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Case Report

Cortical Reorganization after Rehabilitation in a Patient with Conduction Aphasia Using High-Density EEG

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Abstract: Conduction aphasia is a language disorder occurred after a left-brain injury. It is characterized by fluent speech production, reading, writing and normal comprehension, while speech repetition is impaired. The aim of this study is to investigate the cortical responses, induced by language activities, in a sub-acute stroke patient affected by conduction aphasia before and after an intensive speech therapy training. The patient was examined by using High-Density Electroencephalogram (HD-EEG) examination, while was performing language tasks. The patient was evaluated at baseline and after two months after rehabilitative treatment. Our results showed that an intensive rehabilitative process, in sub-acute stroke, could be useful for a good outcome of language deficits. HD-EEG results showed that left parieto-temporol-frontal areas were more activated after 2 months of rehabilitation training compared with baseline. Our results provided evidence that an intensive rehabilitation process could contribute to an inter- and intra-hemispheric reorganization.

Keywords: conduction aphasia; High-Density EEG; brain plasticity; rehabilitation

1. Introduction

Conduction aphasia is an acquired disorder characterized by fluent speech production, reading, writing and normal comprehension, while speech repetition is impaired. Spontaneous language is characterized by paraphasic expressions and word-finding problems [1,2]. Carl Wernicke identified this disorder [3]. Conduction aphasia is well described as "disconnection syndrome" in adults [4] because it is characterized by an interruption of communication between anterior and posterior language areas. Lesions usually involve the left hemisphere. In fact, neuroimaging studies show that this disorder is related to left supramarginal gyrus damage [5]. Another deep brain structure involved in conduction aphasia is the Arcuate Fasciculus (AF). The AF connectivity correspond to various functional areas within the temporal, parietal, and frontal lobes [6,7]. Several studies provided evidence, by the measurement of temporal and spatial dimensions of the reorganizations process, that brain plasticity mechanisms lead to the recovery of aphasia [8,9]. Neurophysiologic studies performed to monitor cortical responses, show that the intra- and inter-hemispheric reorganization of the linguistic neural networks occurred after a stroke that involved linguistic areas [10,11]. These studies were conducted in non-fluent aphasic patients. A neuroimaging study suggested the important role of the right inferior frontal gyrus for the recovery of language function patients with stroke with consequent aphasia; in fact, these findings demonstrated that, in the aphasic population, it could be observed a lower activation of the left brain areas and of the right inferior frontal. These results confirmed that language expression is associated with multiple brain areas [12]. To date, literature studies investigated the neural reorganizations in patients with conduction aphasia in terms of diagnosis and neuroimaging evidence [13–16]. Few studies provided evidence in terms of brain plasticity after an intensive rehabilitative process in patients with conduction aphasia, in fact it was demonstrated that early aphasia rehabilitation is associated with a more recruitment of brain areas, particularly the left inferior frontal gyrus [17]. In the present case, we used High-Density EEG (HD-EEG) to investigate changes of sources electric cortical responses induced by language activities in a sub-acute stroke patient with conduction aphasia, before and after intensive speech therapy training.

2. Case Presentation

We report a case of 50-year-old right-handed female affected by conduction aphasia following to a left ischemic stroke involving white matter of fronto-parietal lobe and left temporo-occipital regions. One week before the acute cerebral event, she underwent surgical replacement of the aortic valve with mechanical prosthesis. She arrived at our rehabilitative unit after one month of the acute event. Neurological, neuropsychological and logopedic assessments were performed. Neurological examination showed right facio-brachio-crural hemiparesis. The patient was vigilant, collaborative, time and space oriented. Drug therapy consisted of taking oral anticoagulants and antihypertensive treatment. The patient was submitted to rehabilitative sessions of physiotherapeutic, neuropsychological and logopedic training. Treatments were performed every day for a session of 60 min for each rehabilitative treatment.

