Improving efficacy of aphasia rehabilitation by using Core Assessment of Language Processing

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Letter to the editor

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Dear Editor,

Stroke is the first cause of acquired disability. While mortality has decreased because of urgent intervention such as thrombolysis or thrombectomy, the morbidity remains high [1]. Aphasia is one of the most severe symptoms in stroke patients and affects about 40% of acute stroke patients [2]. After spontaneous recovery, speech performance stabilizes but frequently remains below the normal threshold [2]. Chronic aphasia hinders cognitive rehabilitation efforts, limits social interaction and professional perspectives, and is associated with substantial daily life difficulties [3].

However, with appropriate therapies, recovering from aphasia is possible even at a chronic stage: intensive rehabilitation focused on the impaired language component is more effective than unfocused rehabilitation, which highlights the importance of deficit-based therapy [4,5]. The limitation is that identifying the impaired language component requires expertise and is complex and time-consuming.

To solve this issue of identifying the impaired component, Jacquemot et al. [6] developed and validated a short and easy-to-use battery, the Core Assessment of Language Processing (CALAP), for a model-driven evaluation of the several language components (see Supplementary material). The CALAP enables rapid identification of the impaired component in people with aphasia, thereby allowing for a deficit-based rehabilitation. The short duration (< 15 min) of the CALAP allows for testing individuals with fatigue and concentration difficulties who are unable to complete longer scales: only one session is needed to identify the impaired component of language.

Here, we aimed to assess whether deficit-based rehabilitation based on CALAP scores for people with chronic aphasia can improve language rehabilitation outcomes. We evaluated 7 individuals (2 females, mean [SD] age 67.3 [11.4] years, range 53–82; mean years of education 12.7 [3.9], range 8–17; mean years from stroke 7.85 [3.44], range 3–13) with the CALAP at 1 week before they were enrolled in the rehabilitation program. The model-driven evaluation with the CALAP allowed for determining the specific impairment for each individual according to the model of language processing shown in Fig. 1 [6,7]. During this study, the participants had no other formal language treatment. The local ethics committee approved the study and participants provided informed consent in accordance with the Declaration of Helsinki.

Two types of personalized and intensive rehabilitation were used with each participant: focused rehabilitation that focused on the individual's specific impairment and aimed to rehabilitate the most impaired component, and unfocused rehabilitation that did not focus on the impaired component. Each rehabilitation program (focused and unfocused) lasted 2 weeks (1-hr sessions 5 days per week). The administration order of the 2 programs was randomly set. Finally, to evaluate the long-term effect of the rehabilitation, participants were assessed at 4 weeks after their last rehabilitation session (Fig. 2).

We evaluated the effect of focused and unfocused rehabilitation on speech comprehension, production and repetition with pseudoword, and word and sentence stimuli (n = 200 items). To reduce an eventual retest effect, each participant was evaluated twice before rehabilitation began; the second evaluation was used as baseline [8]. Focused and unfocused rehabilitation were personalized and adapted to each individual's capacities with progressively increasing difficulty. For instance, for a participant with a word production deficit, such as participant JPR, the focused rehabilitation aimed to activate the most impaired component, which was the lexicon in production (Fig. 1). The rehabilitation started first with naming tasks of high frequency, high imageability, and short words and then proceeded with naming tasks of low frequency, low imageability, and long words. The unfocused rehabilitation always activated a spared component of language. With JPR, this rehabilitation targeted morphology in comprehension. It started with tasks involving morphological intruder detection in a list, then detec-

