conducted after LTLE surgery showed encouraging results on memory, mood and employment. Some of these rehabilitation programs included psychoeducation focused on personal and social aspects of the deficit [22–24], like the toolbox developed over several years to address memory problems in LTLE [22].

In contrast, the rehabilitation of language or word–finding difficulties in LTLE patients has been understudied. The choice of active ingredients adapted to the cognitive and language disorders of LTLE patients has been little discussed. Psychoeducation specifically designed for anomia is lacking. One study provided very few details about the objectives and the implementation of the rehabilitation [25]. Three other studies focused on the rehabilitation of proper names, with encouraging results despite some limitations. Gess et al. [26] compared errorless learning to rote rehearsal for six familiar names in a LTLE patient. Errorless learning resulted in an improvement that was maintained after a delay. The main limitations of the study were the very small number of trained words and the inclusion of only a single case. Minkina et al. [27] also reported a single case study. They used a distributed training procedure that involved different linguistic domains such as semantics, visual features, orthography, phonology, and articulatory-motor representations. Performance improvement was specific to the 10 trained items (i.e., there was no generalization), but the effect–size was small. Finally, Kendall et al. [28] reported a therapy program conducted on three LTLE patients before their surgery. Their procedure was based on a multi-level model of processing in lexical access and incorporated multi-modal tasks (visual, auditory, articulatory), but the psycholinguistic properties of the trained items were not controlled. The effect sizes were large despite quite variable numbers of rehabilitation hours across patients.

1.3. Adapting anomia rehabilitation procedures for left temporal lobe epilepsy patients

The aim of our study was to develop an anomia rehabilitation program, adapted to LTLE patients, comprising both language training and psychoeducation. Despite unresolved questions about brain reorganization in the context of epilepsy, Drane et Pedersen [11] recently drew some general conclusions in their review, allowing us to compare in many ways the organization of anatomo-functional language processes between LTLE patients and other populations. As encouraged by Fridriksson et al. [29], we describe our language rehabilitation program according to the treatment specification system: target, active ingredients, and possible mechanisms of action of the treatment.

The rehabilitation targets were anomia and ease in communication. To select active ingredients, we drew on theoretical considerations from the fields of neuropsychology, cognitive neuroscience, and readaptation sciences. We reviewed the literature on anomia rehabilitation, primarily conducted with stroke patients, but also successfully applied in the context of other pathologies such as primary progressive aphasia [30]. The ingredients were selected from a cognitive point of view while considering the frequent memory problems of LTLE patients (more details in the Methods section).

Finally, for the mechanisms of action, we largely adhered to Kiran and Thompson's hypothesis about brain plasticity driving language recovery after stroke [31] (see also [32]). They identified general principles and factors to be incorporated into language rehabilitation. The first two principles encourage the treatment of impaired—rather than preserved—language processes, to promote underlying recovery mechanisms. The third principle highlights the need to reinforce patients' motivation and attention. Other principles call for repetition and intensity. Finally, task complexity is thought to promote learning and generalization.

1.4. Assessing anomia rehabilitation in single cases

We describe below the implementation and outcome of this new cognitive-based, errorless, daily procedure that we devised and tested for anomia rehabilitation in four LTLE patients. In total, the protocol inclusions spanned 52 weeks, although each procedure lasted a maximum of 10 weeks for each patient. We hypothesized a positive impact of the intervention on naming abilities, especially in trained items and despite the persistence of seizures.

The single case methodologies were used for the interpretation of the results [33]. For statistical analysis, we used the Tau-U indicator [34,35] that was recently used to assess aphasia intervention in stroke patients [36,37].

2. Method

The current study was approved by the Ethics Committee at Aix-Marseille University (project filed under code 2020–07-05–05). All patients provided written informed consent for the use of their anonymized rehabilitation data in the current research.

2.1. Participants

Four patients were recruited between 2017 and 2019 at the Neurophysiology Department of the University Hospital Center in Marseille. The selection criteria were that patients suffered from drug-resistant left temporal epilepsy (LTLE) despite surgical management, complained of word finding difficulties, and had normal intelligence as assessed by neuropsychological tests. The patients' main demographic and clinical features are summarized in Table 1, which illustrates the diversity of their clinical profiles. P1, P2, and P3 had undergone left anterior temporal lobectomy whereas P4 had received radiosurgery in the posterior temporal lobe. Unfortunately, neurosurgical intervention failed to cure P1, P2, and P3′s epilepsy seizures. P4 still experienced some auras. No spontaneous improvement was expected because of the persistence of seizures, and because the time since epilepsy surgery was always above four years, making a spontaneous recovery during our study very unlikely. All four patients had thus been directed to language rehabilitation. The neurologist invited P1, P2 and P3 to participate in an experimental rehabilitation program, and they entered the protocol concurrently in hospital. P4 was invited by the speech therapist and entered the protocol one year later in a private speech therapy office. All patients retrospectively signed informed consent for the use of data collected during their rehabilitation.

For two of the patients (P1 and P4), their complaint contrasted with the absence of language deficits in the standard neuropsychological evaluation (standardized picture naming performance presented in Table 1). The neuropsychological results from the Wechsler Adult Intelligence Scale test (WAIS; Sattler & Ryan, 2009) were within the

Table 1
Demographic and clinical information about the four patients involved in the study.

Patient	P1	P2	P3	P4
Age	47	57	21	53
Gender	Female	Female	Male	Female
Plurilingualism	No	Kabyle only with her mother	No	No
School level	High school	High school	Undergraduate	Undergraduate
Age at first seizure	<8	43	11	20
Seizure frequency	2–3 per week	<1 per month	1 per week	1 per month
Localization of EZ	Left temporo-mesial	Left temporo-mesial	Left latero-mesial	Left temporo-mesial
Presurgical lesion	Astrocytoma in the left temporal lobe	Left amygdala hypersignal	Cortical focal dysplasia T1 and left hippocampus	Hippocampal sclerosis
Surgery	Left anterior temporal resection with hippocampus preserved in 1979	Left anterior temporal lobectomy in 2013	Left anterior temporal lobectomy, amygdalo-hippocampectomy in 2014	Gamma Knife in left temporal lobe in 2011
Handedness	Right	Right	Right	Right
Language lateralization (fMRI)	Left	Left	Left	Left
vIQ / pIQ	75/81	72/84	118/126, in 2012	91/117
Picture naming	80/80 (DO80)	85/105 (Boston Diagnostic Aphasia Examination[38])	80/80 delayed responses (DO80)	80/80 (DO80)
Anxiety score (GAD-7)	20/21	9/21	0/21	7/21
Depression score (NDDIE)	19/24	NA	NA	NA

Note: EZ = epileptogenic zone; MRI: magnetic resonance imaging diagnosis; fMRI: functional MRI; vIQ and pIQ: verbal and performance IQ from the WAIS test [39]; DO80 [40]: standard picture naming test in French administered during the neuropsychological assessment; GAD-7: Generalized Anxiety Disorder scale [41]; NDDIE: Neurological Disorder Depression Inventory for Epilepsy [42].

normal range but showed a contrast with lower verbal as compared with non-verbal performance (i.e., Verbal Intelligence Quotient or vIQ < Performance Intelligence Quotient or pIQ). Anxiety measured by the GAD-7 scale [41] was highly variable across patients.

A complete standardized language assessment was administered through its computerized interface. The "*Batterie d'Evaluation des Toubles Lexicaux*" (BETL) [43] comprises eight sub-tests: naming, writing, semantic questions, reading, identification of pictures, identification of words, pictures matching, and word matching. Each sub-test provides two scores: a performance score out of a maximum of 54 points, and a measure of the time needed to achieve each test (Table 2). On the basis of their results, the speech therapist concluded that the patients showed different profiles. P1 presented a mixed deficit profile, involving both phonological and semantic difficulties. P2 and P3 presented mild semantic deficits. P4 presented a mild naming speed difficulty without semantic deficit. These deficits are not very strong perhaps because the tests are meant for a franker aphasia in other populations (i.e., post stroke, dementia). As we will see below, the naming measure developed to assess the impact of rehabilitation was more revealing.