The patient was evaluated at two time points: at baseline (T0) and after two months of intensive rehabilitative training (T1). The Aachener Aphasie Test (AAT) was administered, to provide evidence about the improvement after the rehabilitative training (Table 1). The 256-channel HD-EEG was recorded during specific language tasks presented on computer screen in order to set a time and to use a standard method without influence of external stimuli. Therefore, we acquired HD-EEG, at T0 and T1, during blocks paradigm administration, consisting of five task periods alternating with rest periods. The paradigm was built by using E-prime 3.0 software and included the following tasks: (a) naming, (b) repetition, (c) reading, (d) writing, (e) figure description. During the rest periods, the patient was instructed to stay at rest without moving.

Table 1. Aachener Aphasie Test (AAT) score at baseline (T0) and after two months (T1).

AAT	Score T0	Score T1
Token test	44	59
Repetition	36	45
Written language	42	53
Naming	42	59
Comprehension	56	56

The naming task consisted in mentioning 24 images of 3 s each, that appeared on the computer screen. The images were divided in two groups of 12 alternating to 10 s of rest.

The repetition task consisted in repeating 16 words of 5 s, which were played by audio speakers. Words were divided in two groups of 8 s alternating to 10 s of rest. The reading task was composed from 16 words to read of 3 s, which appeared on the computer screen. The words were divided in two groups of 8 s alternating to 10 s of rest. The writing task consisted of 16 words that have to be written on paper (6 s of duration) and that appeared on the computer screen. The words were divided in two groups of 8 s alternating to 10 s of rest. Finally, the figure description task consisted in looking for 30 s at a figure and subsequently illustrating it. The total duration of the paradigm was 6 min and 52 s. The EEG-HD sources reconstruction was performed with eLORETA, considering the frequency band 1–40 Hz. Each image represents the cerebral cortex from six different perspectives. The most activated areas are highlighted in yellow. The resting state analysis was performed on a time segment resulting from the merging of the resting state segments between the individual tasks.

All methods were carried out in accordance with relevant guidelines and regulations. As it is case report, ethical approval was not required. Informed consent was obtained from our patient.

3. Results

After two months of neuro-motor rehabilitative treatments, the patient showed an improvement of muscle strength, in particular in the right side, especially for motility of the right hand. In addition, the patient underwent daily speech rehabilitative therapy, with a significant improvement of aphasic deficit.

In particular, at baseline (T0) the patient showed a conduction aphasia characterized by a fluent spontaneous language with stereotypes, circumlocutions and linguistic perseverations. Naming and writing were less compromised. The neuropsychological evaluation showed preserved cognitive functions, in particular about executive functions and moderate depressive symptoms (Table 2). The rehabilitative training was conducted every day with 60 minutes' duration for two months. Speech therapy training was focused on language deficit. The neuropsychologist intervention was characterized by psychological support to improve depressive symptoms. After 2 months of hospitalization (T1), the patient showed a significant improvement in aphasic deficit. The AAT highlighted fluent aphasia with an improvement in repetition, reading, naming and writing functions.

Table 2. Neuropsychological tests.

Test	Score	Cut Off
Raven-Coloured Matrices	31	17.5
Wisconsin Card Sorting Test global score	54.1	90.50
Wisconsin Card Sorting Test perseverative errors	21	42.60
Wisconsin Card Sorting Test no perseverative errors	7.8	29.90

In order to display the images at T0 and T1 with a common scale we add figures which represent the difference of the power current density values between T1 and T0. As for the quantifications of the EEG power, we added the files with the difference of the power current density values of all voxels between T1 and T0 as Supplementary Materials. HD-EEG results, showed during resting state a difference of activated areas at T0 and T1 (Figure 1A).

The activations were different depending of proposed tasks. In particular, at T0, during the naming task, activations were present in the left superior frontal area, while at T1, we found a greater activation in all areas respect to T0, in particular, the left inferior temporal and bilateral frontal area (Figure 1B). The images highlighted a higher cerebral activation at T1 in the left parieto-temporo-frontal areas, during the repetition (Figure 1C), reading (Figure 1D) and writing tasks (Figure 1E). The figure description task involved the left inferior temporal area and bilateral superior frontal gyrus, at T0, while at T1 we found no differences respect to T0 (Figure 1F).

