Cognitive Intervention for people with aphasia: a treatment protocol

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Abstract

Cognitive control processes allow us to detect and resolve conflicts experienced in both linguistic and non-linguistic domains. Up to now, the provided interventions for sentence comprehension focus solely on the linguistic domain, without considering executive functions (EFs) and their essential role in human cognition and behavior regulation. In this study, we aim at presenting a cognitive intervention treatment protocol which can be used to investigate the impact of training EFs in sentence comprehension.

Keywords: Cognitive intervention, aphasia, sentence comprehension.

Introduction

Aphasia is typically restricted to language impairments across modalities in the absence of any other general cognitive impairment or dementia. However, there is a growing consensus that people with aphasia (PWA) may often present with concomitant cognitive deficits in executive functions (EFs), and specifically attention, visuospatial perception, logical thinking, short-term memory and working memory (WM), after a left hemispheric stroke that may compromise everyday communication, quality of life, and mental health.

Language processing requires the integration of linguistic and non-linguistic abilities. For comprehension to be efficient, several components, such as linguistic knowledge (lexico-semantics, morphology, syntax), and cognitive functions, such as monitoring, WM and inhibition, need to be coordinated and integrated to facilitate understanding. Deficits in overall processing capacity or EFs can tax conceptual domains that require high levels of processing resources, affecting differently language and non-language skills. Several studies have shown that EF deficits can negatively influence various language processes in aphasia, such as: lexical-semantic processing, sentence comprehension, spoken discourse, and reading.

Up to now, the provided treatments in clinical settings have been shown to be effective for improving language functions but they have focused on specific grammatical aspects (e.g., Treatment of Underlying Forms; Thompson & Shapiro, 2005), without considering that sentence-level difficulties inevitably interfere with other cognitive processes, such as attention, WM, and EFs in general, which might influence therapy outcomes and explain variable response to treatment. Thus, the application of a cognitive treatment focusing on the enhancement of EFs, might assist individuals with language deficits and facilitate their language performance, thus, providing long-term benefits. Zakarias et al. (2018), for instance, presented evidence for improvements in spoken sentence comprehension, functional communication and everyday memory activities of German-speaking aphasic individuals who undertook a cognitive training enhancing EFs, including WM. To this end, this paper presents the design of a cognitive training program focused on the shared processes between EFs and language processing tasks, that can be implemented to determine whether non-linguistic cognitive treatment predicts language gains in sentence comprehension.

Method

Using a repeated-measures design across three time-points, a baseline, a post-treatment, and a three-month follow-up assessment are administered in the enrolled participants. The protocol incorporates different types of tasks, varying in difficulty, to compensate for the cognitive demands of each task.

Baseline assessment

Prior to treatment, participants are thoroughly assessed in both language and cognitive abilities with a full neuropsychological battery, for diagnostic purposes. Sentence comprehension is assessed (pre- and post-treatment) with an eye-tracking-while-reading task, designed to investigate the on-line resolution of temporal sentential ambiguities (garden-path), to evaluate treatment-induced improvements and the emergence of normal-like cognitive processes. The cognitive tasks include assessment of (a) conflict resolution and cognitive flexibility (the *Eriksen flanker task*; Eriksen & Eriksen, 1974), (b) short-term and WM (*Digit span task*; Wechsler, 1997), (c) visuo-spatial WM (*Corsi Block-tapping task*; Kessels et al., 2000), (d) spatial planning and problem solving (*One-Touch Stockings of Cambridge test*), and attention shift and cognitive flexibility (*Intra-Extra Dimensional Set Shift test*); subtests of the Cambridge Neuropsychological Test Automated Battery (CANTAB) (Sharma, 2021). Participants' scores establish the stability of baseline performance, which can determine possible treatment effects later on, in cases where scores differ significantly from the baseline.

Cognitive treatment

A computer-based cognitive training has been designed to be administered for 45-minute sessions, twice weekly, for a period of 10-12 weeks. The treatment protocol consists of three tasks, designed to enhance cognitive abilities focusing on (a) cognitive flexibility and inhibition of cognitive interference (the *non-verbal Stroop test*; Stroop, 1935), (b) WM (*n*-back test; Kirchner, 1958), and (c) sustained selective attention (*Track-it*; Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013). Tasks are presented in a block order which is assigned randomly to participants.

The *non-verbal Stroop test* assesses cognitive interference and inhibitory control. Participants are presented with words denoting different colors. The association between the color of the presented word and the meaning of the word can be either congruent (i.e., RED written in red) or incongruent (e.g., RED written in green). Participants are asked to press a keyboard button to denote whether the color of the word matches its meaning or not.

The *n-back test* taxes WM and domain-general EFs such as interference control. Participants are presented with a series of visual stimuli (letters) and are asked to press a button on the keyboard when the currently presented stimulus matches the one presented in *n* preceding trials, with the *2-back, 3-back, 4-back* etc. versions. Difficulty level is adaptive, meaning that task difficulty is continuously being adapted to the participant's performance. If a given score is reached, then difficulty level is automatically increased by a single level, while in cases where the threshold is not reached for four consecutive blocks, the difficulty level decreases by one.

Track-It, supports sustained attention. Participants are visually presented with a target moving along a random trajectory on a grid, while distractors also are present. Participants are asked to select the last grid location visited by the target before it disappears. Two types of distractors are used; the homogeneous, where all distractors are identical (e.g., red squares) but differ from the target, and the heterogeneous ones, where all distracters are different from each other and from the target.

Training tasks support similar cognitive processes as the ones used at baseline, thus, allowing us to assess task-specific transfer effects and possible improvements on the outcome measures related to EF training. During treatment, participants' performance is evaluated on a weekly basis.

Follow-up assessment

Immediately after the completion of treatment, participants are assessed on all tasks used during the baseline to examine positive learning/generalization effects in untrained items. All tasks are readministered at 3 months post-treatment to evaluate the long-term (maintenance) effects of treatment on both cognitive and linguistic processes.

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