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The Comparative Effects of Neurofeedback Training and English Instruction through the Total Physical Response Method on the Attention of Young Learners with Attention Deficit Hyperactivity Disorder

Masumeh Taie
Ph.D. Candidate of TEFL, Islamic Azad University, Science and Research Branch, Tehran, Iran

Reza Rostami*
Professor of Psychology, University of Tehran, Tehran, Iran

Massood Yazdanimoghaddam
Associate Professor of TEFL, Islamic Azad University, Garmsar Branch, Garmsar, Iran

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Abstract

Attention plays a vital role in education. Children who have attention deficit hyperactivity disorder (ADHD) suffer from impairing levels of inattention. ADHD is a relatively common childhood disorder (Scahill & Schwab-Stone, 2000), which, if left untreated, results in adverse consequences (American Psychiatric Association, 2013). This necessitates employing attention-training methods, such as neurofeedback training (NFT). But although conventional, NFT is expensive and time-consuming; therefore, the need for finding other methods is felt. The total physical response (TPR) method can provide a suitable venue for teaching young learners with ADHD (Nunan, 2011). Hence, this study was conducted to investigate the comparative effects of NFT and TPR on ADHD young learners' attention. To do so, 16 students with ADHD were selected from a school in Shahryar. They were randomly assigned to NFT and TPR groups, receiving these treatments for twenty sessions, respectively. The Integrated Visual and Auditory Continuous Performance Test (IVA+Plus) was used as the pre- and post-test to measure full, auditory, and visual attention. To answer the research questions investigating the comparative effects of NFT and TPR on ADHD young learners' attention, non-parametric one-way Analysis of Covariance (ANCOVA) was conducted. Moreover, the Wilcoxon Signed Rank test was used to explore within-group differences. The results indicated significant improvements for both groups. Nevertheless, NFT was found to be more effective regarding full and auditory attention. Concerning visual attention, both treatments were similarly effective. The findings suggest both treatments can improve participants' attention. The study has implications for education by shedding light on attention-training methods.

Keywords: neurofeedback training, total physical response, attention deficit hyperactivity disorder, attention

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Corresponding author's email: rrostami@ut.ac.ir

INTRODUCTION

Regulating attention and behavior in agreement with instructed or internal goals is one of the most remarkable capacities of humans (Rico-Picó et al., 2021). Attention is closely related to memory, and goal-driven, self-regulated behavior, in view of its role in executive control (Rueda et al., 2021). Moreover, although there are studies suggesting the possibility of some kind of learning without attention (e.g., Hochstein & Pavlovskaya, 2020), they are mostly related to perceptual learning and not higher-order learning. Hence, education should aim at boosting attention.

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder, which is defined by impairing levels of inattention (American Psychiatric Association, 2013). It "is a relatively *common* [emphasis added] condition of childhood onset" (Scahill & Schwab-Stone, 2000, p. 541). The prevalence of ADHD in Iran varies across different studies. In school-aged children, it ranges from 5.03% to 29% and 2.3% to 15% for boys and girls, respectively (Hakim Shooshtari et al., 2021). Considering the high prevalence of ADHD in children in Iran (Darabi et al., 2022) and the adverse effects of untreated cases of this disorder, such as impairments in social communication, functional restrictions of effective communication, social participation, or academic achievement (American Psychiatric Association, 2013), measures should be taken to improve attention in people with attention deficit.

Neurofeedback training (NFT) is a known cognitive training method for promoting attention, and its efficacy has been supported by many studies (e.g., Enriquez-Geppert et al., 2019; Ghadamgahi Sani et al., 2022; Riesco-Matías et al., 2021). Yet, NFT has been criticized on several accounts, such as being inefficient (Rahmani, et al., 2022), time-consuming, and expensive (Sho'ouri, 2021). Since there are studies indicating an association between socioeconomic disadvantage and the risk of ADHD (Keilow et al., 2020), parents of children with ADHD usually cannot afford its expenses. Therefore, the need for finding other methods for boosting attention is felt.

