North China University of Science and Technology
Tangshan 063210, China

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Speech-auditory feedback training on cognitive dysfunctions in stroke patients

Sun Jinju, Chen Changxiang, Zhang Min, Dou Na, Li Shuxing, Li Dan

College of Nursing and Rehabilitation, North China University of Science and Technology, Tangshan 063210, China

Corresponding author: Chen Changxian, Email: hlxccx@163.com

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Abstract

Objective: This experiment was undertaken to observe the effect of speech-auditory feedback training by Forbrain on cognitive dysfunctions in stroke patients.

Methods: 120 stroke patients with cognitive dysfunctions were randomly divided into experimental group 1(n=40), experimenta1 group 2 (n=40) and control group (n= 40). The control group received conventional rehabi1itation, whi1e additionally, the experimental group 1 received standard Forbrain speech-auditory feedback training and the experimental group 2 received a non-standard Forbrain speech-auditory feedback training. All the subjects were assessed with Montreal Cognitive Assessment scale (MoCA) at baseline and conclusion of the study.

Results: After a 10-week intervention, the scores of visuospatial construction (2.05±0.50), attention and concentration (2.15±0.36), memory (2.18±0.59) and the total score of MoCA (18.75±2.05) in experimental group 1 were higher than those in experimental group 2 (1.80±0.46, 1.90±0.441, 1.90±0.55, 17.53±2.41) and control group (1.78±0.53),1.85±0.36,1.70±0.56, 17.18±2.37) (P<0.05). The scores of language in experimental group 1 (2.03±0.48) and experimental group 2 (1.85±0.53) were higher than those in control group(1.70±0.46) (P<0.05).

Conclusion: Speech-auditory feedback training, provided by Forbrain, can improve cognitive functions of stroke patients.

Key words: Stroke; Cognition Dysfunction; Forbrain, Speech-auditory feedback training

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Stroke has emerged to be one of the leading threats to health, and even life, of our nationals. It has been reported that stroke can result in minor to severe neurological damage, and 83% stroke patients are suffering from at least one cognitive impairment and 50% stroke patients are living with several (≥3) cognitive functions [1-2], which seriously affects the life quality of patients and imposes a heavy burden on families and the society[3]. To date, the most commonly used clinical rehabilitation methods are visual training, computer-assisted cognitive training and language training [4-5].

Sensory integration refers to the integration of sensory information of various human organs at the brain level, so that different parts of the nervous system would coordinate and, as a result, behaviors can be improved [6]. The method has been proven effective in cases of attention problems, autism and cognitive disorders [7-8].

Forbrain is a device for cognitive training, based on the brain's cognitive neuroscience and the patent technology of dynamic processing of human voice. It is a comprehensive system involving visual, auditory and language training.

The training is not limited by time or place as the device is easy to use. It has been used in elderly patients with memory loss, children with attention problems and autism. However, no report on its effect on cognitive dysfunction is found. Herein lays the impetus of this study to investigate the speech-auditory feedback training by Forbrain in stroke patients with cognitive dysfunctions.

1. Subjects

Between June 2015 and June 2016, 120 hospitalized stroke patients with cognitive dysfunctions were selected from the Rehabilitation Department in Tangshan Gongren Hospital. The sample was composed of 84 males and 36 females, between 45-74 and with an average age of 57.9±7.0. Among all the participants, there were 89 cases of cerebral infarction and 31 cerebral hemorrhage; as to the location of the lesions, 44 participants were on the left hemisphere, 55 on the right and 21 on both sides.

The inclusion criteria were: 1. diagnosis of stroke corroborated by the standard established by The 4th Conference of Chinese Cerebrovascular Disease in 1995 and CT or MRI results; 2. first onset with the course of disease being more than 1 month, stable vital signs and clear consciousness; 3. no moderate or severe encephalatrophy, leukoaraiosis, visual field defect or spatial neglect found through examinations; 4. absence of conscious disorders and history of mental diseases; 5. cognitive dysfunction shown by a score of MoCA<26 (the original score was added by one point if the subject had less than 12 years of schooling); 6. approval by the Ethics Committee of the hospital, willingness of the subject and a written version of informed consent.