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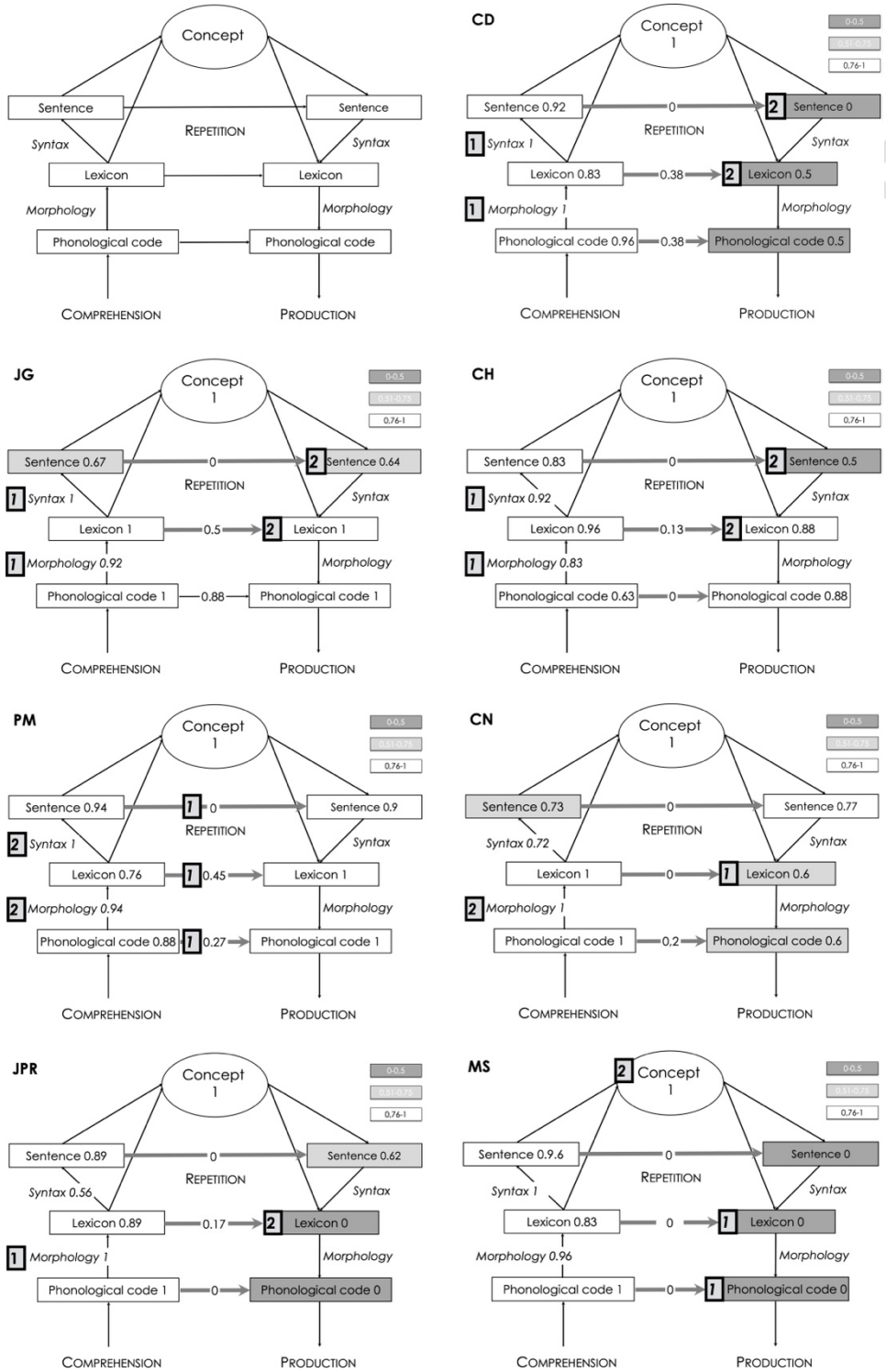

Fig. 1. Psycholinguistic model of oral language processing (upper left) with Core Assessment of Language Processing (CALAP). The model distinguishes the comprehension, production, and repetition modality and within each modality, the different components: phonology (set of speech sounds), morphology (how the sounds combine to form words), lexicon (words), syntax (how words combine to form sentences) and concept (semantic knowledge) that can be selectively impaired. The CALAP allows for evaluating each component of this model. For each participant, we reported the CALAP outcome in the model of speech processing. The score of the different components was normalized according to each participant's performance, so the component best score was attributed a value of 1 and the lowest score a value of 0. This allows for identifying the components the most impaired for each participant with the lowest value. The color of the component represents the normalized score, the darker color for the lowest value (i.e., the impaired components). In this graph, digits "1″ and "2″ are for the first and second program of rehabilitation, respectively. The focused rehabilitation is the one that activates the components at the lowest value (with the darker color) and the unfocused therapy the one that activates the components at highest value (with the lightest color).