2.2. Experimental design

To assess the effect of our anomia rehabilitation, we set-up a single case quasi-experimental protocol with an "AB design" [44]. The basic design comprised two phases: the baseline phase (phase A) and the intervention phase (phase B). The baseline phase A comprised three naming measurements to assess the stability of performance before treatment (P4 received only two initial baseline tests due to an error of omission). Phase B comprised five repeated naming measurements, once a week, during the rehabilitation intervention. In addition, two patients were also evaluated in a follow-up phase (phase C) with an additional follow-up naming measurement. A schematic of the sequence is provided in Fig. 1.

2.3. Outcome measurements

We defined one primary outcome and several secondary outcome measures, presented in Table 3. The primary outcome was naming performance for trained items across phases A, B, and C. The first secondary outcome was naming performance for untrained items. The other secondary outcomes were based on standardized tests, administered before and after the procedure by a speech therapist. The French "Batterie d'Evaluation des Troubles Lexicaux" or BETL [43] was used. The full data was collected for P1, P2 and P3; P4 did not complete the final assessment.

A final secondary outcome was the measure of subjective anomia complaint. Subjective complaints about anomia were recorded before and after the rehabilitation phase with a visual analogue scale (0 = no complaint; 10 = extreme embarrassment) along with a series of lab-developed questions about psychological, social, professional, and

Table 2
Language performances before rehabilitation.

BETL scores/54 + time (sec)	P1		P2		P3		P4	
	Score (/54)	Time	Score (/54)	Time	Score (/54)	Time	Score (/54)	Time
Naming	**35**	**454 s**	49	241 s	51	**162 s**	51	**202 s**
Writing score	**38**	605 s	52	456 s	54	385 s	51	361 s
Semantic questions	NA	NA	**43**	1076 s	48	**1257 s**	50	760 s
Reading	53	47 s	53	**114 s**	54	**104 s**	54	57 s
Picture identification	50	245 s	54	216 s	54	164 s	53	213 s
Word identification	54	**209 s**	52	188 s	54	164 s	NA	NA
Picture matching	49	275 s	49	321 s	53	257 s	51	248 s
Word matching	48	**451 s**	48	251 s	54	256 s	51	201 s
Anomia complaint	5		5		5		7	

BETL extensive lexical assessment battery in French ("*Batterie d'Evaluation des Troubles Lexicaux*"; Tran & Godefroy, 2015). Pathological scores in bold. NA: not available. Anomia complaint is an added in-house test (0: no complaint – 10: maximum complaint).

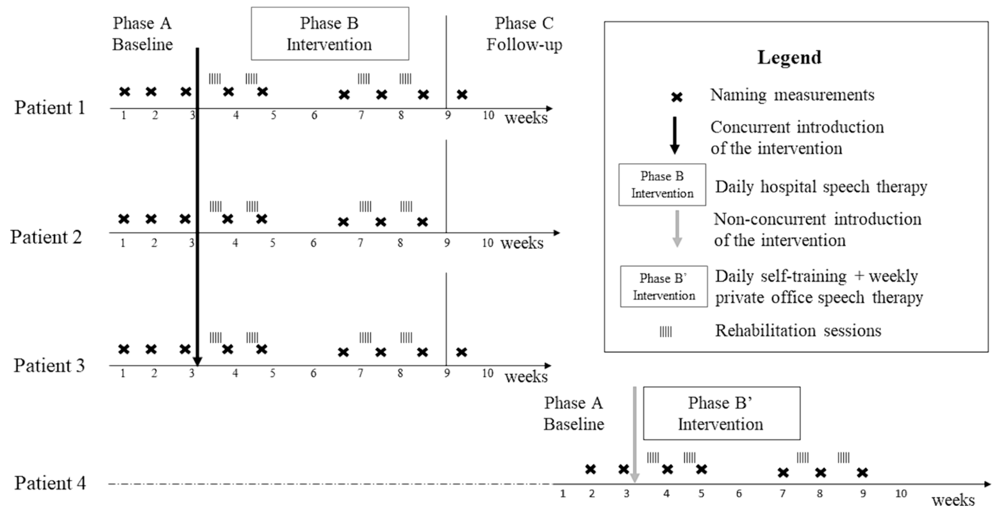

Fig. 1. Experimental design. Four patients were exposed to a repeated measures AB design, which included multiple assessments during both baseline (Phase A) and intervention (Phase B). Two of the patients completed an additional follow-up naming measurement (Phase C). During phase B, the intervention was daily hospital speech therapy. For patient 4, the corresponding phase B' was an intervention incorporating daily self-training and speech therapy at a private office once a week.

Table 3
Outcome measurements.

Procedure	Primary Outcome	Secondary Outcomes
Repeated measures of naming	Specific rehabilitation effects on trained items	Generalization effects on untrained items
Standardized Tests		Effects on BETL Language Assessment for naming, identification of pictures, and picture matching
Anomia Complaint questionnaire		Effects on anomia complaint intensity, on psychological, social, communicational impact, and on stress

BETL: "*Batterie d'Evaluation des Troubles Lexicaux*" [43].

communication impacts of anomia, as well as stress factors. The full questionnaire is available in the Appendix.

2.4. Materials

2.4.1. Repeated measures of naming performance

The evolution of naming performance during the different phases of the rehabilitation procedure was assessed with a naming task. The materials were taken from the Multipic database [45]. Multipic is a collection of 750 colored pictures normed for two dimensions relevant for cognitive research on language: name agreement and visual complexity. To these dimensions we added word frequency and phonological length, based on the database Lexique.org [46]. From Multipic, we selected low frequency stimuli that were more likely to reveal the patients' word finding difficulties [47]. We distinguished animals from objects (manufactured artifacts, vegetables, or other), and controlled typicality within each semantic category with the database BASETY [48]. In total, we selected 71 low frequency-atypical items (from two broad semantic categories: 33 animals and 38 "other"). We also selected 33 high frequency-typical items (15 animals and 18 "other") to vary the difficulty and maintain patients' motivation during the naming task. Item frequency was below nine occurrences per million for atypical items, and above 15 occurrences per million for typical items. Word length could not be perfectly matched across semantic categories or frequency/typicality groups. Name agreement for the 104 items was high, with a mean of 84 % ($SD = 17$). This set of 104 pictures was used for a performance assessment in repeated measures of naming.

2.4.2. Language rehabilitation

For the rehabilitation procedure, we used 40 pictures, half of animals and half of objects from other semantic categories. All these items were low frequency and atypical according to the criterion above. For each patient, we selected from the previously described set of 104 pictures the items that they could not name or that they named after a substantial delay during the baseline phase. There were between 27 and 31 such items per patient, with comparable numbers of atypical animals ($M = 13$, $SD = 1.82$) and atypical other items ($M = 14$; $SD = 1.41$). Then, we selected additional items from the Multipic database [45] to reach 20 atypical animals and 20 atypical other items for each patient. The 40 pictures were grouped in sets of five items belonging to the same semantic category. During the different tasks of the rehabilitation procedure, these items were presented either as pictures or as words. In addition, fifteen yes/no questions were created for each item regarding five different features: semantic category, visual feature function, situation, and object parts. For each item and feature, one third of the questions required a "yes" response. The rehabilitation procedure (pictures and questions) was computerized in a file comprising the different steps for each item. A full list of the materials is provided in "[Anomia Rehabilitation]" on the Open Science Framework webpage https://osf.io/jsqr8/?view_only=d92237b10c3c4fa2a9a15355f719f3c5.