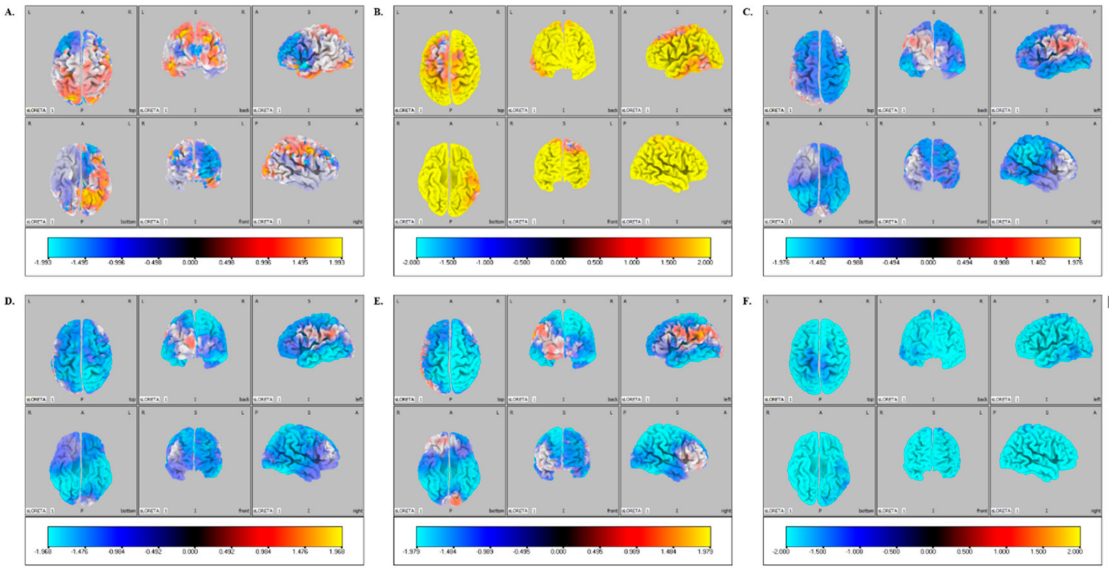

Figure 1. The difference in power current density between T1 and T0. The red/yellow areas indicated a greater activation at T1, the blue areas indicated a greater activation at T0. (**A**) resting state (**B**) naming task (**C**) repetition task (**D**) reading task (**E**) writing task (**F**) figure description task.

4. Discussion

We investigate the cortical responses induced by language activities in a patient with conduction aphasia. Our results showed that an intensive rehabilitation in subacute stroke is very useful for language deficit outcome. In our case, we used a neurophysiologic method, such as HD-EEG, to obtain objective data and provide evidence of the importance and effectiveness of an intensive rehabilitative training in an aphasic patient. In fact, a study conducted on stroke patients with HD-EEG demonstrated that, with respect to standard EEG, high-density EEG could describe the asymmetric electrical signals of the brain activity in stroke patients [18]. Results showed that, during the repetition, reading and writing tasks, the left parieto-temporo-frontal areas are more activated at T1 respect to baseline evaluation. The recruitment of new neural patterns provided to compensate the near injured area generating the phenomenon of brain plasticity [19,20]. The results obtained from the HD-EEG recording are also supported by motor, neuropsychological and speech improvement obtained by the patient after rehabilitation. In fact, we observed an improvement in all AAT subtest, especially in repetition, written language and naming (Table 1). The compensation mechanisms that involved neural patterns of the near lesional side, assumes that the synaptic plasticity modulates the structure and functionality of the cerebral system in more or less long lasting, depending on the events that influence them such as experience, in our case the intensive rehabilitation process. It well known that the left hemisphere is specialized in language [21,22]. The literature studies highlight that, after an early brain injury involving the left side, there could be an inter-hemispheric language reorganization [23,24].

5. Conclusions

Our results provide evidence that an intensive rehabilitation could contribute to an inter- and intra-hemispheric reorganization in sub-acute stroke patients affected by extensive brain damage involving language areas.

Supplementary Materials: The following are available online at http://www.mdpi.com/2076-3417/10/15/5281/s1.

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