According to Nunan (2011), among different language teaching methods, total physical response (TPR) can provide a suitable venue for teaching young learners with ADHD. Yet, few studies have investigated the effect of TPR on attention. Furthermore, (to the author's knowledge) even those few studies are mostly not empirical, and they have just concluded through reasoning that TPR can improve attention (e.g., Kováčiková & Reid, 2018). There are experimental studies on the effect of TPR on ADHD, but (to the author's knowledge) they fall into two categories. That is, either they are not concerned directly with the effect of TPR on attention (e.g., Pramesti, 2021), or they have not measured attention objectively (De La Cruz et al., 2020).

The reason for juxtaposing TPR and NFT is that there are studies indicating that both methods have the potential to increase attention (Kováčiková & Reid, 2018; Riesco-Matías et al., 2021). Moreover, since NFT is a known attention-training technique, the effects of TPR on attention can be compared with the effects of NFT on attention. One of the advantages of comparative studies is that identifying an improvement potential may be easier when there is a reference level (Ellingsen et al., 2009). Therefore, this study has been carried out to investigate the comparative effects of NFT and TPR on young ADHD learners' attention. To do so, 16 schoolgirls with ADHD took part in this study. They were randomly divided into two groups, receiving NFT and TPR treatments, respectively, for twenty sessions. Full attention, auditory attention, and visual attention were measured by the IVA+Plus test prior to and after treatments. Non-parametric ANCOVA and the Wilcoxon Signed Rank test were used to answer the research questions.

LITERATURE REVIEW

Attention Deficit Hyperactivity Disorder (ADHD)

According to American Psychiatric Association (2013), ADHD is a neurodevelopmental disorder characterized by impairing levels of inattention, disorganization, and/or hyperactivity-impulsivity. Inattention and disorganization include inability to stay on task, appearing not to listen, and losing materials at levels not consistent with age or developmental level. Hyperactivity-impulsivity includes overactivity, constant moving, not being able to stay seated, barging into other people's activities, and not being able to wait. If left untreated, ADHD may bring about impairments in social communication, functional limitations of effective communication, social participation, or academic achievement (American Psychiatric Association, 2013).

Such impaired functioning may, in part, be due to inattentiveness (Sroubek et al., 2013). According to American Psychiatric Association (2013), "ADHD occurs in most cultures in about 5% of children" (p. 61). It should be mentioned that "a huge variability in prevalence rates is detected among different studies, ranging from as low as 1% to as high as nearly 20% among school-age children" (Ercan et al., 2015, pp. 1145–1146). This variation is reported not only across different studies in the world but also in Iran. According to Hakim Shooshtari et al. (2021), the reported ADHD prevalence among school-aged children in Iran fluctuates between 5.03% and 29% for boys and 2.3% to 15% for girls.

As it can be observed, ADHD has inflicted a large population in the world, hence its significance. Many effective treatments are available for ADHD, including pharmacological, nonpharmacological, and multimodal treatments (Harpin et al., 2016). Recognition of parents' attitudes towards different treatment types is important because it may improve our understanding of the type of therapeutic decisions they make (Jiang et al., 2014). On the whole, "[a]dverse effects, concerns about stigmatization, and the child's dislike of taking pills, all contribute to parents' decisions to discontinue medication even when the child shows symptomatic benefit" (Charach et al., 2006, p. 75). Therefore, many parents would rather not use any form of medication for the treatment of their children's ADHD (Charach et al., 2006). Consequently, for these children, alternative treatment methods must be adopted. One of the nonpharmacological cognitive methods for alleviating symptoms of ADHD, which is gaining increasing attention, is neurofeedback (Enriquez-Geppert et al., 2019).

Neurofeedback Training (NFT)

Historical Background of Neurofeedback

In 1875, the electrical activity of the brain was discovered by Richard Caton, the British physician and physiologist (Caton, 1875). Later, in 1924, this electrical activity was recorded by Hans Berger, the German psychiatrist. Following the term electrocardiogram, Berger coined the term electroencephalogram (EEG) to refer to it (Berger, 1929). These, together with Pavlov's conditioning and Skinner's operant conditioning, were inspirations for the development of biofeedback and EEG biofeedback, also known as neurofeedback.