2.5. Procedure

2.5.1. Repeated measures of naming performance

The procedure was computerized with the software E-Prime 2.0 Standard [49] which allowed audio recording of each naming trial for off-line assessment. Patients sat in front of a computer where the pictures to be named were presented one by one for 12 s. They were instructed to name each item without any article, as quickly as possible while avoiding errors. Between presentations, a fixation cross was displayed in the center of the screen for 1000 ms, to help patients focus their attention. The patients received no feedback during the naming task to prevent potential improvement resulting from a learning during testing, which could be difficult to differentiate from the effect of the rehabilitation proper. Acoustic responses were analyzed offline with the software Check Vocal [50] to assess the correctness of each response. Audio files were analyzed by an independent assessor who was blind to the experimental factors and conditions. Another conducted a doubleblind assessment for 36 % of trials in phase A and for 25 % of the trials in phase B. Inter-rater agreement was evaluated for both phases with Cohen's kappa coefficient ($k = 0.88$ for phase A and $k = 0.89$ for phase B). These data are available in "[Anomia Rehabilitation]" on the Open Science Framework webpage https://tinyurl.com/mpppvw2v.

2.5.2. Language rehabilitation

In this section, we outline the different ingredients on which the anomia rehabilitation procedure we have adapted for LTLE patients is based. We chose to multiply and combine these ingredients, hoping to maximize opportunities for rehabilitative success.

From a cognitive perspective, rehabilitation procedures in post-stroke aphasia are mostly based on explicit psycholinguistic models [51,52]. A well-established aspect of these models is the distinction between semantic and phonological processing stages during lexical access [12,53–55]. In so-called "semantic rehabilitation procedures", semantic features such as physical, perceptual, or categorical properties are explored and associated with a targeted word [56]. In "phonological procedures", the proposed tasks target the phonological properties of the words [57]. The benefits of each of these two approaches have been widely documented for several years [58]. Recent studies showed benefits from the combination of semantic and phonological training [59–61]. In post-stroke anomia rehabilitation, the use of written word tasks promoted maintenance and generalization of results [62,63]. This could be due to orthography providing an additional memory cue [64–67]. A recent *meta*-analysis confirmed the relevance of written tasks as one of the most important contributing factors to the success of anomia rehabilitation following a stroke [68]. Finally, multi linguistic domains or multi-modal procedures are encouraged [51]. They are likely to involve the different psycholinguistic processes that are engaged in word production: semantic processing, lexical retrieval, phonological encoding, orthographic processing, et cetera. Given the standing cognitive accounts for word–finding difficulties in LTLE patients mentioned in the Introduction, combining semantic, phonological and orthographic tasks seemed the most relevant approach for our purposes. During our procedure, items with shared semantic features were grouped to induce a contextual priming [69–72]. In addition, the semantic complexity (operationalized in terms of atypicality in the category) was controlled to improve generalization effects to other words [70,73]. Orthographic and phonological tasks were added. Finally, the production of gestures was also elicited where possible [74].

To facilitate memorization, our procedure also included the use of personal cues to facilitate word retrieval in anomia rehabilitation [75]: we asked the patients to recall personal facts about each trained item when possible. Because of LTLE patients' memory problems, we also considered Gess et al.'s work. [26] They have stressed the importance of "errorless" learning procedures, in which the information to be memorized is provided directly to the patient to prevent them from making mistakes and thus memorizing erroneous information. This approach has been argued to be as efficient as "errorful" learning (in which the patient has to find the word with the help of some cues) and it is often preferred by patients [76,77]. For these reasons our procedure was based on errorless learning.

As verbal short term memory skills could predict anomia rehabilitation success [78], we also decided to tax verbal working memory in two tasks of the rehabilitation (reverse spelling and "backwards-chaining").

Little is known about the optimal dose in anomia rehabilitation. As highlighted by Doogan et al. [79], determining the right dose of practice and the best strategy between mass and spaced practice remains a challenge, considering that studies have shown positive effects of anomia rehabilitation despite varying duration and intensity of training (one hour to 12 h a week, with a total of 10 to 36 h) [77,80–83]. We planned the rehabilitation at the highest level of intensity that would be compatible with the standard healthcare French system. This resulted in a frequency of training at five sessions a week (one hour a day). The rehabilitation program lasted four weeks for a total of 20 h of training.

During a session, for each item, the written and spoken name was provided to the patient who then performed the different tasks: read, copy, delayed copy, spell, recall, reverse spell, analyze phonologically, recall a personal memory, answer semantic yes / no questions, gesture (if relevant), and recall. When the procedure was completed on a set of five (semantically related) items, a final "backwards-chaining" task was performed. On each trial, the patient either saw one picture and heard its name or saw the picture only. The task was to repeat the picture's name, or to name the silently presented picture. The sequence required patients to switch quickly from a word to another (in the spirit of "n-back" working memory rehabilitation protocols [84]. The actual sequence of items was [1*, 2*, 1, 2, 3*, 2, 3, 4*, 3, 4, 5*, 4, 5, 1*, 5, 1] (stars indicate picture plus sound). In total, patients reached at least eight naming opportunities per item during the procedure.

The patients' attention and motivation were challenged by the most demanding steps of the procedure (for example, reverse spelling and "backwards-chaining"). Patients P1, P2 and P3 received classical face to face rehabilitation sessions delivered by a speech therapist. P4 received one standard session a week, with the rest of the rehabilitation protocol, four sessions per week, completed at home with the computerized files. The complete list of rehabilitation materials is provided in "[Anomia Rehabilitation]" on the Open Science Framework webpage https://tinyurl.com/mpppvw2v.

Educational programs for patients and their caregivers have shown their value in post-stroke aphasia [85] and in primary progressive aphasia [86]. In addition to matters of language processing proper, the speech therapists provided patients with psychoeducation about their anomia to facilitate communication. They informed the patient about the cognitive origin of anomia and about managing nervousness in various verbal interaction situations, considering psychological features in LTLE patients such as stress and anxiety. Examples of the therapeutic objectives and key messages of psychoeducation are "Encourage the patient to express his/her beliefs about the disorder.", "Mutual help exists in natural communication situations. Accepting help from others is a natural behavior that is simply amplified when the word is missing."; the full list is presented in the appendix.

Therapists documented any adverse or notable events reported by patients (e.g., seizures) and any concurrent event that could be suspected to influence the effect of the therapy (e.g., seizures, unplanned changes in medication). They also reported the number of rehabilitation sessions, the number of trained items, adherence to task procedure, duration of sessions, and completion of the psycho-education program. The patient who trained at home with a self-rehabilitation procedure recorded in a notebook each task she completed, and the duration of each session (Table 4).

2.6. Data analysis

We decided to combine several methods previously considered in the

Table 4
Conduct of the rehabilitation program reported by speech therapists and by P4 for her self-administered sessions.

	P1	P2	P3	P4
Number of baseline probes	3	3	3	2
Number of rehabilitation sessions	20	20	20	23
Sessions' duration	45 min	45 min	45 min	Variable§
Number of trained items	40	40	50	43
Completed steps of the procedure	yes	yes	yes	all except gesture
Completion of psychoeducation program	yes	yes	yes	yes

§: 9*45 min sessions with speech therapist, 6*45 min, 4*30 min, 4*15 min self-administered sessions.

single case methodology literature: visual analysis and non-overlap of phases indicator for the calculation of effect-sizes and p-values. The multiple measurements of naming performance were intended to test the effect of language rehabilitation on word retrieval. The evolution of naming performance was quantified by the number of correct responses during the different phases for each patient. Naming performance values were analyzed with the Scan Package [87] of R [88] implemented in RStudio [89]. The evolution of correct response rates was analyzed for trained and untrained items separately. The evolution of correct responses on untrained items served as a control to assess the specificity of the intervention and to examine potential generalization effects.

