Positive effects of computerized executive function training in aphasia. A pilot study

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Introduction

An increasing number of findings suggests that executive functions (EFs) affect language abilities in aphasia. Two components of EFs, updating working memory representations and conflict resolution, are supposed to play a role in various language processes, including syntactic and semantic processing in aphasia (e.g., Novick et al, 2013; Thothathiri et al., 2012). Research in experimental psychology implies that EF skills can be enhanced with intensive practise and that these improvements can transfer to untrained tasks sharing the same processing components (e.g., Dahlin et al., 2008; Jaeggi et al., 2011). In line with these results, Novick and colleagues (2013) showed that training of EFs can lead to improved accuracy in syntactic processing in healthy young adults.

The current study extends this line of research to aphasia with three major research questions: 1) Can EFs be enhanced through training in aphasia? 2) To what extent is the effect of training transferred to other EF processes, and 3) of most interest, does training of EFs lead to transfer to language? In order to approach these questions, we modified a computer-based adaptive training task (Novick et al., 2013) to be appropriate for patients with aphasia and tested pre-post performance differences on tasks related to EFs and language.

Methods

Participants performed an EF training targeting two EF components: Updating working memory representations and conflict resolution. We designed an adaptive training task in which task demands were continuously adjusted according to participants' performance. Participants practised the training task four times a week for a month, in twenty-minute sessions each day. Before and after the training, participants were assessed by tests related to EFs and language (see below).

Participants

Three patients (K.K., B.L., and B.B) with chronic Broca's aphasia (post onsets: 12, 8, 12 months, respectively) participated in the study. All participants had a left hemisphere lesion, were right-handed and spoke Hungarian as their primary language. They were classified

using the Western Aphasia Battery (Kertész, 1982; Hungarian adaptation: Osmánné-Sági, 1991).

Training task

We programmed a modified n-back task with lures. Based on the classical n-back paradigm, focusing on updating working memory, participants were exposed to a stream of letters and were asked to press a button when the letter presented was the same as the one appearing *n* trials before. In addition, lures were incorporated into the task; letters that occurred either immediately before or after the *n*th-back item, requiring participants to resolve the conflict between the representation of the target and that of a highly familiar lure. Participants had to perform at three lure levels before n increased (no lures, n+1 lures only, and both n+1 and n-1 lures). If they performed accurately at a given level, then the level of difficulty increased, if they did not, then it decreased following four unsuccessful attempts.

Assessment tasks

We designed a letter n-back task to measure the performance on a task with the same structure and stimuli as the training task, but with different timing, and an auditory n-back task to assess the performance on a task with the same structure as the training task but with different stimuli. We used the standardized Test for the Reception of Grammar-Hungarian (TROG-H, Bishop, 1983, Hungarian adaptation: Lukács et al., 2009) to assess comprehension of grammatical structures and sentences, and the Boston Naming Test (Kaplan et al., 1983) to assess naming ability.

Results

Group level and individual performances on the training and the pre-post tasks are shown in Figure 1. Group level analyses (Fig 1.A) using Friedman's ANOVA showed that participants improved on the training task ($\chi^2(12) = 21.25$, $p < .05$). To analyse performance at the individual level (Fig 1.B), correlation between number of training session and mean level at a session was calculated using the Pearson correlation coefficient. According to this, K.K. showed a significant increase in performance ($r = .701$, $p < .01$), B.L. showed a tendency for increase ($r = .501$, $p = .08$), and B.B. did not show statistically significant improvement ($r = .220$, ns.).

Pre-post differences on the assessment tasks were tested using McNemar's test for each participant separately (Fig 1.C). Concerning the EF tasks, B.B. improved significantly on both the auditory and the letter 1-back tasks ($p = .016$, $p = .008$, respectively), K.K. improved on both conditions of the letter n-back task ($p = .063$ for 1-back, and $p = .031$ for 2-back). B.L. did not show significant improvement on any of the EF tasks. Concerning the language tests, as shown by the TROG, K.K. and B.L. improved significantly on sentence comprehension ($p = .016$, $p < .001$, respectively). Results on the BNT showed that only B.B. improved significantly on naming ($p = .031$).