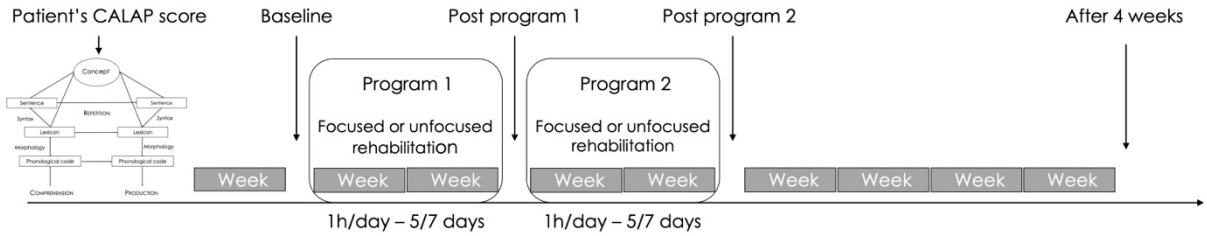

Fig. 2. Time course of the rehabilitation program.

tion of morphologically legal and illegal pseudowords, and finally detection of morphological errors in sentences. Participants' performance was analysed by comparing performance before and after focused rehabilitation, before and after unfocused rehabilitation, and after 4 weeks of rest by using McNemar tests [5]. Using Fisher's exact test, we tested both the independence of the rehabilitation outcome and rehabilitation type (focused or unfocused) and the independence of the rehabilitation outcome and rehabilitation order (first or second program).

Participants' impairment is reported on the model of speech processing, as well as the components on which the 2 rehabilitation programs focused on. For 3 participants, CN, MS and PM, the focused rehabilitation was the first program and for 4, CD, CH, JG and JPR, it was the second program (Fig. 1).

Accuracy performance at baseline, after the first program, after the second program and 4 weeks after the last rehabilitation session is reported in Fig. 3. Accuracy was analysed for each participant according to the type of rehabilitation (focused and unfocused) regardless of the administration order. After the focused rehabilitation, performance improved in 6 of 7 participants (number of correct responses before and after the focused rehabilitation, $n = 200$ in each case. Participant CD: 116 vs 135, McNemar $\chi^2 = 7.9$, df = 1, $p = 0.004$; CH: 135 vs 149 correct, McNemar $\chi^2 = 9.5$, df = 1, $p = 0.002$; CN: 156 vs 175 correct, McNemar $\chi^2 = 11.2$, df = 1, $p < 0.001$; JG: 174 vs 189 correct, McNemar $\chi^2 = 7.3$, df = 1, $p = 0.007$; JPR: 153 vs 178 correct, McNemar $\chi^2 = 18.2$, df = 1, $p < 0.001$; MS: 81 *vs* 96 correct, McNemar $\chi^2 = 5.9$, df = 1, $p = 0.01$; and PM: 168 vs 171 correct, McNemar $\chi^2 = 0.4$, df = 1, $p = 0.5$). In contrast, after the unfocused rehabilitation, which did not activate the impaired components, accuracy did not significantly improve (number of correct responses before and after the unfocused rehabilitation, $N = 200$ in each case. Participant CD: 110 vs 116 correct, McNemar $\chi^2 = 0.4$, df = 1, $p = 0.6$; CH: 131 vs 135 correct, McNemar $\chi^2 = 0.2$, df = 1, $p = 0.7$; CN: 175 *vs* 179 correct, McNemar $\chi^2 = 4.0$, df = 1, $p = 0.08$; JG: 173 vs 174 correct, McNemar $\chi^2 = 0$, df = 1, $p = 1$; JPR: 157 vs 153 correct, McNemar $\chi^2 = 0.09$, df = 1, $p = 0.8$; MS: 96 vs 100 correct, McNemar $\chi^2 = 0.5$, df = 1, $p = 0.5$ PM: 171 vs 180 correct, McNemar $\chi^2 = 2.4$, df = 1, $p = 0.1$). Rehabilitation outcome was not independent of the rehabilitation type (two-sided Fischer's exact test, $p = 0.005$), showing that focused and unfocused rehabilitations are not associated with the same outcome. Rehabilitation outcome was independent of the rehabilitation order (two-sided Fischer's exact test, $p = 0.6$), thus showing no association between the administration order and rehabilitation efficiency.