2.6.1. Visual descriptive analysis

The visual interpretation of data is frequently used to analyze treatment effects in single case methodology [33,90–92]. The data are examined individually within and between phases using visual descriptors:

(i) Change in levels: the medians of the data points within each phase were compared to detect an expected increase of level [91].
(ii) Trend lines: the projection of the baseline trend into the intervention phase was used to assess the acceleration of change due to the intervention so as to differentiate a possible effect of the repetition of the measure (re-test effect) from a progressive effect of intervention [33].
(iii) Variability: we projected the variability band of phase A into phase B (based on the calculation of the range of the data) to illustrate the effect of the intervention despite the variability due to the epileptic condition of the patients [91].
(iv) Consistency of data patterns was assessed across the different patients.

2.6.2. Effect-size calculation and statistical analysis using Tau-U

We selected the Tau-U indicator [35] which has been proposed for non-randomized and auto-correlated language data in aphasia intervention [36]. Non-overlap measures quantify the proportion of data from one phase that does not overlap with data from the previous phase. The larger the index of non-overlap, the more compelling is the demonstration of the effect. Several non-overlap measures have been used in single case research but most of them have been criticized, opening a field of methodological research [33]. Tau-U indicator combines non-overlap between phases and trend within the intervention phase, thus allows for correction of trend in phase A or B. Tau-U is derived from Kendall's Rank Correlation and the Mann Whitney *U* test and performs reasonably with auto-correlated data [34,35]. Tau-U also presents the dual advantage of providing an effect-size for the intervention and a statistical value to refer to. Lee and Cherney [36] specify that effect size does not necessarily reflect improvement due to the intervention, and therefore, it is preferable to use the p-value of this indicator alongside visual analysis to confirm or refute the demonstration of the effect. As recommended by Brossart et al. [34], the choice of a Tau-U indicator among the four available options ($\text{Tau-U}_{\text{A vs B}}$; $\text{Tau-U}_{\text{A vs B - trend A}}$; $\text{Tau-U}_{\text{A vs B + trend B}}$; $\text{Tau-U}_{\text{A vs B -trend A + trend B}}$) was guided by our hypothesis. We considered the possible factors that could influence the dependent variable during the experiment and chose $\text{Tau-U}_{\text{A vs B + trend B}}$. $\text{Tau-U}_{\text{A vs B + trend B}}$ refers to the percent of data showing improvement between phase A and B and within phase B. The index is useful when a progressive improvement of performances is expected. This is the case in our intervention which concerns the evolution of correct responses following the progressive presentation of items. Another advantage is to control for possible effect of seizures that can induce variability in performance. No improvement was expected in performance within phase A because all patients were in chronic phases of their pathology and distant in time of surgery.

The effect-sizes and p-values were calculated with the Scan Package [87] which ensures that a corrected effect-size between −1 and 1 is obtained, thus resolving a limitation of Parker et al.'s methodology [35] identified by Brossart et al. [34].

2.6.3. Reliable change index in standardized tests

Concerning the results in the subtests of the of the BETL [43], reliable change indices (RCI) were calculated from the difference between the scores obtained before rehabilitation and the final assessment administered following the rehabilitation phase. We used the standard deviation of the test–retest differences available in Tran et Godefroy [93] for the following BETL sub-tests: naming, pictures matching and identification of pictures. We calculated RCI with Jacobson & Truax' formula [94] and corrected for practice effects with a confidence interval using Standard Error of Difference (SE_{diff}) for a 90 % confidence interval [95].

3. Results

3.1. Primary outcome: Correct responses on trained items

The left panels of Figs. 2-5 illustrate the evolution of performance in naming for trained items from phase A to phase B for patients P1, P2, P3 and P4, respectively. The visual descriptors represented are changes of level, trend, and projection of stability band of correct response rates.

For all the patients, we observed an increase in level between phase A and phase B for trained items. The trend of phase B's data points suggested an acceleration towards improvement. All the data points of phase B were above the projection of variability band of phase A into phase B. These three visual features consistently revealed an improvement for trained items across P1, P2, P3 and P4 during phase B. Performances were maintained a week following the last training session for P1 and P3 in phase C.

Non-overlap was calculated using $\text{Tau-U}_{\text{A vs B + trend B}}$. Effect-sizes were high and significant for all patients (Table 5).

3.2. Secondary outcomes

3.2.1. Untrained items

The right panels of Figs. 2-5 show changes of level, trend, and projection of stability band of correct response rates for untrained items from phase A to phase B for P1, P2, P3 and P4, respectively. For P1, changes in level and position of data points were higher in phase B, but the trend did not reveal any acceleration of improvement in the intervention phase. These observations suggest an improvement, consistent with the significant and positive improvement in effect size ($\textit{Tau-U} = 0.73$, $p = 0.009$).

For P2, all the criteria of the visual analysis showed an improvement for untrained items. Statistical analysis confirmed these observations ($\textit{Tau-U} = 0.89$, $p = 0.002$). For P3, neither the visual nor the statistical analysis showed any improvement for untrained items ($\textit{Tau-U} = 0.54$, $p = 0.052$). For P4, although the analysis of trends did not show an acceleration of improvement during intervention, the indicators change in level, comparison of phase B to variability band of phase A, and Tau-U analysis showed an improvement ($\textit{Tau-U} = 0.83$, $p = 0.004$). Overall, across the four patients, the visual and statistical analysis showed encouraging results on untrained item performance.

3.2.2. Standardized tests

The results of the standardized tests are presented in Table 6. Reliable change indices (RCI) were calculated for the BETL sub-tasks naming, identification of pictures and picture matching, for P1, P2 and P3. RCI analysis indicated that P1 improved in picture identification and in picture matching. P2 improved in naming and picture matching but decreased in word identification. P3's performance remained close to ceiling for identification of pictures and picture matching. He improved in naming, but his improvement could be related to a simple test–retest effect, as the confidence interval of the RCI correction includes values below 1.96. Concerning P3, it is interesting to note that his