Exclusion criteria were: 1. history of mental illness, retardation or coma; 2. severe dysfunction of the heart, liver or kidney, malignant tumors or other critical conditions deemed unsuitable for the training; 3. drug or alcohol abuse; 4. severe visual, auditory or language degradation.

Those120 stroke patients were randomized and grouped using random numbers in EXCEL: (1) patients were numbered 1 to 120 by their time of admittance into the hospital; (2) Allocate random numbers to those patients by RAND function; (3) Arrange the random numbers by the ascending order. The first 40 were grouped as the experimental group 1, the last 40 as the control group, and the middle as the experimental group 2.

The difference among these 3 groups in demographic information, course of disease, nature of disease and sides of lesions was not statistically significant ($P > 0.05$), therefore, the groups are inter-comparable. See Table 1.

Table 1. Comparison between 3 Groups on at Baseline

		Experimental Group 1 (n=40)	Experimental Group 2 (n=40)	Control Group (n=40)	x^2	P
Age [n (%)]	45-54	15(37.5)	15(37.5)	17(42.5)	0.375	0.984
	55-60	17(42.5)	18(45.0)	16(40.0)		
	>60	8(20.0)	7(17.5)	7(17.5)		
Gender [n (%)]	Male	27(67.5)	28(70.0)	29(72.5)	0.238	0.888
	Female	13(32.5)	12(30.0)	11(27.5)		
Education [n (%)]	None	13(32.5)	13(32.5)	14(35.0)	0.415	0.981
	0-9 years	17(42.5)	15(37.5)	17(42.5)		
	More than 9 years	10(25.0)	11(27.5)	9(22.5)		
Time since Onset [n (%)]	1-2 months	17(42.5)	19(47.5)	15(37.5)	0.837	0.933
	2-3 months	14(35.0)	13(32.5)	15(37.5)		
	More than 3 month	9(22.5)	8(20.0)	10(25.0)		
Nature of Disease [n (%)]	Cerebral Infarction	29(72.5)	30(75.0)	30(75.0)	0.086	0.958
	Cerebral Hemorrhage	11(27.5)	10(25.0)	10(25.0)		
Sides of Lesions [n (%)]	Left	14(35.0)	15(37.5)	15(37.5)	0.480	0.975
	Right	19(47.5)	17(42.5)	19(47.5)		
	Bilateral	7(17.5)	8(20.0)	6(15.0)		

2. Methods

2.1 Intervention

(1) The control group: conventional rehabilitation training and care delivered by rehabilitation therapists and nurses:

- 45 minutes of occupational therapy (OT) like daily life training, vocational training, etc.
- 45 minutes of physical therapy (PT) including muscle training and laser therapy
- 20 minutes of traditional treatment including acupuncture and massage

Each for 5 sessions per week, 10 weeks in total.

Rehabilitation care included:

- training on daily living ability like eating, dressing and going to the toilet, 20 minutes per session, 5 sessions a week for 10 weeks in total.
- health education and psychological care: diet guidance and

supportive psychological care, 10-20 minutes per session, 2-3 sessions a week for 10 weeks in total.

(2) Experimental group 1: Forbrain speech-auditory feedback training in addition to the conventional rehabilitation training and care in the control group.

The training equipment is composed of a microphone of high sensitivity, a headset with bone conduction device and an electronic dynamic filter. The mechanism of Forbrain speech-auditory feedback training is that the device is developed based on neuroscience and human processing of voice which can be understood as bone and air conduction.

A sound in transmission would arrive firstly at the tympanic membrane through the external auditory meatus, and then vibration of the membrane would transmit through the inner ear and transform into nerve impulses, which then travel along the auditory nerve toward auditory cortex. Thus, we can perceive the sound and the process is called air conduction.

On the other hand, when a person makes a sound, the vocal cord vibrates, and the vibration is transmitted firstly through bone and secondly through air conduction via the tympanic membrane. When a person speaks, the sound is delivered directly to the vestibular-cochlear nerve in the inner ear without passing through the eardrum and the middle ear. The vibrations produced by these sounds are likewise transformed into nerve impulses here, which pass through auditory pathways to auditory cortex. Thus, our voice is heard and the process is named bone conduction.