Four of the participants were tested 4 weeks after the last rehabilitation program. Their performance did not significantly change, which suggests that the positive effect of the focused rehabilitation may last several weeks (number of correct responses before and after 4 weeks, $n = 200$ in each case. Participant CH: 149 vs 144 correct, McNemar $\chi^2 = 0$, df = 1, $p = 0.8$; CN: 179 vs 174 correct, McNemar $\chi^2 = 0.2$, df = 1, $p = 0.7$; JG: 189 vs 185 correct, McNemar $\chi^2 = 0.4$, df = 1, $p = 0.5$; MS: 100 vs 101 correct, McNemar $\chi^2 = 1.5$, df = 1, $p = 0.2$).

Our results show that the CALAP efficiently guided rehabilitation and could improve the outcome of rehabilitation for people with aphasia. We first evaluated participants' language performance with the CALAP to identify the specific impaired components. We then contrasted 3 types of intensive rehabilitation, focused and unfocused, on the most impaired language components for each participant. The intensive and personalized rehabilitation focused on the impaired component identified by the CALAP was more efficient than the unfocused rehabilitation, which is consistent with previous studies [4,5,9]. Therefore, the CALAP results are suitable for the design of effective rehabilitation programs for people with aphasia.

Because the CALAP assesses each component of language processing and identifies patient-specific impairment in <15 min without any expertise, it fills an unmet need. It allows 1) for any clinician (neuropsychologist, speech therapist, nurse, physician, etc.) to assess a patient without delay, thus allowing for patient care without wasting time; 2) for specifying the language component(s) that are deficient; and 3) for efficiently guiding speech and language therapists in the development of rehabilitation programs. Two weeks of rehabilitation focused on the impaired component is more efficient than 2 weeks of unfocused rehabilitation. However, because in addition to the frequency of rehabilitation, the dose of rehabilitation (i.e., the total number of rehabilitation hours) can affect the outcome of rehabilitation, we cannot exclude that unfocused rehabilitation would also improve the participant's perfor-

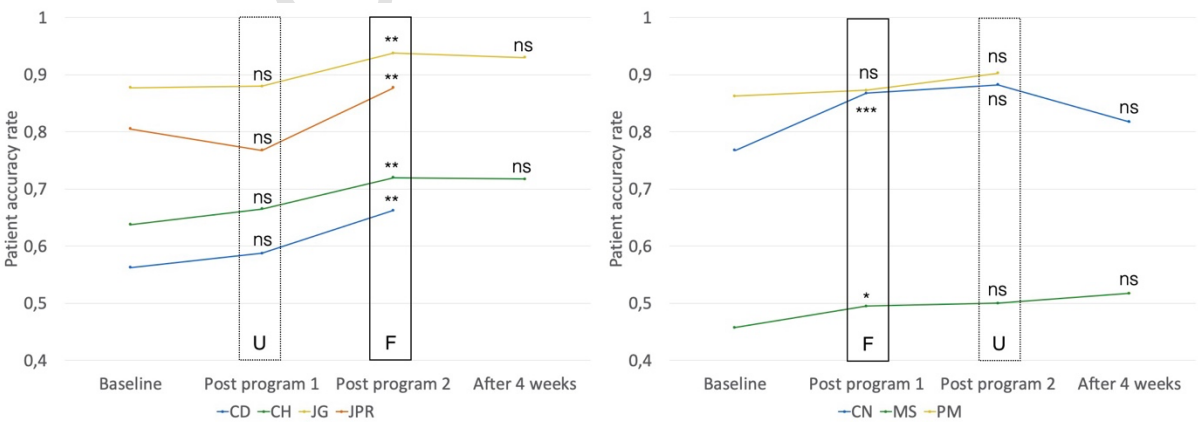

Fig. 3. Participants' accuracy rate at baseline, after the first and second program of rehabilitation and 4 weeks after their last rehabilitation program. Focused rehabilitation (F, solid line) is focused on the impaired components, whereas unfocused rehabilitation (U, dot line) does not target the impaired components. McNemar p-value is reported; ns, non-significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

mance with longer programs [10]. We acknowledge that the good results here may also be driven by the intensive therapy with sessions each day over 2 weeks [11]. Adherence to the rehabilitation program and individuals' motivation also affect the recovery, so even if model-driven therapy is the most efficient, individuals' requests should also be taken into account during the rehabilitation sessions [10]. The brevity of a 2-week deficit-based rehabilitation may also contribute to individuals' motivation.