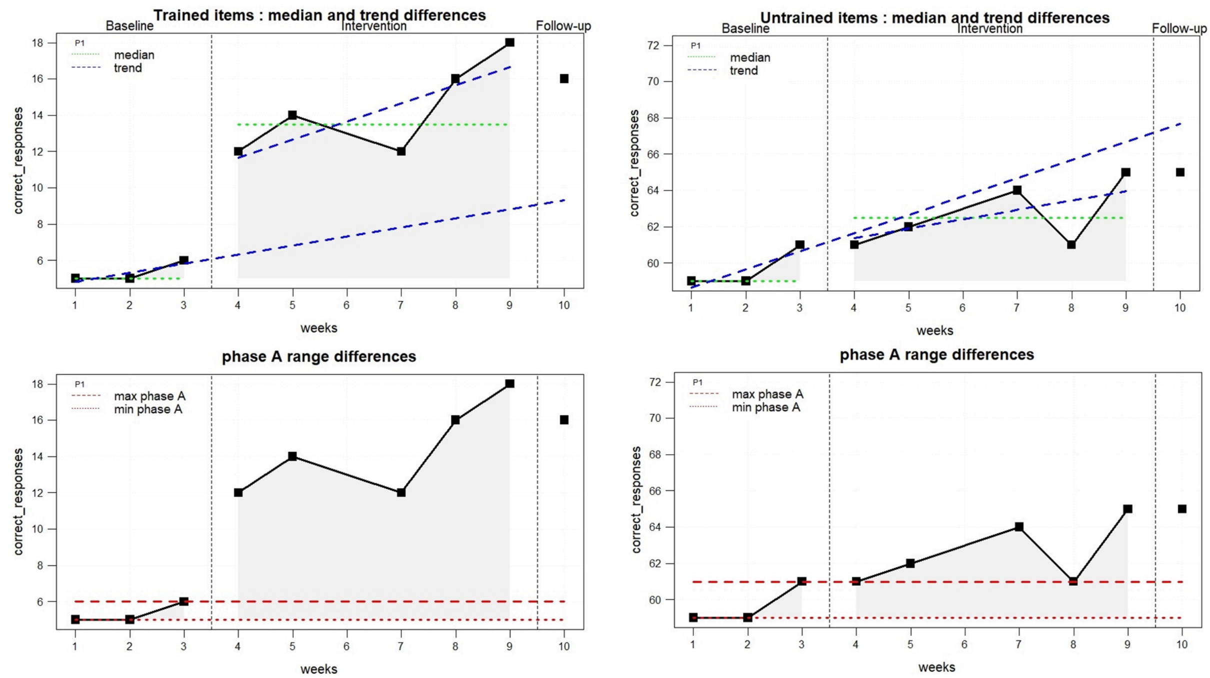

Fig. 2. Visual analysis of P1′s correct responses for trained and untrained items. On each panel, the left vertical line separates baseline weeks (phase A) from the intervention weeks (phase B), and the right vertical line separates intervention weeks from the follow-up measure (phase C). Black squares and lines depict the actual performance. Green lines show median performance in each phase. Blue lines show the trend (the linear tendency of data points) in each phase; the trend in phase A is projected onto phase B for ease of comparison. Red lines (dotted and dashed) show the range of performance during phase A. The plots are created with the Scan Package [87].

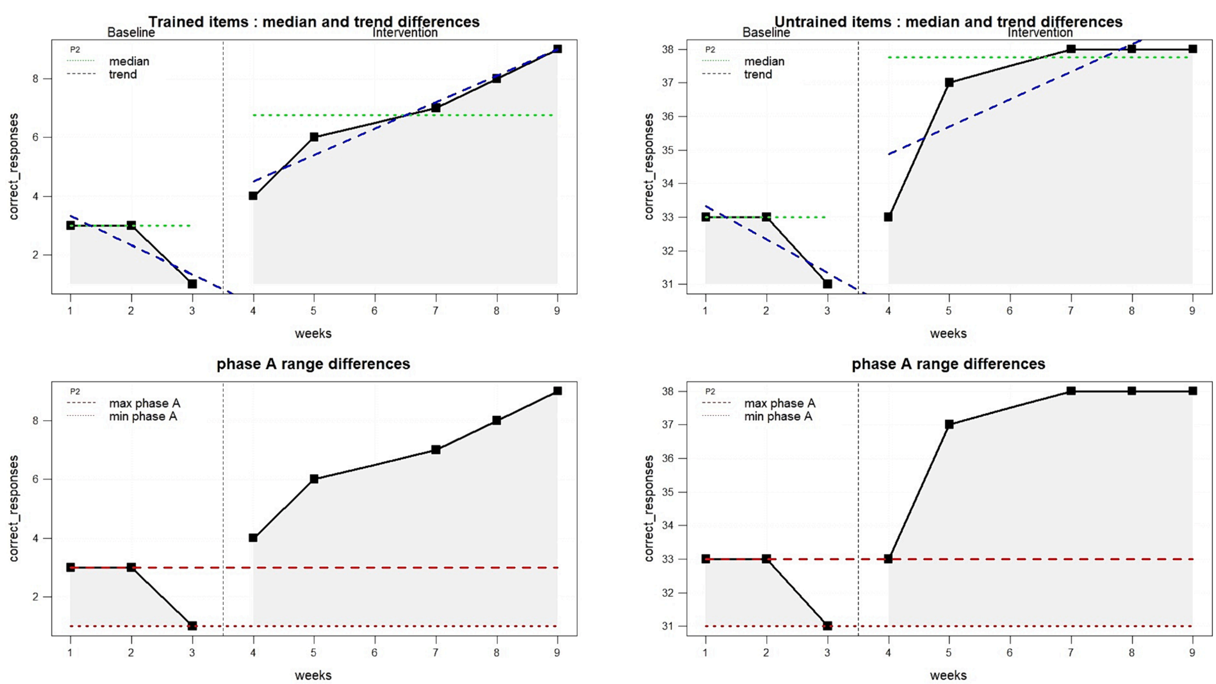

Fig. 3. Visual Analysis of P2′s correct responses in trained and untrained items. See Fig. 2's captions.

performance went from below normal, to within normative ranges for two of BETL's sub-tests (naming time and semantic question time), but RCI could not be calculated for these two subtests because test-retests differences were not available in the literature. P4 did not undergo the final assessment.

3.2.3. Anomia complaint

Several dimensions of anomia complaint were documented before and following the rehabilitation using an in-house questionnaire. Anomia complaints were heterogeneous and evolved variably across patients but also across dimensions. For example, P1 reported improvement of social or psychological experience about anomia while at the same time reporting an increase of anomia complaint, despite

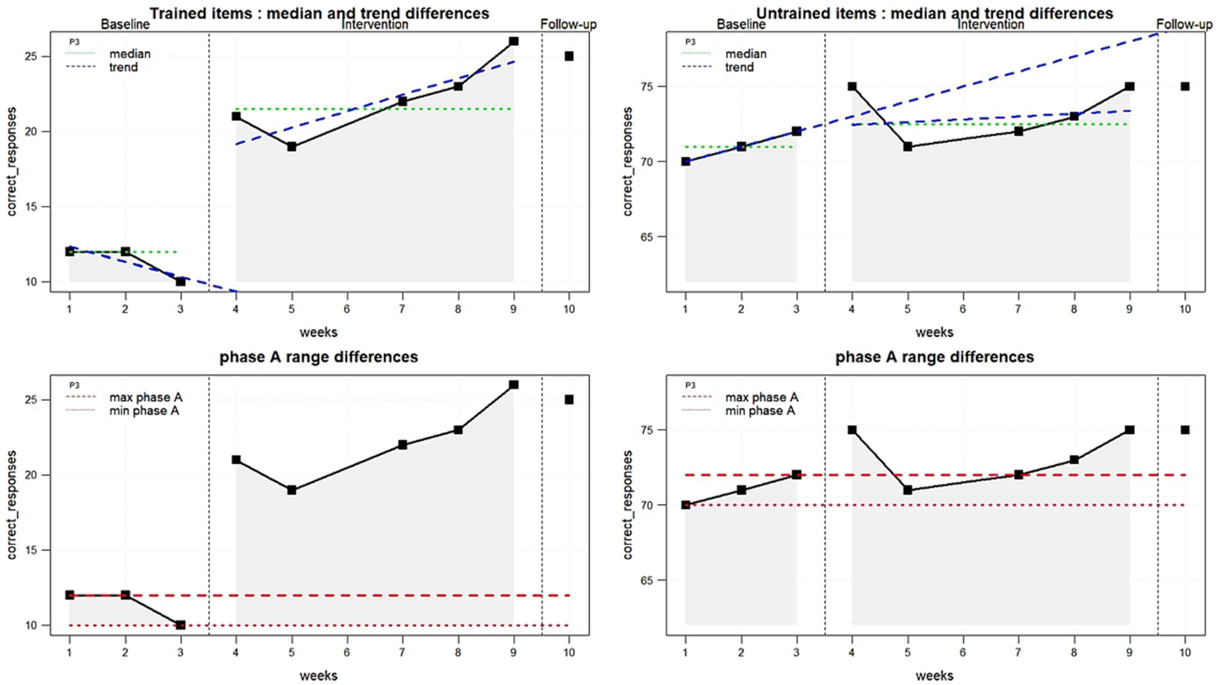

Fig. 4. Visual Analysis of P3's correct responses in trained and untrained items. See Fig. 2's captions.

