A Visual Attention Training Program for the Improvement of Auditory Comprehension in Aphasia

Shiva Javadipour[1], Vahid Nejati*[2] Fariba Yadegari[3], Sheyda Javadipour[4], Seyed Amin Alavi Fazel[5]

ABSTRACT

Attention as a non-linguistic cognitive component appears to play a role in language performance. Few research have identified evidence of contribution of attention training in improvement of auditory comprehension with Individuals with Aphasia (IWA). Based on the previous studies, it was hypothesized that visual attention training improves auditory comprehension in IWA with moderate severity. Three adults (two male and one female) with chronic aphasia participated in the study, all with attention and auditory comprehension deficits included in the study using the auditory comprehension subset of Persian version of the Western Aphasia Battery (P-WAB) and Farsi Aphasia Test (FAT). Adopted attention cognitive tests of Stroop and Continuous Performance Test (CPT) were used to measure cognitive capabilities pre-treatment. NEurocognitive Joyful Attentive Training Intervention (NEJATI) was used as an attention cognitive intervention in a 6-weeks training program through single subject non-concurrent multiple baseline design across participants to evaluate treatment effects. Cohen's d-static was used to quantify treatment effect size. Two of the three participants showed significant improvements in their auditory comprehension skills with corresponding effect sizes that were large and medium in magnitude (d = 5.7 and d = 4.1 respectively). The third participant did not show any sign of improvement (d = 0.5). The hypothesis that attention training leads to improvement in auditory comprehension in moderate aphasia has been confirmed in this study. Cognitive factors can also play a role in the effectiveness of the treatment. This finding needs to be more investigated in larger population of aphasia patients with control for cognitive abilities variabilities.

Key Words: Aphasia, Auditory Comprehension, Multiple Baseline Single Subject, Visual Attention Training

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Introduction

Following brain damage, Individuals with Aphasia (IWA) are traditionally viewed to exclusively have language impairments which can lead to impaired reading, writing, speaking, and listening abilities (Chapey, 2008). In this view, it is well-recognized that the assessment and treatment of IWA is focused on the language deficits (Hula and McNeil, 2008). Further, there is robust evidence about non-linguistic cognitive impairments such as memory, attention and executive functions in IWA (Glosser and Goodglass, 1990; Helm-Estabrooks, 2002; Helm-Estabrooks *et al.*, 2000; Keil and Kaszniak, 2002; McNeil *et al.*, 1991; Murray, 2012; Purdy, 2002).

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These cognitive impairments exacerbate language impairment and should be improved during rehabilitation of IWA. There are several studies that state the role of different cognitive function in language abilities such as working memory (see Gathercole and Baddeley (2014) for review) inhibitory control (Giezen *et al*., 2015), cognitive flexibility (Declerck *et al*., 2017), and attention (Gardner-Neblett *et al.,* 2014; Maxfield *et al*., 2016).All mentioned cognitive functions play an important role in the recovery of language impairments but intervention in all domain is impossible for therapist. For a cost benefit intervention for IWA in the cognitive domains, the most important cognitive functions that may considered as the most central and basic cognitive function is attention. Attention play a crucial role in all domain of cognitive functions (Posner *et al*., 2004).

Attention as a non-linguistic cognitive component seems to play a large part in language performance (McNeil *et al*., 1990; Hula and McNeil, 2008) including language production (Crosson *et al*., 2007; Murray, *et al*., 1997), reading comprehension (Coelho, 2005; Sinotte and Coelho, 2007), and auditory comprehension (McNeil *et al*., 1991; Murray *et al*., 1997; Murray *et al*., 1997).

Attention can be defined as a "selective process that occurs in response to the limited processing capacity of the brain" (Banich, 1997). A general model of attention was introduced by Kahneman (1973) which is based on resource allocation proven to be particularly useful for investigation of cognitive–linguistic interactions in brain-damaged subjects (Kahneman, 1973; Norman and Bobrow, 1975). In particular, McNeil applied this model (attention as a resource allocation) to IWA and concluded that language deficits have roots in resource deficiency rather than being a mere language deficit. In fact, it is argued that the capacity of language processing resources that have been damaged. "Failure occurs when there are insufficient resources or when available resources have been channeled to other tasks" (Murray *et al*., 1997).