Discussion

In sum, the training task proved to be adequate to evoke a training effect, however individual differences clearly seem to affect development on the training task. This is in agreement with earlier studies showing that individuals greatly vary in their responses to EF training. Importantly, we observed pre-post improvements in both EFs and language assessment in some individuals with aphasia. Although this suggests that transfer effects occurred, data collection with control participants is in progress to exclude retest effects as an alternative explanation. Together, our results suggest that cognitive functions can be enhanced through training in aphasia, and this might lead to improvement on language abilities.

Acknowledgments

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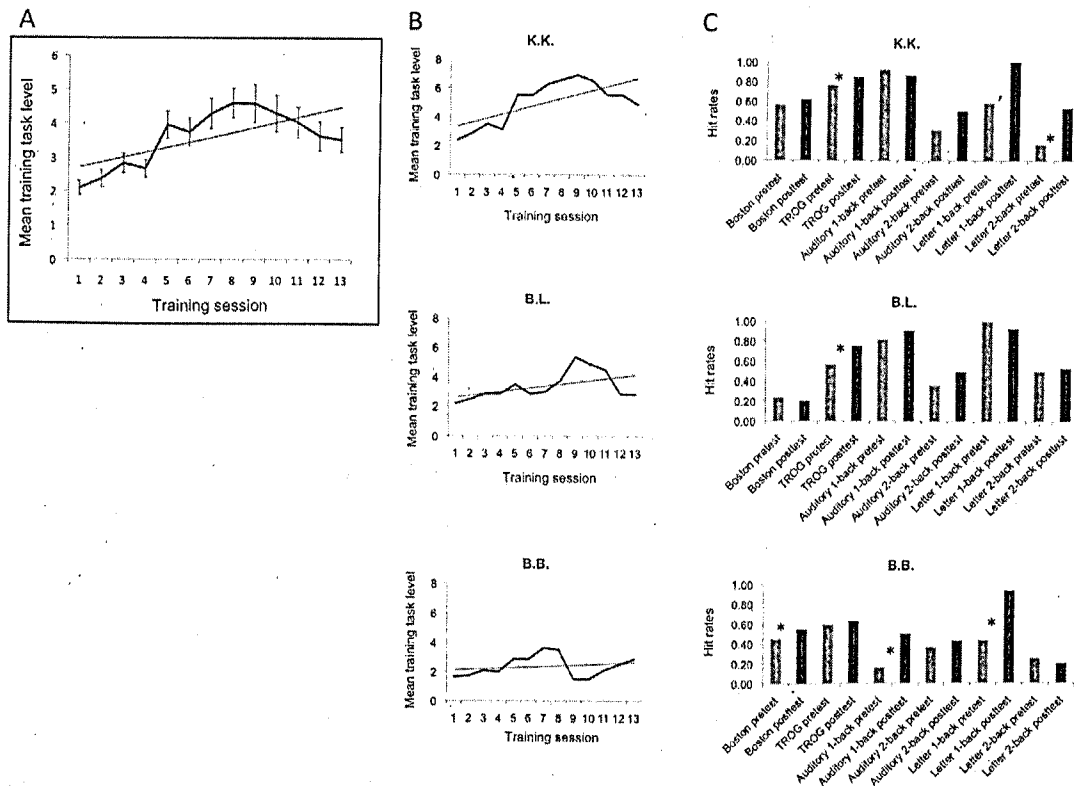
Figure Captions

Fig. 1. Training performance and pre-post performances on assessment tasks. A. Performance on the training task during the thirteen sessions of training at the group level. B. The same shown separately for each participant. C. Performance on the assessment tasks before (pretest) and after (posttest) the training shown separately for each participant. Asterisks indicate significant pre-post differences (*$p < .05$). Primes indicate tendencies for pre-post differences ('$p < .1$).