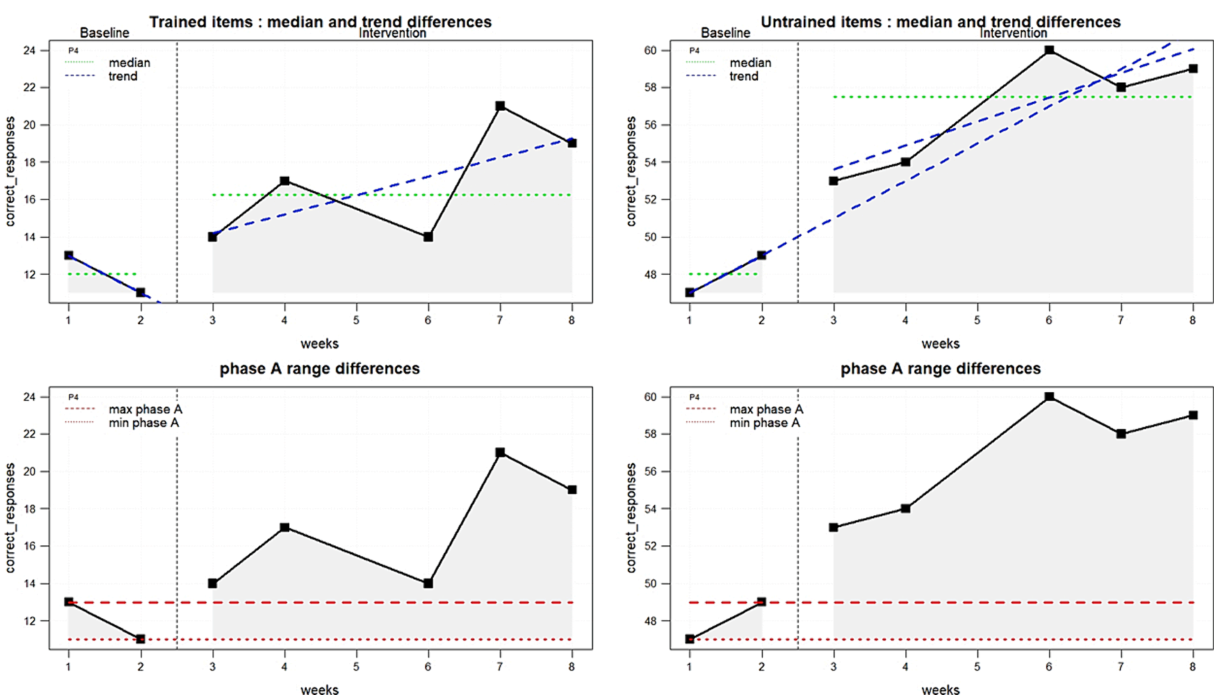

Fig. 5. Visual Analysis of P4's correct responses in trained and untrained items. See Fig. 2's captions.

improvements in the rehabilitation. The opposite was observed for P2 and P3. The three patients reported an improvement in at least one dimension but were also more plaintive in others. These mixed results are documented in Table 7.

3.2.4. *Notable events*

Seizures or auras occurred at the same rate as before the intervention. P1 reported a seizure following the fourth week, P2 following the second week, and P3 following the third week. P4 felt several auras following the sixth week and slightly increased her epileptic treatment for a few days. Another event was reported by P3 and P4 to the speech therapist. These patients spontaneously started to use the training procedure for daily life needs (for example to retain film's titles, actors 'names). P4 also spontaneously reported being able to find words with greater ease following the tenth training session. P3 performed the rehabilitation procedure very quickly and asked to be given additional items to work on at home. The speech and language therapist provided 10 more items to work on reaching a total of 50 trained items.

Table 5
Correct responses: effect-sizes and p-values for trained and untrained items for P1, P2, P3 and P4.

—	Trained items		Untrained items	
	Tau-U$_{A\ vs\ B\ +\ trend\ B}$	*p-value*	*Tau-U*$_{A\ vs\ B\ +\ trend\ B}$	*p-value*
P1	0.77	0.005*	0.73	0.009*
P2	0.97	0.000*	0.89	0.002*
P3	0.85	0.002*	0.54	0.052
P4	0.66	0.024*	0.83	0.004*

*significant p-values.

4. Discussion

Our study investigated a rehabilitation procedure targeting word retrieval abilities, a cognitive function that is the subject of frequent complaints from left temporal lobe epilepsy (LTLE) patients following surgery. Three of these patients completed the procedure concurrently while the fourth was tested one year later in a different self-administered procedure.

4.1. Summary of results

The primary outcome measure was the evolution of naming performance for trained items across the weeks of the procedure. Visual analysis comparing phase A (baseline) and phase B (intervention) converged with statistical analysis, both consistently indicating an improvement across patients for trained items from the start of the rehabilitation.

The secondary outcome measures concerned the evolution of performance on untrained items. There were discrepancies across indicators within each patient, but the overall descriptive pattern was one of performance improvement. For P1 and P4, statistical analysis and some of the visual analysis indicators suggested an improvement. For P2, both visual and statistical analysis revealed a generalization to untrained items. For P3, neither visual nor statistical analysis indicated a clear improvement; this patient showed an immediate improvement in performance at the start of rehabilitation, followed by a decline in performance after the fourth week.

In standardized tests reliable change indices (RCIs) were computed for patients P1, P2, and P3 to assess the impact of the rehabilitation. Results were quite variable across patients. For P1, RCIs indicated an improvement in picture identification and picture matching. P2 improved in naming and picture matching despite a notable decrease in picture identification. P3 did not improve in terms of RCI but presented a noticeable improvement in naming reaction times which placed him in the normality zone. Finally, the impact of rehabilitation on subjective complaint was heterogeneous (and will be interpreted separately).

4.2. Interpretation of the results

Minkina et al. [27] and Gess et al. [26] single-case studies provide the primary context for our study. Where they involved a limited set of items (ten and six proper nouns, respectively), our study examined the effects of rehabilitation on a much larger number of words (around thirty trained and around seventy untrained items). The use of large item sets is greatly encouraged by Nickels et al. [96] to improve the reliability of results. Furthermore, we note that no statistical analysis was used in the study by Gess et al. [26]. The analysis used by Minkina et al. [27] relies on means and the calculation of an effect size, which is also open to criticism due to the very nature of repeated measures of performance, largely subject to autocorrelation, and the lack of robustness on such a small sample size [97].

In this context, the improvement of naming skills across four diverse patients is the principal strength of our study. The improvement in trained items validates the effectiveness of our rehabilitation program. We believe that the positive impact of rehabilitation can be attributed to the careful selection of diverse active ingredients: semantic, lexico-

Table 6
Reliable Change Index (RCI) and interval confidence correction for Language performances in standardized tests (BETL) [43].

	Before rehabilitation	**Following rehabilitation**	***RCI***	**Correction [-1.64 SE_{diff}; +1.64 SE_{diff}]**
P1				
Naming	35	35	0	[-2.60; 2.62]
Picture identification	50	52	**5.45**	[4.50; 6.41]
Picture matching	49	53	**10.05**	[8.77; 11.33]
P2				
Naming	49	53	**5.83**	[3.22; 8.45]
Pictures identification	54	50	**−10.91**	[-11.86; −9.95]
Picture matching	49	52	**7.53**	[6.25; 8.82]
P3				
Naming	51	53	4.37	[1.76; 7.00]
Picture identification	54	54	0	[-0.95; 0.95]
Picture matching	53	53	0	[-1.27; 1.28]

P4 did not undergo the final BETL assessment. RCI: Reliable Change Index.
Results in bold denote $RCI > 1.96$ or < -1.96 which survived correction when interval confidence was considered in the correction for practice effect (i.e., for which the confidence interval was also > 1.96 or < -1.96).