The speech-auditory feedback training with Forbrian integrates visual, auditory and language training and it is developed based on bone conduction when a person talks, enhancing the sound heard by the person. It transmits sound through bone conduction to the nervous system and brain, therefore, auditory feedback and comprehension of the information is improved and the patient can speak in a more accurate and stable fashion. In this way, the auditory-speech feedback [10] is further trained.

Operation: Turn on the device. When the blue light is on, instruct participants to wear the Forbrain. They can select their favorite material, be it stories, essays, novels, magazines and newspapers, and read out loud. During the process, instruct the patient to adjust his pronunciation and stress timely according to the sound perceived through bone conduction, in order to optimize the effects of the training.

For those who are illiterate or with literacy problems, patients can sing their favorite songs for the purpose of training.

Training Schedule: start keeping time when the patient starts reading. 20 minutes per session, 5 sessions a week, 10 weeks in total.

(3) Experimental Group 2: Non-standard Forbrain speech-auditory feedback training in addition to conventional rehabilitation training and care in the control group.

The non-standard Forbrain speech-auditory feedback training involves the wearing of a device of identical appearance with that used in experimental group 1. However, the device does not have the dynamic vocal processing technology or electronic dynamic filter and it only transmits the sound through bone conduction. It has no effect in improving "speech-auditory feedback". The operation of the device and train schedule is the same as experimental group 1.

2.2 Assessment

All three groups of patients were assessed by trained researchers using MoCA at baseline and after the 10-week intervention. MoCA was designed by Nasreddine[11] based on clinical experience and reference to Mini-mental State Examination (MMSE), and it was translated into Chinese in 2007 by Wang Wei and his team. The scale has good reliability and validity with the coefficient of stability at 0.86 and Cronbach's α at 0.82[12].

The scale has 11 indexes, covering 8 aspects of cognition: attention and concentration, executive function, memory, language, visuospatial construction, abstract thinking, calculation and orientation. The total score is 30 and 26 is set as the baseline for normal cognitive capacity. A score less than 26 is indicative of impaired cognitive function and 1 point would be added to the score if the subject received less than 12 years of education [12].

2.3 Statistical analysis

Statistical software SPSS17.0 was used for statistical analysis. Measurement data was described by $\bar{x}\pm s$. Comparison among three groups was conducted by Analysis of Variation, that between two groups by LSD and that between enumeration data by x^2 test. The level of significance was set a priori at $P = 0.05$.

3. Results

3.1 MoCA scores before intervention

Before the experiment, the overall difference and that of each individual aspect compared among 3 groups were neither statistically significant (P> 0.05) (see Table 2).

Table 2: cognitive function of 3 groups before intervention ($\bar{x} \pm s$)

MoCA	Experimental Group 1(n=40)	Experimental Group 1(n=40)	Control Group (n=40)	*F*	*p*
visual visuospatial skills	1.53±0.55	1.60±0.59	1.63±0.59	0.325	0.723
Executive function	2.00±0.45	1.98±0.58	2.03±0.58	0.086	0.918
Attention and concentration	1.75±0.44	1.83±0.39	1.80±0.41	0.347	0.708
Language	1.43±0.50	1.58±0.50	1.60±0.50	1.438	0.242
Calculation	1.53±0.93	1.68±0.99	1.83±1.035	0.919	0.402
Abstract thinking	1.18±0.55	1.20±0.46	1.13±0.56	0.210	0.811
Memory	1.60±0.74	1.83±0.59	1.63±0.59	1.460	0.236
Orientation	4.05±0.39	3.98±0.36	3.90±0.44	1.425	0.245
Total	15.80±2.24	16.38±2.70	16.30±2.73	0.594	0.554

3.2 MoCA scores after intervention

After the 10-week intervention, the scores of visuospatial skills, attention and concentration, memory and the total score in experiment group 1 were significantly higher than those in experiment group 2 and control group (P <0.05). The scores of language in experimental group 1 and 2 were higher than that in the control group and the difference was of statistical significance. (P <0.05). See Table 3.