One possibility for resource allocation deficits in aphasia could be the poor evaluation of task demands. IWA may fail to allocate sufficient effort or attentional resources because of their difficulties in task's demands monitoring following brain damage (Thompson, 2006). Further, regarding the role of attention deficits in linguistics abilities Korda and Douglas (1997) argue that attention deficits may have an important influence on auditory comprehension which is defined as "the ability to understand spoken language" (Helm-Estabrooks, 2011).

Few have studied the relationship between treating attention deficits and auditory comprehension in IWA. Most IWA experience some degree of auditory comprehension deficit and inefficient allocation of attention could be a significant contributor to these deficits (McNeil and Kimelman, 1986; McNeil *et al*., 1991). Variability in performance of auditory comprehension tasks is argued to be associated with unstable access to intact language system which is due to attentional deficiency (McNeil, 1983).

Some clinicians rely on direct language stimulation approaches to address auditory comprehension deficits even though they are not supported by robust research (Helm-Estabrooks, 2011). While others have recently found positive effects on auditory comprehension using less direct approaches of training, applying nonverbal visual attention skills (Helm-Estabrooks, 2011; Helm-Estabrooks *et al*., 2004; Murray *et al*., 2006).

Helm-Estabrooks *et al*. (2000) used the Attention Training Program (ATP) for treating auditory comprehension deficits in two chronic mixed nonfluent aphasics with varying results. Their first participant, who showed poor cognitive skills at baseline, showed improvement in both cognition and auditory comprehension. On the other hand, their second participant who initially demonstrated good cognitive and attentional skills experienced less improvement.

Murray *et al*. (2006) designed a single subject study for examination of the effect of attention training. They used a combination of verbal and non-verbal tasks of Attention Process Training (APT-II) (Sohlberg and Mateer, 2001) to assess the impacts on performance of auditory comprehension in one patient with mild conduction aphasia and cognitive deficits. The results showed small improvements in auditory comprehension. Helm-Estabrooks (2011) argues that the small improvement could have been caused by relying on verbal treatment tasks that insert high linguistic load on the patient. As such she poses a question of whether treatment tasks involving only non-verbal stimulant would lead to better performance auditory gains. In this line, Helm-Estabrooks and Karow (2010) designed the Problem Solving Treatment Program (PSTP), which address cognitive abilities by multiple

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tasks, many of them have no linguistic demands. Khan (2013) examined the effect of the visual subtests of PSTP on two participants, both with chronic, moderate-to-severe auditory comprehension deficits. Results indicated that one of the two participants experienced significant gains in her auditory comprehension abilities.

Although the current body of research is dearth, evidence suggests that IWA with moderate-to-severe forms of aphasia can make gains when visual attention is trained. Further, the inter-relationship between auditory and visual comprehension is confirmed by Vachon and Tremblay (2008) who argue that "processing auditory and visual information is restricted by similar attentional limitations". For example, the processing of spatial stimuli through visual attention can be facilitated by accompanying auditory stimuli (Teder-Sälejärvi *et al*., 1999).

The aim of the present study was to explore the impact of visual attention training on auditory comprehension abilities. It was hypothesized that a resource allocation focused training on visual attention will lead to improved auditory comprehension abilities in IWA with moderate severity and to a lesser extent for milder forms of aphasia.

Methods

Participants

Three adults with chronic aphasia (MZ, HGH, and AN) participated in the study. The participants' age varied from 55 to 70 years (M= 62 years), and time post onset of stroke ranged from 20 to 48 months (M= 32 months). All participants signed an informed consent before starting the study. The inclusion criteria ensured that the participants not to have a history of neurological or psychiatric disorders before their strokes. They had a mild or moderate aphasia quotient (AQ) as indicated by Persian version of the Western Aphasia Battery (P-WAB) (Nilipour *et al*., 2014). AQ scores ranged from 66.6 to 77.5 (M = 70.9) (See Table 1).

None of the participants received any other individual speech-language or cognitive treatment during the course of the study. All of the participants demonstrated auditory comprehension deficits on the auditory comprehension subtests of P-WAB (including Yes/No Questions, Auditory Word Recognition, and Sequential Commands) and the Farsi Aphasia Test (FAT) Nilipour (1993) (including Basic Word Discrimination, Commands, and Complex Ideational Material). They also, demonstrated impairments in attention on the cognitive tests including adapted versions of Stroop and Continuous performance test (CPT) in the pre-treatment testing.