Table 7
Complaint questionnaire about anomia: percent of complaint for each domain.

	P1			**P2**			**P3**		
	Pre rehab	**Post rehab**	**diff**	**Pre rehab**	**Post rehab**	**diff**	**Pre rehab**	**Post rehab**	**diff**
Analogue scale of complaint	50 %	70 %	+20 %	50 %	50 %	0 %	50 %	50 %	0 %
Psychological impact	34 %	22 %	−12 %	8 %	14 %	+ 6 %	12 %	24 %	+12 %
Social impact	93 %	53 %	−40 %	53 %	26 %	−27 %	0 %	0 %	0 %
Professional impact	100 %	80 %	−20 %	0 %	0 %	0 %	0 %	0 %	0 %
Communication impact	80 %	80 %	0 %	13 %	13 %	0 %	86 %	40 %	−46 %
Stress factor	80 %	40 %	−40 %	0 %	60 %	+60 %	0 %	0 %	0 %

P4 did not complete the final questionnaire. 0% no complaint, 100% maximal complaint. “Pre rehab”: level of complaint before the patient entered the rehabilitation program. “Post rehab”: level of complaint following the rehabilitation program. “diff”: difference of complaint between Pre rehab and Post rehab.

phonological and orthographic tasks. The procedure takes into account the verbal memory deficits and is informed by the existing literature on post-stroke anomia rehabilitation. While we cannot attribute the effect of rehabilitation to a specific ingredient, we highlight that holistic approaches to rehabilitation, including cognitive training as well as psychoeducation, are recognized and encouraged in the field of rehabilitation science [98].

The improvement for trained items is concordant with our initial hypothesis. The more variable results observed for untrained items are encouraging, especially in light of the frequent observation of limited generalization effects in post-stroke anomia rehabilitation [e.g. [58]. P3′s performance – neither visual nor statistical analysis improvement with untrained items – deserves a special mention. At the start of rehabilitation, P3 showed an immediate improvement but it was immediately followed by a decline after the fourth week. We interpret this decline as the negative effect of a seizure that occurred at this time. In addition, his performance variations concern barely five points; P3 had high performance levels for untrained items to begin with, which could have masked progress by a ceiling effect. Despite non pathological score in the standardized tests (BETL) but only in reaction times, we consider that P3 had true anomia as reflected by the low performance in naming atypical items in baseline before rehabilitation (only 10/25 correct responses). In addition, this patient complained about his word finding abilities.

The results of the standardized tests are more difficult to interpret. P1′s improvement in picture identification and picture matching may indicate an improvement in semantic or lexical processing; in contrast, P2′s improvement in naming and picture matching despite a notable decrease in picture identification is difficult to interpret within the standard models of processing in lexical access [e.g., [12–14]]. Here again, P3′s case is noteworthy. This patient only improved in the response time measures (for which no RCI was available). The RCI method is recommended by Mazur-Mosiewicz et al [24] but has also been criticized for the risk of identifying false positive or false negative results [99,100]. For this reason, its results should not be considered clinically significant when taken in isolation, but rather as additional information to be aggregated with other results.

We believe that the use of the single case methodology was an appropriate means by which to explore the initial effect of an original rehabilitation procedure in this pathological field. Firstly, our design provided more than three opportunities to demonstrate the experimental effect (three patients and a replication for one patient in a different setting). Moreover, the assessor who scored the data was blind to the phase, thanks to the recordings of the outcome measure (picture naming responses). Inter rater agreement (IRA) was controlled and was high. Another strength of our study is the careful choice of methods for analyzing the results. Visual descriptive analysis combined three visual aspects: the observation of variability was justified by the inherent variations in epileptic pathology. The analysis of trend and level (also called dual criterion [101]), informed us about the changing performances between phases. According to Coon and Rapp [102], "collecting at least three A-phase data points and at least five B-phase data points produced low levels of false positives (i.e., less than 5 %) when data depicted in A-B designs (the fundamental unit of multiple baseline designs) were evaluated using the dual-criterion".

Brossart et al. [34] considered Tau-U indicator as a robust index against the autocorrelation problem. We argued the choice of the indicator among the available options by precise hypothesis. We believe that this dual and argued approach is acceptable to limit the risk of error in the interpretation of our results.

4.3. Social validity of the rehabilitation procedure

The three speech therapists involved in the rehabilitation procedure reported very few deviations from the initial protocol. This reveals the feasibility of the procedure and the patients' adherence. P4 achieved a dose-duration level comparable with that of the other three patients, despite following the procedure independently rather than with a speech therapist. P3 and P4 further reported using the training procedure spontaneously for daily life needs such as remembering actors' names or movie titles. This patients' endorsement is hopeful and reinforces our confidence in the applicability of the program in daily life situations.

One difficulty in rehabilitation research is to measure the clinical relevance of the induced improvement. As pointed out by Howard et al. [97], a change should only be considered clinically significant if it results in a direct impact on the patient's life. In this study, we considered several types of behaviors such as rehabilitation-related performances, performance in standardized tests, but also the subjective experience of the patient. We expected that subjective anomia complaints, recorded before and after rehabilitation, would provide an indirect measure of the social validity of the treatments. The questionnaire we used included an analogue visual scale and questions about the psychological, social, professional, and communication impact of the deficit in daily life. Remarkably, these subjective assessments did not always align with benefits observed in the primary (objective) outcome measures, nor did the level of complaint always correspond to the self-assessment of social or psychological improvement. We hypothesize that a higher level of complaint in some domains could result from the intervention increasing awareness of the language deficit. On the contrary, improvements in social or psychological experience could be interpreted as a positive effect of either the psycholinguistic or psychoeducation components of the rehabilitation program. Mood could also have influenced patients' responses. The latter interpretations remain speculative, pointing to some limitations of this novel not yet validated questionnaire. Although questionnaires for people with aphasia exist, these have rarely focused on patients' complaints but rather on the functional effectiveness of the aphasic person's communication and do not comprise items specifically related to anomia (Bordeaux Verbal Communication Scale, [103,104]; Communication Outcome after stroke, [105]. The use of quality-of-life scales does not seem appropriate to obtain information on the subjective experience of the disorder given the diversity of dimensions they cover 108].

4.4. Impact of seizures on rehabilitation outcome

Controlling the impact of seizures on rehabilitation or performance is another important challenge in our population of interest in this study because LTLE patients who have experienced seizures for years present a significant memory decline and a negative impact on language recovery following epilepsy surgery [106–108]. All the patients enrolled in our study presented with frequent seizures. The occurrence of seizures could explain some of the variability in our results. P1, P2 and P3′s naming performance declined following seizures (that happened after the fifth, the second and the fourth week, respectively). P4 also presented a naming decline in trained items following the fifth week after she experienced auras that week, the unique week she had them in the rehabilitation period. Even if we requested patients to document any seizures that occurred during the rehabilitation period, we could not conclude about their impact as we had no way to objectively control their occurrence. Patients could have also missed, forgotten or misinterpreted some epileptic events. We also observed naming decline for P1, P2 and P4 in the reported seizure periods. This issue is of course specific to the rehabilitation of patients with epilepsy, probably requiring further methodological developments that depart from rehabilitation protocols designed for stroke patients. Finally, the improvement that occurred during rehabilitation despite the persistence of seizures is very encouraging. This point seems particularly important in the perspective of offering this type of intervention prior to surgery, at a time when the patient is likely to present numerous seizures.

4.5. Limitations

Despite the encouraging observations, several limitations of our study must be acknowledged.