Here, we focused on individuals mainly impaired by speech production. The successful programs of rehabilitation are the ones targeting speech production components. However, the specific components varied by participants' deficit: sentence, lexicon and/or phonological code. To go further, including individuals with various profiles would be required to determine whether the CALAP can efficiently guide rehabilitation in all types of aphasia or whether additional tools are necessary in specific patterns. For example, a similar protocol should be assessed in individuals with major speech comprehension deficits. Finally, further evaluation after a longer period than 4 weeks of rehabilitation suspension would determine whether and when additional a 2-week program of focused rehabilitation should be proposed.

In contrast to current batteries assessing language capacity, the CALAP was designed to guide rehabilitation relying on a functional model of language processing. By reducing the time for the evaluation of deficits in people with aphasia, the CALAP can reduce the delay for setting an efficient deficit-based rehabilitation and will benefit from the greatest potential for recovery early after stroke [12]. Its use, for designing model-driven rehabilitation, is likely to improve clinical practice and care of people with aphasia, thereby reducing the burden placed upon such individuals and caregivers.

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Conflict of interest

None declared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.rehab.2022.101630.

References

[1] Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of stroke during 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet Lond Engl 2014;383:245–54. https://doi.org/10.1016/s0140-6736(13)61953-4.

[2] Pedersen PM, Jørgensen HS, Nakayama H, Raaschou HO, Olsen TS. Aphasia in acute stroke: incidence, determinants, and recovery. Ann Neurol 1995;38:659–66. https://doi.org/10.1002/ana.410380416.

[3] Lazar RM, Boehme AK. Aphasia As a Predictor of Stroke Outcome. Curr Neurol Neurosci Rep 2017;17. https://doi.org/10.1007/s11910-017-0797-z.

[4] Hillis A. The role of models of language processing in rehabilitation of language impairments. Aphasiology 1993;7:5–26.

[5] Jacquemot C, Dupoux E, Robotham L, Bachoud-Levi AC. Specificity in rehabilitation of word production: a meta-analysis and a case study. Behav Neurol 2012;25:73–101. https://doi.org/10.3233/BEN-2012-0358.

[6] Jacquemot C, Lalanne C, Sliwinski A, Piccinini P, Dupoux E, Bachoud-Lévi A-C. Improving language evaluation in neurological disorders: the French Core Assessment of Language Processing (CALAP). Psychol Assess 2019;31:622–30. https://doi.org/10.1037/pas0000683.

[7] Ramus F, Peperkamp S, Christophe A, Jacquemot C, Kouider S, Dupoux E. A psycholinguistic perspective on the acquisition of phonology. In: D'Imperio Fougeron, Kühnert V, editors. Lab. phonol. 10 var. phon. detail phonol. Represent. Berl. Mouton Gruyter. Berlin: De Gruyter Mouton; 2010. p. 311–40.

[8] Schramm C, Katsahian S, Youssov K, Demonet JF, Krystkowiak P, Supiot F, et al. How to Capitalize on the Retest Effect in Future Trials on Huntington's Disease. PLoS ONE 2015;10 e0145842–e0145842. https://doi.org/10.1371/journal.pone.0145842.

[9] Vuksanović J, Milovanović T, Konstantinović L, Filipović SR. Effect of type of language therapy on expressive language skills in patients with post-stroke aphasia. Int J Lang Commun Disord 2018;53:825–35. https://doi.org/10.1111/1460-6984.12390.

[10] Doogan C, Dignam J, Copland D, Leff A. Aphasia Recovery: when, How and Who to Treat? Curr Neurol Neurosci Rep 2018;18:90. https://doi.org/10.1007/s11910-018-0891-x.

[11] Breitenstein C, Grewe T, Floel A, Ziegler W, Springer L, Martus P, et al. Intensive speech and language therapy in patients with chronic aphasia after stroke: a randomised, open-label, blinded-endpoint, controlled trial in a health-care setting. Lancet 2017;389:1528–38. https://doi.org/10.1016/S0140-6736(17)30067-3.

[12] Laska AC, Hellblom A, Murray V, Kahan T, Von Arbin M. Aphasia in acute stroke and relation to outcome. J Intern Med 2001;249:413–22.

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