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Interaction between linguistic and numerical abilities of Hungarian patients living with mild or moderate aphasia

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Introduction

There are competitive conceptions of the relation between linguistic and numerical abilities (Semenza, 2008; Roselli, Ardila, 1997, Denes, 2011). Recently numerous study have reported that numerical abilities are connected with language processing (De Luccia, Ortiz, 2015; Messina, Gianfranco, Basso, 2009), at the same time some numerical mechanism are independent from language (Rath et al. 2015; Semenza, 2008). Our aim was to compare Hungarian aphasic patients' numerical abalities in different arithmetical and numerical tasks (as counting, arithmetic operations: addition, subtraction, multiplication and division, and complex numerical tasks) with healthy controll's depending on the severity of their linguistic abilities.

Methods

Patients and methods

We examined 17 aphasic patients' numerical abilities. Patients were tested by linguistic and numerical tests as follows: Hungarian version of Western Aphasia Battery (Osmanné Sági, 1991), Boston Naming Test (Kaplan, Goodglass, Weintraub, 2001) and Token Test (Osmanné Sági, 1983), Hungarian version (Igács et al, 2008) of Number Processing and Calculation (NPC, Delazer et al. 2003) were used. Depending on the severity of aphasia 8 mildly and 9 moderately damaged aphasic patients were invited to this research. All of the patients were treated at the Department of Neurorehabilitation of Neurology of the University of Szeged. Healthy controlls were matched to the clinical group. All of data of the participants were included by the ethical norms of the Department. All of them were Hungarian native speakers.

Results

Patients with aphasia showed worse performance during the tasks correlated to healthy groups. They had the worst results in calculation (69%) and numerical transcoding tasks (81%). Multiplication (61%) and division (63%) seemed to be the most difficult operations while they could solve the addition exercises almost correctly (85%). They also had difficulties in solving text problems (57%) and written calculations (57%). Comparing mildly and moderately damaged aphasic patients' performance we found that mildly damaged aphasic patients had significantly better performance (77%) than severe ones (60%) in all kind of tasks.

1. To compare the general performance of the three groups, we conducted a One-Way ANOVA with the GROUP factor (healthy, mildly aphasic, moderately/severly aphasic). The ANOVA was significant, $F(2, 25)$

= 17.980, *MSE* = 92.020, $p < .010$, $\eta_p^2 = 0.590$. The healthy group showed the best performance, followed by the mildly aphasics and the moderately/severly aphasics. Post hoc tests revelaled that the healthy group did not differ significantly from the mildly aphasic group ($p = .105$), but there was a significant difference between the healty and moderately/severly aphasic groups ($p < .001$) and between the midly and moderatly/severly aphasics ($p = .007$).

2. To see if there are any selective diffences in between the different arithmetical operations of the three groups we conducted a Mixed Design ANOVA with the following factors: GROUP (healthy, mildly aphasic, moderately/severly aphasic) and OPERATION (addition, subtraction, multiplication and division).

The main effect of GROUP was significant, $F(2, 25) = 9.032$, *MSE* = 714.773, $p = .001$, $\eta_p^2 = 0.419$, so was the main effect of the OPERATION, $F(1.980, 49.508) = 19.698$, *MSE* = 220.903, $p < .001$, $\eta_p^2 = 0.441$. Most importantly, the interaction of GROUP x OPERATION also reached significance, $F(3.961, 49.508) = 6.402$, *MSE* = 220.903, $p < .001$, $\eta_p^2 = 0.339$, indicating that the effect of opeartion was was not similar in the three groups.

Post hoc tests revealed that there was no difference in performance with different operations in the healthy group (all *p*s > .999). Mildly aphasics showed better performance on the addition/subtraction items than on the division items (significant difference between addition and division, $p = .012$; trend level difference between subtraction and division, p =.053). Moderately/severly aphasics showed a better performance on the addition/subtraction items than on the multiplication/division items (all ps < .001). From another perspective, while performance on the addition and subtraction items did not differ between groups (all *p*s > 0.261), multiplication and division was better accomplished by healthy individuals than by moderately/severly aphasics (both *p*s < .002); and the mildly aphasiacs also performed better on these items than the moderately/severly aphasics (multiplication $p = .009$, division $p = .086$ – a trend towards significance).

Discussion

Aphasic people's numerical performance is worse than that of a healthy control group, depending on the rate of the linguistic disruption/disturbance. As for the overall numerical performance of aphasic people, there is a significant difference between healthy and semi-severe aphasic, as well as between mild and semi-severe aphasic groups. The examined task-groups also reflected upon the significant differences between the groups. The participants of the study achieved the best results in the task-group tackling the notion of number, whereas the calculation task-group appeared to be the most difficult. In the case of arithmetic facts and rules, when studying basic arithmetic operations, both aphasic groups had better results in addition and subtraction than in multiplication and division. By analysing the results of textual tasks, it can be said that the patients could do half of the tasks successfully. According to these analyses, the performance in textual tasks did not depend on the required operation, however, the mild and the semi-severe aphasic groups' performance was worse in all four basic arithmetic operations.

Our findings have shown that aphasic patients had difficulties with numerical tasks. It can be seen that the range of numerical abilities are influenced by linguistic disorders.

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