In 1962, Joe Kamiya found out that some subjects would learn through operant conditioning not only to determine whether they were in the alpha state but also to use feedback to produce this state (Kamiya, 1962). In the same vein, Sterman and Wyrwicka (1967) showed that it was possible to teach cats to produce sensorimotor rhythm (SMR) through operant conditioning (i.e., by providing food rewards for the occurrence of SMR). Later, Sterman and Friar (1972) were successfully able to suppress seizures in an epileptic patient following SMR EEG feedback training- now known as neurofeedback or EEG biofeedback.

Neurofeedback Definition and Priming

Neurofeedback is a neural stimulation technique for changing brain behavior (Mirifar et al., 2022). In other words, it is an electroencephalographic biofeedback technique for training individuals to change their brain activity (Thompson & Thompson, 2021). "Biofeedback is a behavioral training program wherein individuals learn to control their own autonomic nervous system, thereby attaining the ability to control such bodily functions as heart rate, blood pressure, skin temperature, or muscle relaxation" (Huber &

Gillaspy, 2011, p. 38). When biofeedback, a system operating based on operant conditioning and feedback, is used for controlling brainwaves, it is referred to as EEG biofeedback or neurofeedback (Thompson & Thompson, 2021). NFT can be used for treating or alleviating different diseases and disorders, such as ADHD, seizure disorders, depression, anxiety, and posttraumatic stress disorder (Thompson & Thompson, 2021).

Enriquez-Geppert et al. (2017) have summarized the basic setup of a brain-computer interface for neurofeedback (see Figure 1). According to them, first, the EEG gets recorded. Then, the data undergo processing, which refers to artifact detection, rejection, or correction. Afterwards, feature generation and extraction, and computation of the data will take place. Finally, during the last stage, which closes the feedback loop, the presentation of the feedback signal will happen. At this stage, participants try to learn to utilize the feedback signal to change their brain activity that complies with instructions.

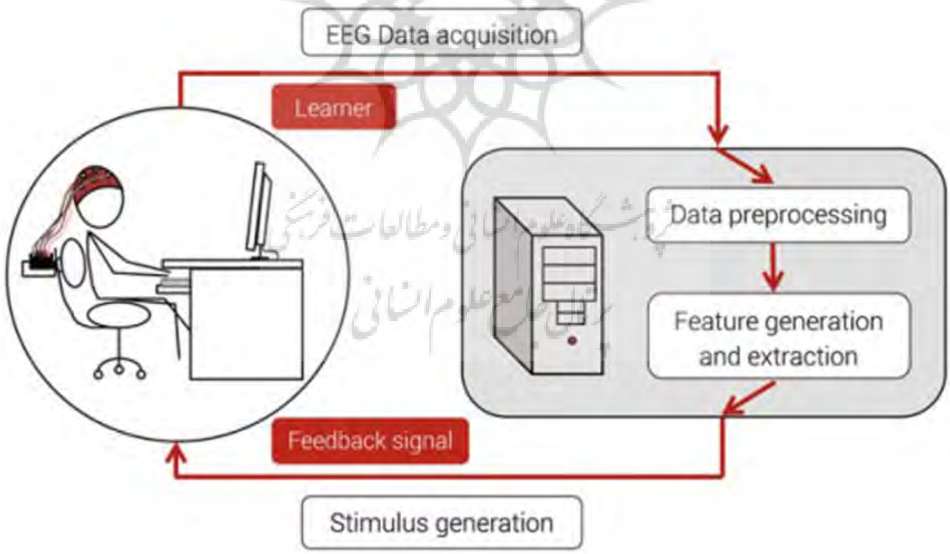

Figure 1. The basic setup of a brain-computer interface for neurofeedback (Enriquez-Geppert et al., 2017, p. 151)

During a typical NFT session, one or more electrodes are positioned on the scalp, and on the earlobes usually one or two are placed. No electrical current is put into the brain (Hammond, 2011). Through using electrodes, which are attached to the scalp, the electrical activity of the brain is sent to an electroencephalograph and a computer. These data are then processed and shown to the trainee in a format similar to that of a video game (Butnik, 2005). In some versions, the trainee sits in front of a computer monitor and tries to play a game. The neurofeedback device has been devised in such a way that if, for instance, the trainee increases the desired brainwave activity or decreases the undesired one, the game continues. But, the game stops if the trainee's mind begins to wander (Amen, 2015).