Experimental Design

We used a single subject non- concurrent multiple baseline (MB) across participants (Thompson, 2006) to study possible treatment effects. MB is a suitable method in single subject studies where the effects of a single intervention on a number of conditions, settings or individuals are desirable. MB provides two benefits: (i) it is does not require withdrawal of intervention from patients and (ii) since the intervention effects is not desirable to be reversed (Byiers *et al*., 2012).

To control for external variables and to ensure consistency across the subjects the length of the baseline phase was extended. In our study the auditory comprehension as the dependent variable was repeatedly measured in baseline probes for each participant. Following the completion of baseline probes, intervention was presented. Probing continued throughout the treatment phases. After termination of the treatment, follow-up probes were conducted as part of the maintenance phase which lasted between 2 and 6 months depending on subjects' availability. We started the treatment for each participant by visually inspecting the plotted measurements when the responses of the participant seemed to stabilize by examining the level, trend (slope), and variability of performance during the baseline and intervention phases (Horner *et al*., 2005; Kennedy, 2005; Parsonson *et al*., 1992).

Cohen's d statistic was used to determine the effect size of the treatment for each participant in auditory comprehension. It is a well-known and widely used statistic in aphasia studies and quantifies the magnitude of the change in level, which is firstly detected by visual inspection. It is the most reliable estimator of the effect size when the pre-treatment variance is a non-zero value (Beeson and Robey, 2006). Cohen's d statistic is calculated: (see Equation 1)

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$$d = \frac{\bar{x}_{A_2} - \bar{x}_{A_1}}{s_{A_1}}$$

Effect sizes (d) were calculated by subtracting the mean of the baseline scores ($\bar{x}_{A_1}$) from the mean of the maintenance scores($\bar{x}_{A_2}$) and dividing the result by the standard deviation of the baseline scores (s_{A_1}). d index signifies the extent of the treatment success: the higher the score the better the treatment effect.

By reviewing studies in aphasia, Beeson and Robey (2006) point out that d-statistics is context-dependent which means the interpretation of an obtained d score needs to be compared for particular benchmarks. For example, syntactic production treatment yielded benchmarks of 6.0, 12.0, and 18.0 and the lexical retrieval treatments yielded benchmarks of 4.0, 7.0, and 10.1 for small, medium, and large effect sizes, respectively.

To overcome human error, we used an inter-rater agreement. Reliability of the scoring of participant responses was conducted by a colleague who was blind to the phases of the study as suggested by Thompson (2006).

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Experimental Intervention

We used NEurocognitive Joyful Attentive Training Intervention (NEJATI) as cognitive rehabilitation intervention. NEJATI is a computerized program that aims to improve attentional impairment and was created by Nejati, Pouretemad, and Bahrami (2013). This nonverbal visual attention training program has been used in other studies (Nejati *et al*., 2013; Nejati *et al*., 2017; Oskoei *et al*., 2016; Oskoei *et al*., 2013). NEJATI' tasks of attention are not relying on the involvement of any verbal stimuli, making it ideal for use in IWA. This is the first study which used NEJATI for attention impairment in IWA.

Outcome Measures

Pre- and post-treatment measures were taken and compared to assess the effectiveness of the treatment on patients. Throughout the study, during the baseline, treatment, and maintenance phases, multiple probes from the patients provided insight into the patients' response to the treatment. Further details of the different measurements are given in the below sub-sections.

Probing schedule

Token Test administration and scoring are quite simple and different studies have confirmed validation of its sensitivity to aphasia (Spreen and Risser, 2003). Also the obtained scores highly correlate with other auditory comprehension tests scores (Morley *et al.*, 1979). The test involves 62 oral commands divided in five sections of increasing complexity. Part V contains twenty-two questions that include relational concepts that can even identify "latent aphasic" patients who cannot easily be diagnosed using other tests, as noted by Boller and Vignolo (1966). This suggests that Part V by itself has the potential to identify those patients with left hemisphere lesions misclassified as non-aphasic and thus could be used without the other 40 questions (Lezak *et al*., 2012). The patients are required to comprehend the token names and the verbs and prepositions in the instructions.