Table 3 cognitive function of 3 groups after intervention ($\bar{x} \pm s$)

MoCA	Experimental Group 1(n=40)	Experimental Group 2	Control Group (n=40)	*F*	*p*

visuospatial skills	2.05±0.50[ab]	1.80±0.46	1.78±0.53	3.697	0.028
Executive function	2.30±0.52	2.23±0.48	2.28±0.45	0.250	0.780
Attention and concentration	2.15±0.36[ab]	1.90±0.44	1.85±0.36	6.792	0.002
Language	2.03±0.48[ab]	1.85±0.53[b]	1.70±0.46	4.349	0.015
Calculation	1.65±0.945	1.78±1.03	1.90±1.01	0.632	0.533
Abstract thinking	1.50±0.51	1.33±0.47	1.25±0.44	2.931	0.057
Memory	2.18±0.59[ab]	1.90±0.55	1.70±0.56	7.046	0.001
Orientation	4.15±0.43	4.03±0.28	3.95±0.39	2.991	0.054
Total	18.75±2.05[ab]	17.53±2.41	17.18±2.37	5.254	0.007

Note: a: $P<0.05$ when compared with experimental group 2; b: $P<0.05$ when compared with control group

4. Discussion

Cognitive dysfunction after stroke usually slows the rehabilitation process, resulting in prolonged hospital stay [13], as those patients struggle to cooperative with medical professionals. Researches shows that simulation induced by early rehabilitation training is conducive to the establishment of new neural pathways, and eventually new neural network can be established to promote cognitive rehabilitation.

The results of the study showed the scores of visuospatial skills, attention and concentration, memory and the total score in experiment group 1 were significantly higher than those in experiment group 2 and control group ($P <0.05$), in line with results published by de Almeida Avila [16]. This suggests that sensory integration training can effectively facilitate the recovery of cognitive function in patients. The scores of language in experimental group 1 and 2 were higher than that in the control group and the difference was of statistical significance ($P <0.05$), which may be associated with daily speech training.

It can be inferred that speech-auditory feedback training provided by Forbrain is based on the following mechanism:

(1) During the training, dynamic filter installed on the device can block the noise from the surrounding environment, highlighting the perception of the user's own voice. In this way, the user can concentrate on the content of their own reading, and the part of the cerebral cortex in charge of attention would be activated. That is how the patient's attention and memory is improved,

consistent with the result of Song Mei Xian's study, which shows the patient's attention and memory can effectively be enhanced through reading and repeating [17].

(2) The auditory training is an effective intervention in that it corrects the misperception of sound of the auditory system. When exposed a sound, part of the brain in charge would be stimulated and therefore cognitive functions are refined, which cannot be achieved by mere communication therapy or prescription [17-18]. This study required patients to read aloud, their voice was collected and processed through microphones. During the process, patients' understanding and application of sentences were enhanced and at the same time, their auditory and visual perception were sharpened. Further, the corresponding regions of the brain such as temporal lobe and primary motor cortex were stimulated to contribute to better cognitive and language functions [19].

(3) When the patient is reading aloud, he concentrates on the content of reading and the eye moves along lines. This is good for the integration of visual and auditory information. Such stimulation of multiple senses and their interactions could facilitate the reorganization of the neural network [20]. This funding is confirmed by Zhang Rumei et al [21] and their research showed that auditory training can effectively improve memory and cognitive function in patients with cerebral damage.

(4) It has been reported that auditory integration training, through the input of sound, can effectively stimulate brain activity, so that neuro-network of the cerebral cortex is reorganized and cognitive functions improved [6]. Forbrain integrates visual, language and auditory training and this speech-auditory feedback training is not only as entertaining as other auditory training, it is also engaging, patient-friendly and safe to use. Patients appear to be more compliant to such an intervention and as a result, their cognitive functions will be better improved.

In summary, Forbrain speech-auditory feedback training is convenient, safe as well as entertaining, greatly improving the patient's compliance with treatment. It is shown that this is a more convenient alternative for the rehabilitation of cognitive function in stroke patients. However, limitations on time and sample size necessitate further researches.

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