In all cases, the trainees can have knowledge of their own brainwave, which is "visually displayed to them, typically in the form of a bar graph whose height is proportional to the real-time EEG amplitude and which fluctuates accordingly" (Bagdasaryan & Le Van Quyen, 2013, p. 2). Through operant conditioning, trainees can "learn to manipulate this visual feedback, increasing/decreasing it to a predefined threshold level, with a reward when amplification/suppression to this threshold is achieved" (Bagdasaryan & Le Van Quyen, 2013, pp. 2–3).

There are different protocols for NFT, and none of them is considered a gold standard (Kropotov, 2016). In the context of NFT, the term protocol refers to the places of electrodes and frequencies which will be rewarded and inhibited (Ogrim & Hestad, 2013). People with ADHD usually have greater rates of slower EEG activity (delta, theta, or even alpha) in comparison to faster beta activity; therefore, most studies on ADHD have used protocols directed toward decreasing the large quantity of slow frequencies while enhancing the magnitude of fast frequencies (Yucha & Montgomery, 2008). Three standard NFT protocols are theta/beta (theta suppression/beta enhancement), sensorimotor rhythm (SMR), and slow cortical potential (SCP) (Enriquez-Geppert et al., 2019).

Total Physical Response (TPR)

TPR is a language teaching method established by James Asher, a professor of psychology at San Jose State University, California. This method tries to teach a foreign language by having students listen to commands in a foreign language and immediately obey them by performing physical actions (Asher, 1969). It is associated with the natural approach to language learning because it has some similarities to how children learn their first language (Asher, 1969). According to Asher et al. (1974), three key ideas underlying TPR are as follows: (1) Most linguistic items can be taught through imperatives. And if this technique is used creatively by teachers, it will be motivating to students for a long-term training program, (2) Listening skill can help other skills to develop. There is a large magnitude of transfer from listening to other skills, (3) Language learning is most optimally achieved through the engaging students' bodies when commands are set. This approach will help the internalization of language in chunks rather than word by word.

TPR is based on the stimulus-response pattern of behaviorism. Because in this method, the learners' correct response to a teacher's verbal stimulus results in praise (Wheeler, 2013). TPR has put lots of emphasis on the elicitation of physical responses from the learners, such as moving, reaching, jumping, grabbing, etc. Therefore, this method puts emphasis on right-brain learning. Asher believes that motor activity is a right-brain function, and it should happen before left-brain language processing (Asher, 1982). Moreover, TPR is a good example of embodied cognition in language acquisition (Zhou, 2021). Embodied cognition is a learning theory suggesting that the incorporation of knowledge into the body's sensorimotor system makes learning and understanding abstract concepts easier (Chettaoui, et al., 2022).

TPR is appropriate for children with ADHD (Nunan, 2011) because it reduces anxiety. Anxiety disorder is one of ADHD's common comorbidities (Quenneville et al., 2022). TPR reduces anxiety of children with ADHD by not forcing them to speak when they are not ready. According to Asher

(1969), "[i]f the student achieves a high level of listening fluency then the transition to speaking may be graceful and non-stressful" (Asher, 1969, pp. 16–17). TPR also reduces anxiety by employing the element of fun because, according to Asher (1982), it encourages commands that are zany, playful, bizarre, and crazy. Moreover, physical activity reduces anxiety (Carter et al., 2021).

Furthermore, it is appropriate because children have a limited attention span, and this limited span gets worse in the case of children with ADHD (American Psychiatric Association, 2013). To solve this problem, Nunan (2011) has recommended changing activities so that learners will not lose interest. In Nunan's (2011) view, TPR activities can provide a suitable venue for realizing such an aim because they are motivating and suit different learning styles, such as visual, auditory, and kinesthetic. Also, TPR is appropriate for children with ADHD because it caters to their strong bodily-kinesthetic intelligence because this method "relies on the use of bodily-kinesthetic intelligence" (Maftoon & Najafi Sarem, 2012, p. 1235).