In this study, Part V was measured as the probe at all stages in the same fashion. The number of probes was different across participants, with a minimum of five baseline probes and staggered to 8 and 12. To ensure that participants would not overlearn and respond based on the order of the questions, the questions were presented randomly at each probe. Probing was continued until performance was relatively stable. The test scores were computed in accordance with the rules of the test designers (Roelien Bastiaanse, 2016). Multilingual Token Test is available for up to 40 languages (including Persian) digitally for iOS.

When the patient's baseline performance stabilized by visually inspecting the trend treatment was initiated. Token probes were collected twice a week during the treatment phase. Post treatment, during the maintenance phase, follow-up probes were collected.

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Pre- and Post- treatment testing

The pre- and post-treatment tests included the auditory subtests of the FAT, the P-WAB and the Diagnostic Reading Test (Shirazi and Nilipour, 2005). These were administered before and after the treatment period to evaluate participants' auditory comprehension skills and assess the effectiveness of the treatment. To evaluate potential changes in attention skills resulting from the intervention, the cognitive attention tests including adapted versions of Stroop and CPT were directed before and after the treatment period.

The Diagnostic Reading Test

It is a Persian diagnostic reading test designing for detection reading problems. DRT is a test of oral reading rate, comprehension, and accuracy. It consists of three passages of increasing length and difficulty that are followed by comprehension questions.

The Stroop Test

An adapted version of the original color- word Stroop task (Stroop, 1992) was used in this study. The task consisted of three stages. In the first stage participants were asked to identify the color of stimuli, a set of color names (e.g., red, green, blue, yellow), by pressing the corresponding colored key on the keyboard. In the second stage, different color hues were presented and participants would name the color of each hue. The third stage was the incongruent condition in which the meaning of the color word and the print color differed and participants would call the color of the word. Each stage includes 25 trials.

Continuous Performance Test (CPT)

CPT is a standardized computerized tool used to assess different aspects of attention such as its sustainability (Munkvold *et al.*, 2014). The modified version used in this study consisted of pairs of numbers which were printed on both sides of the screen, and respondents were asked to press the space bar if both numbers on the screen were similar. 150 stimuli were presented pseudo randomly so that 20% of stimuli were targets. In addition, inter-stimulus interval which is the temporal interval between presenting two stimuli was 500 milliseconds. CPT's omission and commission errors were used to assess attention in this study. Omissions indicated the number of targets which the individual missed to respond and commissions showed the number of times that the individual responded to nontarget stimuli (Conner, 2004).

Procedure

The intervention program was provided by the first researcher for a duration of six weeks to the subjects. The subjects attended three sessions per week lasting 40-45 minutes. In order to comfort the patients, treatment was performed by therapist (S.J.) at their home in a quiet environment. Task administration was computerized and presented on a Sony VAIO Laptop (Intel Core i3 3120M (2.50 GHz) processor; 15.5 in .60Hz monitor).

In a treatment session, each subject performed three tasks of the intervention program that included the sustained attention, visual span, and shifting attention training. For this purpose, we present the three-joyful computer based tasks to participants. These tasks were graded and increased in level of difficulty based on participants' response. the progression of the tasks was based on the amount of flanker stimuli, the presentation velocity, and the speed of rule changing. When the subjects reached the desired level or when the assignment seemed very difficult for them, the task was stopped to reduce disappointment.

For example, in one of these tasks, the user would arrange faces in different categories based on three properties; emotional status (sad, angry and neutral), hair color (green, white and black) and skin color (yellow, white and black). Faces have one property of each category and participant should act only based on the presented rule i.e. select one of the three features of the faces and act based on that. Throughout the therapeutic session no feedback regarding the accuracy of participants' responses were given to the patients.

Results

Response to treatment

The results of the three participants (MZ, HGH, AN) from the auditory comprehension probes are shown in Figure 1-3 respectively. MZ showed signs of stability after 5 probes with M = 6; HGH stabilized after 8 probes with M = 7.8, and for AN, twelve probes were taken before treatment could begin with M = 6.1. During the intervention, MZ and HGH, showed improvement in their performance with M = 9.6, and M = 11.4 with immediate effect to treatment and an overall positive trend. For AN no change in the mean performance was observed (M = 6.1) with no significant observable trend. Robey (1998) benchmarks for effect size magnitude in aphasia research were employed to interpret the change in scores. He suggested 2.6, 3.9, and 5.8 as values corresponding to small, medium, and large effect sizes respectively. The results showed that the level of change in auditory comprehension from baseline to maintenance was 5.7, 4.1, and 0.5 for MZ, HGH and AN signifying large, medium and no effect respectively. Also, inter-rater agreement was high.