As Howard et al. [97] pointed out, even if generalization is "clinically desirable", differentiating generalization effects from a more general non-specific effect remains problematic. The improvement of performance on untrained items observed in some patients could be interpreted as a lack of specificity of our intervention rather than a generalization effect. Nevertheless, the lack of improvement during the baseline phase and the replication of improvement across the four patients during the rehabilitation phase strengthens our attribution of the effect to the rehabilitation.

Another methodological limitation of our study concerns the monitoring of dose. The dose can either refer to the total number of hours of therapy, the number of items trained, or to the number of repetitions of each item during the procedure. In our study, the intensity and duration of therapy was similar across patients. The number of trained items was also quite similar from patient to patient (40 items) except for P3 who was provided 10 additional training items at his request. In Laganaro et al. [109], the size of effect of a similar therapy for stroke patients varied more with the number of trained items than with the number of repetitions. More items (96 trained words) resulted in better outcomes than fewer items (48 trained words). The number of repetitions within the procedure was also controlled in our study. Patients reached at least eight naming opportunities per item. Nevertheless, some patients could have engaged in more repetitions than others within each session. Indeed, we did not monitor how many times each patient repeated the whole procedure for each item. A patient who achieved the procedure faster was allowed to repeat it several times during a session. In Harnish et al.'s [110] procedure of anomia rehabilitation in post-stroke patients, eight opportunities of naming per session for the same trained item were sufficient to improve naming accuracy from the first session. Off et al. [111] further questioned dose effect but did not conclude about a link between effect-size and the number of repetitions. They explained the positive effect of repeated practice by consolidation [112]. This interpretation seems particularly relevant to our LTLE patients who present with memory deficits in addition to language impairments [24]. Indeed, they have been improving since the beginning and then progressively during the rehabilitation phase. This result indicates the effectiveness of the rehabilitation program from the first week, but the dose of rehabilitation required to achieve maximum gain remains unknown.

One additional limitation of our study is the absence of a final assessment for P4.

Finally, our hypothesis for aligning protocol with those used for post-stroke anomia is motivated by the similarity in the cognitive deficits in the two pathologies. Our approach disregards differences in physio pathological mechanisms that may lead to different recovery patterns. Examining these differences will require consideration of functional brain patterns activity alongside behavioral changes [113].

5. Conclusion

We developed a targeted anomia rehabilitation program for left temporal lobe epileptic patients and invited four patients to take part in the program for four weeks. One participant followed a mixed face to face / self-rehabilitation procedure. We used single case methodology to analyze the effect of our program. Despite the persistence of seizures, we observed positive results for trained items, and encouraging results for untrained items and standardized tests. These objectivized changes did not result in a systematic variation of changes in anomia complaint scores. This study offers promising perspectives regarding the unmet needs of language rehabilitation in the context of temporal lobe epilepsy surgery.

Ethical statement

The current study was approved by the Ethics Committee at Aix-Marseille University (project filed under code 2020–07-05–05). All patients provided written informed consent for the use of their anonymized rehabilitation data in the current research.

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CRediT authorship contribution statement

Véronique Sabadell: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Agnès Trébuchon:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition. **F.-Xavier Alario:** Writing – review & editing, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data and supplementary materials that support the findings of this study are openly available at the Open Science Framework under "Anomia Rehabilitation" at https://osf.io/jsqr8/?view_only=d92237b10c3c4fa2a9a15355f719f3c5.

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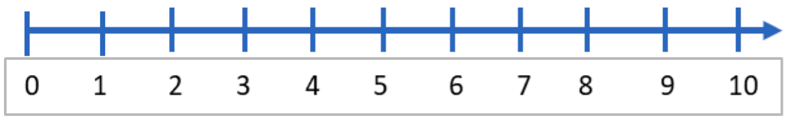
Appendix 1

Anomia complaint Questionnaire

	Are you bothered by word loss in everyday life?	*Yes /No*
1	If yes, how much do you estimate this discomfort on a scale of 0 to 10	



For each question, please circle the answer that you think is most appropriate:

0	**1**	**2**	**3**	**4**	**5**
never	**rarely**	**a few times**	**often**	**very often**	**all the time**

2	Are you embarrassed to find your words when you speak?	**0**	**1**	**2**	**3**	**4**	**5**
3	Do you have words on the tip of your tongue?	**0**	**1**	**2**	**3**	**4**	**5**
	In the last two weeks,						
4	How often did you experience word loss?	**0**	**1**	**2**	**3**	**4**	**5**
5	Were you anxious about having a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
6	Were you ashamed of having a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
7	Were you frustrated when you have had a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
8	Did you feel that you irritate others when you have a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
9	Did you talk less in the presence of people close to you to avoid having a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
10	Did you talk less in the presence of unfamiliar people to avoid having a word loss?	**0**	**1**	**2**	**3**	**4**	**5**
11	Did your word deficit limit your social life or your relationships with others? (For example, visiting close friends or relatives)	**0**	**1**	**2**	**3**	**4**	**5**
12	Did you reduce the length of your sentences to avoid word loss?	**0**	**1**	**2**	**3**	**4**	**5**
13	Did your word loss hinder your professional life?	**0**	**1**	**2**	**3**	**4**	**5**
14	To avoid word loss, did you anticipate in your head the sentence you want to say?	**0**	**1**	**2**	**3**	**4**	**5**
15	Did your word loss prevent you from expressing exactly what you want to say?	**0**	**1**	**2**	**3**	**4**	**5**
16	Did you have more difficulty finding your words when you are stressed?	**0**	**1**	**2**	**3**	**4**	**5**

	Question number
Psychological impact	5, 6, 7, 8
Social impact	9, 10, 11
Professional impact	12
Communicational impact	13, 14, 15
Stress factor	16

Appendix 2

Psychoeducation

Understanding of the anomic disorder, valuing the patient's strengths

Therapeutic objectives. Encourage the patient to express his/her beliefs about the disorder.
Explain the cognitive origin of the anomia.
Encourage the patient to recognize his or her communication skills

Animation techniques and possible supports. Hillis and Caramazza Cognitive Model (1990) [114]- FNAF file « L'aphasie vous connaissez » p. 20 [115]
Discuss the different aspects of communication: verbal, non-verbal, pragmatic

Key messages.

- There is a difference between "word knowledge" and "oral form of the word". These are two separate processing steps in the brain: just because you have lost a word does not mean you have lost all the knowledge around the word.
- It is only a small step in the chain that is malfunctioning or a defect in activation.
- It is not a psychological disorder or a loss of intelligence
- You have strengths to communicate as well as compensatory resources due to the knowledge of your disorder

Reflection on exacerbating or facilitating factors, acceptance of help

Therapeutic objectives. Awareness of the existence of more difficult and easier communication situations
Identify factors that facilitate communication

Acceptance and solicitation of help from others

Animation techniques and possible supports. Evocation of situations experienced by the patient

To introduce the concept of « invisible disability »

Key messages.

- Identify factors that modify communication situations: familiarity of the interlocutor, time pressure, stress
- Recognize the usefulness of the interlocutor's help (give the missing word, leave time, ask questions). Mutual help exists in natural communication situations. Accepting help from others is a natural behavior that is simply amplified when the word is missing.

Managing stressful communication situations for the patient

Therapeutic objectives. Promote a calming behavior for the patient

Learn to inform and educate the people around you

Animation techniques and possible supports. Evocation of possible situations: employer, children's teacher, administrative employee…

Key messages.

- "Communication is built by two people. It is not up to you alone to carry the burden of the lack of a word. The interlocutor must help".
- To warn the interlocutor beforehand induces a helping behavior from the interlocutor and allows you to use all your energy to communicate and not to camouflage your difficulties
- Checking that the other person understands reassures you that your message is clear and that you can communicate.

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