PURPOSE OF THE STUDY

Considering the paramount importance of attention in education, this research was conducted to investigate the comparative effects of NFT and TPR on ADHD young learners' attention. The research questions (RQs) in this study, aim at exploring between-groups comparisons (i.e., whether NFT or TPR is more efficient at boosting full attention, auditory attention, and visual attention, respectively). In this respect, the following RQs were posed:

(1) Is there any significant difference between the effects of NFT and TPR on ADHD young learners' full attention?

(2) Is there any significant difference between the effects of NFT and TPR on ADHD young learners' auditory attention?

(3) Is there any significant difference between the effects of NFT and TPR on ADHD young learners' visual attention?

METHOD

Participants

Sixteen children with ADHD aged 7 to 12 were enrolled to attend this study by using a convenience sampling procedure. The participants were selected from a school in Shahryar, from beginner English learners suspected to have ADHD. They were all Iranian schoolgirls whose mother tongues were Persian. The participants were randomly assigned to two equal groups of A and B, receiving NFT and TPR for twenty sessions, respectively. The schematic representation of the design of the study is like the following:
Group A → IVA+Plus (pretest) → NFT treatment → IVA+Plus (posttest)
Group B → IVA+Plus (pretest) → TPR treatment → IVA+Plus (posttest)

Instrumentation

Integrated Visual and Auditory Continuous Performance Test (IVA+Plus)

IVA+Plus is a test designed by Sandford and Turner (1994). It has been used for two purposes in this study: a) as one of the screening devices assisting in the diagnosis of ADHD, and b) to measure participants' attention. It should be mentioned that this test can be used for both purposes (Sandford & Turner, 1994; Wang, et al., 2021). IVA+Plus falls under the category of Continuous Performance Tests (CPTs). It is a computerized test of attention in which the testees should respond to 500 intermixed auditory and visual stimuli. Stimuli are auditory and visual *1* or *2* (i.e., testees would see or hear a *1* or a *2*). The task of the testees is to click the mouse when they see number *1* or hear the word *one* and to refrain from clicking when they see number *2* or hear the word *two* (IVA+Plus, n.d.). This test has two composite scores (i.e., Attention Quotient and Response Control). The attention quotient is subdivided into auditory and visual attention. And auditory and visual attention are subdivided into vigilance, focus, and speed (Tinius, 2003). Figure 2 represents different attention scales measured by the IVA test.

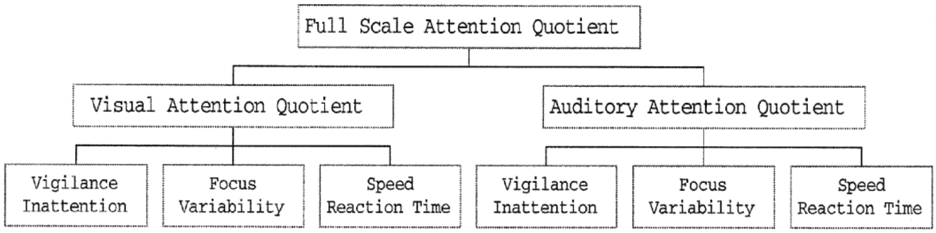

Figure 2. Descriptions of scales measured in the IVA CPT (Tinius, 2003, p. 452)

Since this study is concerned just with the attention quotient and its subdivisions (i.e., auditory and visual attention), the sub-subsections (i.e., vigilance, focus, and speed) and the response control scores have not been discussed. It should be mentioned that IVA+Plus "yields an extremely large number of possible scores" (Strauss, et al., Spreen, 2006, p. 576). Therefore, different researchers use just part of the test. In this study, IVA+Plus was used for measuring ADHD young learners' attention before and after NFT and TPR treatments. The assessments were carried out at intervals of 2–5 days before and after interventions. "Attention refers to the process of selecting task-relevant stimuli and inhibiting task-irrelevant distractors, and it helps us to allocate the mental resources involved in a vast number of simultaneous inputs from visual, auditory and other sensory modalities" (Wu, et al., 2021, p. 1). Therefore, visual attention and auditory attention refer to the ability to select simultaneous inputs from visual and auditory modalities, respectively.