The pre- and post- treatment testing scores

Table 2 shows the results of pre-and post-treatment tests. From the auditory comprehension tests (FAT and P-WAB), two of the participants (MZ and HGH) demonstrate improvement in all the associated subtests. The third participant (AN) shows some improvement but to lesser degrees and not in all subtests.

In the DRT posttreatment scores indicated improvement for both MZ and HGH MZ showed positive changes in reading time, comprehension and speed. HGH demonstrated small changes in time and speed, yet, his scores in the pretreatment testing was generally better than that of MZ. AN also demonstrated small positive changes on the reading time and comprehension. Although, she showed reduced accuracy score compared to the pre-testing for the first and third text of the DRT.

The cognitive attention tests of CPT indicated of improvement for MZ and HGH on the omissions and commission measures which is an indication of improved sustained attention. For AN, however, performance on the CPT showed small changes. For Stroop, the scores showed reduced error rate in both MZ and HGH. For AN there was no sign of treatment impact.

Table 1. Participant characteristics

Participant	Age (years)	Gender	Months post onset	P-WAB AQ	Aphasia severity	location/type of stroke
MZ	63	Male	48	68.6	Moderate	Left MCA/I
HGH	55	Male	30	77.5	Mild	Left MCA/I
AN	70	Female	20	66.6	Moderate	Left MCA/H

Note. P-WAB AQ = Persian version of Western Aphasia Battery (Nilipour et al., 2014) aphasia quotient, MCA = Middle Cerebral Artery. I = Ischemic, H = Hemorrhagic.

Table 2. Pre-and post-treatment tests results in three participants

Tests	Subtests		MZ				HGH				AN			
			Pre-treatment		Post-treatment		Pre-treatment		Post-treatment		Pre-treatment		Post-treatment	
			Score	%	Score	%	Score	%	Score	%	Score	%	Score	%
FAT	Basic Word Discrimination		18/37	48%	25/37	67%	32/37	86%	35/37	94%	12/37	32%	17/37	45%
	Commands		5/15	33%	10/15	66%	8/15	53%	12/15	80%	3/15	20%	3/15	20%
	Complex Ideational Material		2/12	16%	5/12	41%	3/12	25%	6/12	50%	2/12	16%	2/12	16%
P-WAB	Yes/No Questions		7/10	70%	8/10	80%	8/10	80%	9/10	90%	6/10	60%	7/10	70%
	Auditory Word Recognition		9/20	46%	11/20	55%	13/20	65%	17/20	85%	11/20	55%	11/20	55%
	Sequential Commands		2/10	20%	4/10	40%	3/10	30%	8/10	80%	3/10	30%	4/10	40%
	AQ		61.66		79.16		72.5		82.5		66.6		69.1	
			Score		Score		Score		Score		Score		Score	
Cognitive tests	Stroop	Error rate	56%		44%		44%		34%		64%		58%	
	CPT	Omission error	13		5		10		8		17		15	
		Commission error	41.8%		23.5%		31.2%		21.1%		57.5%		49.1%	
DRT	Text 1	Time	120		97		65		62		153		145	
		comprehension	60%		80%		75%		100%		60%		80%	
		Speed(wpm)	17.5		21.64		32.3		33.8		13.72		14.48	
		Accuracy	7		10		11		13		11		10	
	Text 2	Time(s)	142		124		77		69		123		118	
		comprehension	60%		75%		60%		100%		60%		80%	
		Speed(wpm)	21.5		24.67		39.74		44.34		24.8		25.9	
		Accuracy	5		7		15		16		10		11	
	Text 3	Time(s)	150		128		67		63		137		125	
		comprehension	40%		60%		60%		100%		50%		70%	
		Speed(wpm)	20.4		23.9		45.67		48.57		22.33		24.4	
		Accuracy	5		7		15		16		9		7	

Note. FAT= Farsi Aphasia Test (Nilipour, 1993); P-WAB= Persian version of Western Aphasia Battery (Nilipour et al., 2014); CPT= Continuous Performance Test; DRT= Diagnostic Reading Test (Shirazi and Nilipour, 2005).