Data Collection Procedure

The first criteria for selecting participants were teachers' and parents' reports. In these reports, teachers and parents were asked whether they thought their children were suffering from ADHD and whether they thought they had nearly no command of English. Based on these reports, 53 students were selected. The selected students were interviewed by the researcher to make sure that they nearly had no command of English. It should be mentioned that the reports were just used for screening purposes, although some parents claimed that their children had already been diagnosed with ADHD.

Subsequently, the selected students sat for the IVA+Plus test to help with the initial diagnosis of ADHD. Based on the results of this test, 23 students with an initial diagnosis of ADHD were selected. Finally, to ascertain the diagnosis of ADHD, the selected students were referred to a psychiatrist. Based on the psychiatrist's diagnosis and as confirmed by administering the structured clinical interview for American Psychiatric Association (2013), 16 students were recognized to be suffering from ADHD. The selected students were in stable clinical condition at the time of enrolment, as recognized by the psychiatrist. Written, informed-consents for attending the research were obtained from the participants' parents or their guardians. The participants were randomly divided into groups A and B. Group A in this study received 20 sessions of one-hour NFT, and group B had 20 sessions of one-hour TPR. NFT and TPR sessions were held three times a week in the morning before noon.

During NFT sessions, a trained operator, after attaching some electrodes to each child's head, briefed them in Persian that they have to focus their attention while watching a computer game. The operator explained that, by focusing their attention, they have to keep the green bar (representing the desired brainwave) up and the red one (representing the undesired one) down; otherwise, the game stops, and they have to attract their attention again to make the game restart. The sessions were held for each participant separately. The neurofeedback protocol used for ADHD in this study was a "beta-training protocol with Fz–Cz placement of electrodes and the NF parameter as the ratio of EEG power in the 13- to 21-hz band and EEG power in the 4- to 12-hz frequency band" (Kropotov, 2016, p. 258).

Following Professor Asher's (personal communication, January 10, 2019) recommendation, Nancy Márquez's (2011) book was used for TPR classes. Care was taken to make commands as funny as possible. Aside from using the TPR's major technique, namely commands (Asher, 1969; 1982; Asher et al., 1974), some classic TPR activities such as *Simon says* were used. In this game, students are supposed to perform only those orders that have been preceded by the clause *Simon says*. To make the game more interesting and students more motivated, the researcher changed it slightly. In each round, one of the students was appointed boss. Afterward, her name was used instead of Simon (e.g., *Setayesh says*). Then, the teacher or the student herself, if willing, would give orders. Following the game's rule, students were supposed to jump up high if the order was *Setayesh says, jump up high* and make no movement if the order was just *Jump up high*.

Some of the other activities used were carrying out commands with music songs. The other group of activities involved a whiteboard. Here, participants were asked to carry out drawing orders (e.g., *Draw a house!*) or to draw something on an incomplete drawing while being blindfolded. For example, the teacher drew a circle as an incomplete face and asked students to complete the drawing by issuing orders (e.g., *Draw the hair!*). In the same vein, the other group of activities involved using a noticeboard. Here, participants were asked to carry out sticking orders or to stick something on an incomplete drawing while being blindfolded (e.g., *Stick the nose!*). Other activities involved performing commands involving the use of realia (e.g., ball, teddy bear, book, notebook, pen, pencil, lunch box, school bag, school plastic cup, etc.). Moreover, as students made progress, an attempt was made to use more action sequences comprising three or more connected commands (e.g., *Take a pin. Pick up a nest. Stick the nest on the tree.*). Furthermore, new (unheard-of) commands were issued occasionally. Each session started by reviewing commands issued in the previous session or sessions.

RESULTS

Since the two samples in this study were selected from among ADHD young learners whose population does not meet the normality assumption, and due to the small sample sizes in this study, all RQs were analyzed through nonparametric tests.