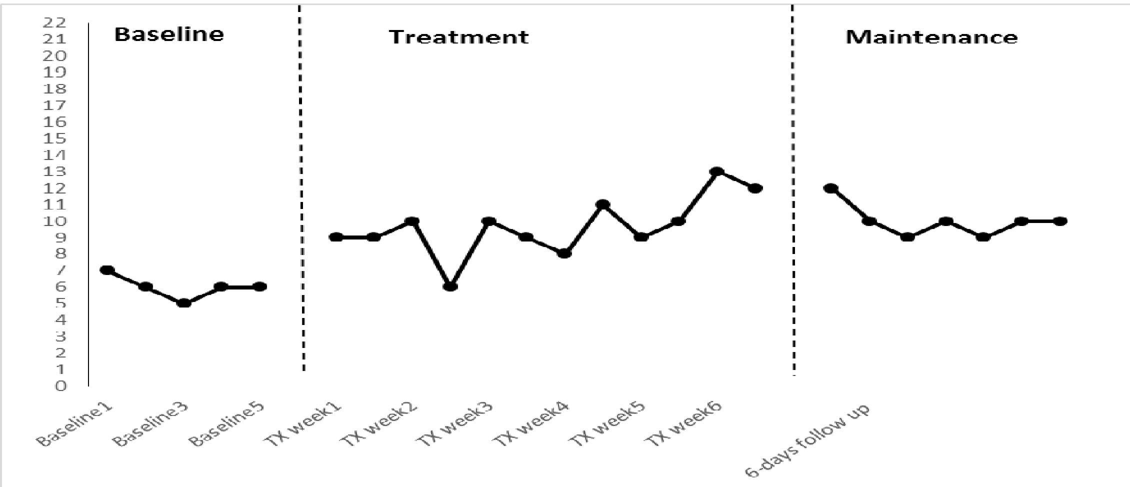

Figure 1. MZ' auditory comprehension probes

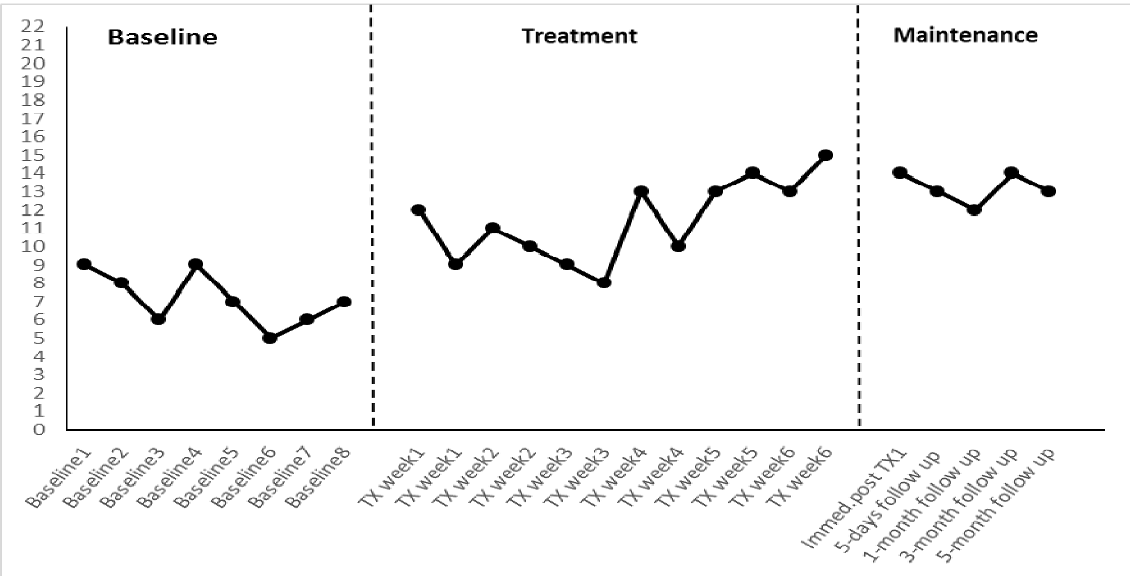

Figure 2. HGH' auditory comprehension probes

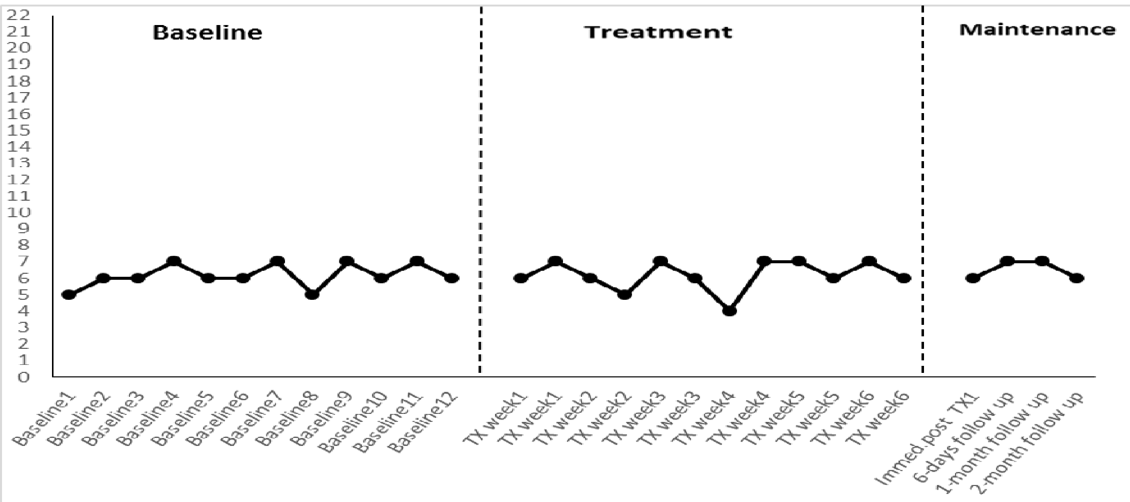

Figure 3. AN' auditory comprehension probes

Discussion

The results clearly indicate improvements in two of the three participants (MZ with moderate and HGH with mild severity) when intervention was applied to the patients. While no improvement was observed by the third patient (AN) with moderate severity. This partially confirms our hypothesis that attention training has promising positive treatment effects on IWA with moderate severity.

MZ who initially demonstrated low auditory performance and attentional skills, responded best to the intervention as indicated by the large d-score of 5.7. HGH who initially demonstrated better auditory and attentional performance compared to MZ, due to his milder form of aphasia, also experienced improvement in auditory measures but to a lesser extent as was hypothesized (d-score = 4.1). These findings confirm with that of Helm-Estabrooks *et al*. (2000) who also identified improvement in patients in response to their proposed attention training program. Albiet, the third participant (AN), against our expectations, did not respond to the treatment at all with a d-score of 0.5 which needs explanation.

Firstly, MZ and AN both had moderate AQ while AN performed worse in all the cognitive pretreatment tests and that it may be a major contributing factor explaining the lack of response to the treatment. This may imply that for a patient to respond positively to a visually attention based treatment program requires a minimum set of cognitive abilities. This highlights further the importance of the attention as a resource allocation in aphasia treatment (McNeil *et al*., 1991).

Another factor that could contribute to the effectiveness of the training or lack thereof could be associated with the length of the baseline period. AN was the last participant who joined the study and was held in the baseline period consisting of 12 probes compared to MZ who only had 5. This may have contributed to AN losing motivation to the treatment. This highlights one limitation of the non-concurrent multiple probes methodology.

Yet another factor could be associated with the intensity and duration of the treatment program (Kleim and Jones, 2008). Using meta-analysis, according to Robey (1998), an intensive treatment program consists of at least 5 hours per week. And the higher the intensity the more effective the outcome. Our study consisted of about 2 hours of training (3 sessions per week each lasting 40 to 45 minutes) which is less than what is considered an intensive program. Thus, AN may have needed a more intensive program for it to be effective.

Limitation and Further research

Treatment of aphasia using attention training is still young and this study aimed at investigating this further following a detailed single subject study regiment. The hypothesis that attention training leads to improved auditory comprehension in moderate aphasia has been confirmed in this study and other studies with one caveat: that other cognitive abilities may play a part in the effectiveness of the treatment. This requires further investigation.

Further, a more intensive program could be combined with the proposed NEJATI program to improve outcome performance. For example, homework tasks could be designed and assigned between training sessions to patients with the aid of a partner at home.

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