Between-Groups Comparisons

To answer research questions in this study, three non-parametric one-way ANCOVA were conducted to compare the mean of the NFT group with that of the TPR group on full, auditory, and visual attention, respectively. The results were obtained after controlling for the effect of the pretest on full, auditory, and visual attention, respectively. As displayed in Table 1, the NFT group had a higher mean than that of the TPR group on the posttest of full attention and auditory attention after controlling for the effect of these items on the pretest. And as regards visual attention, an opposite scenario is observed.

Table 1: Descriptive statistics; posttest of full, auditory, and visual attention by groups with pretest

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
NFT Full Attention	103.319	2.206	98.554	108.084
TPR Full Attention	91.806	2.206	87.041	96.571
NFT Aud[a] Attention	108.774	2.614	103.126	114.421
TPR Aud[a] Attention	82.726	2.614	77.079	88.374
NFT Vis[b] Attention	97.412	3.395	90.076	104.747
TPR Vis[b] attention	102.088	3.395	94.753	109.424

a. Auditory

b. Visual

Table 2 shows the results obtained from non-parametric ANCOVA. The results (F (1, 14) = 11.99, $p < .050$) and (F (1, 14) = 8.67, $p < .050$) indicated that the NFT group significantly had a higher mean on full attention and auditory attention than those of the TPR group. However, concerning visual attention, the results (F (1, 14) = .119, $p > .050$) showed that there was no significant difference between NFT and TPR groups' means on the posttest of visual attention after controlling for the effect of the pretest.

Table 2: Nonparametric analysis of covariance; posttest of full, auditory, and visual attention by groups with pretest

Attention Type		*DFH*	*DFE*	*p* Value
Full Attention	11.997	1	14	.004
Aud[a] Attention	8.670	1	14	.011
Vis[b] Attention	0.119	1	14	.735

a. Auditory
b. Visual

Thus, the results indicated that while the NFT group had significantly higher mean scores on full attention and auditory attention than those of the TPR group, no significant difference was observed between the two groups regarding visual attention.

Within-Group Analyses

While between-groups analyses indicated significant differences between NFT and TPR groups concerning full attention and auditory attention, other analyses are needed to investigate differences occurring within each of these groups from the pre- to post-test. Put simply, within-group analyses are needed to find out the efficacy of NFT and TPR in boosting full attention, auditory attention, and visual attention, respectively. To do so, Wilcoxon Signed Rank tests were conducted to compare each group's medians on full, auditory, and visual attention sections of the pretest with those of the posttest. As displayed in Table 3, the NFT and TPR groups' median scores on the posttests of full, auditory, and visual attention were higher than those on the pretests. Table 4 displays the results of the Wilcoxon Signed Rank test.

Table 3: Median scores and mean ranks on pretest and posttest of full, auditory, and visual attention by groups
a. Auditory

Group	tion Type	Median		*N*	Mean Ranks	Sum of Ranks
	Full Attention	Pre Full = 68.50	Negative Ranks	8	4.50	36.00
		Post Full = 103.00	Positive Ranks	0	.00	.00
			Ties	0		
NFT			Total	8		
	Aud[a] Attention	Pre Aud[a] = 59.50	Negative Ranks	8e	4.50	36.00
		Post Aud[a] = 101.00	Positive Ranks	0[c]	.00	.00
			Ties	0[d]		
			Total	8		
	Vis[b] Attention	Pre Vis[b] = 81.50	Negative Ranks	8	4.50	36.00
		Post Vis[b] = 103.50	Positive Ranks	0	.00	.00
			Ties	0		
			Total	8		
	Full Attention	Pre Full = 84.00	Negative Ranks	8	4.50	36.00
		Post Full = 97.00	Positive Ranks	0[c]	.00	.00
			Ties	0[d]		
TPR			Total	8		
	Aud[a] Attention	Pre Aud[a] = 86.50	Negative Ranks	7	4.57	32.00
		Post Aud[a] = 92.00	Positive Ranks	1[c]	4.00	4.00
			Ties	0[d]		
			Total	8		
	Vis[b] Attention	Pre Vis[b] = 76.50	Negative Ranks	8	4.50	36.00
		Post Vis[b] = 101.00	Positive Ranks	0[c]	.00	.00
			Ties	0[d]		
			Total	8		

b. Visual

Concerning the NFT group, the results (Z = -2.52, p < .05, r = .999 representing a large effect size) showed that this group had a significantly higher median score on the posttest of full attention than that of the pretest. The other results (Z = -2.52, p < .05, r = .99 representing a large effect size) depicted that the NFT group had a significantly higher median score on the posttest of auditory attention than that of the pretest. And finally, the results (Z = -2.52, p < .05, r = .99 representing a large effect size) demonstrated that the NFT group had a significantly higher median score on the posttest of visual attention than that of the pretest.

With respect to the TPR group, the results (Z = -2.52, $p < .05$, r = .99 representing a large effect size) showed that the TPR group had a significantly higher median score on the posttest of full attention than that of the pretest. The other results (Z = -1.97, $p < .05$, r = .778 representing a large effect size) indicated that the TPR group had a significantly higher median score on the posttest of auditory attention than that of the pretest. And finally, the results (Z = -2.52, $p < .05$, r = .99 representing a large effect size) indicated that the TPR group had a significantly higher median score on the posttest of visual attention than that of the pretest.

Table 4: Wilcoxon Signed Rank test; pretest and posttest of full, auditory, and visual attention by groups

Group	Attention Type	*Z*	Pretest- Posttest
	NFT Full Attention	*Z*	-2.527
		Asymp. Sig. (2-tailed)	.012
NFT	NFT Aud[a] Attention	*Z*	-2.521
		Asymp. Sig. (2-tailed)	.012
	NFT Vis[b] Attention	*Z*	-2.521
		Asymp. Sig. (2-tailed)	.012
	TPR Full Attention	*Z*	-2.521
		Asymp. Sig. (2-tailed)	.012
TPR	TPR Aud[a] Attention	*Z*	-1.975
		Asymp. Sig. (2-tailed)	.048
	TPR Vis[b] Attention	*Z*	-2.521
		Asymp. Sig. (2-tailed)	.012

a. Auditory
b. Visual

Overall, both NFT and TPR groups show significant improvements in their full attention, auditory attention, and visual attention from the pretest to the posttest of IVA+Plus.

DISCUSSION

The major hypothesis in this research was that, similar to NFT, the TPR method of language teaching has the potential to improve attention. The results indicated significant improvements for both NFT and TPR groups in their full attention, auditory attention, and visual attention. Nevertheless, NFT was found to be a more effective treatment concerning full attention and auditory attention. And as regards visual attention, both treatments were found to be similarly effective. In this section, first, a general discussion and then a specific discussion of RQs have been provided.

Generally, it can be argued that the obtained results can be supported, in part, by noting that both NFT and TPR are based on the same learning theory (i.e., behaviorism). NFT is based on reinforcement learning, namely operant conditioning (Mirifar et al., 2022), and TPR is also based on the stimulus-response pattern (Wheeler, 2013) and reinforcement learning of operant conditioning (Asher, 1966). Operant conditioning can be a very helpful teaching model for children with ADHD (Wender & Tomb, 2017). There are many pieces of evidence supporting the efficacy of operant conditioning for improving undesirable behaviors in children with ADHD (e.g., De Meyer et al., 2019; Ryan & McDougall, 2009). Also, theoretically, it can be argued that while both NFT and TPR are based on behaviorism (Mirifar et al., 2022; Wheeler, 2013), attention itself may include habit learning mechanisms (Seger, 2018). According to Seger (2018), the habitual nature of attention can be shown by the fMRI and EEG studies conducted by Anderson et al. (2014) and Luque et al. (2017), respectively. Therefore, if attention can be construed to be habitual, then it can be improved through methods based on behaviorism such as NFT and TPR.

With respect to RQs 1-3, it can be argued that the supremacy of NFT over TPR as regards full attention and auditory attention is not unexpected. It should be noted that there is not only a lack of comparative studies comparing the efficacy of NFT and TPR regarding attention, but also there are a few empirical studies objectively measuring the effects of TPR on attention. Nevertheless, the obtained results are expected because there are many studies supporting the efficacy of NFT for improving ADHD young learners' attention (e.g., Louthrenoo et al., 2022; Riesco-Matías et al., 2021).

Moreover, there are studies indicating the efficacy of NFT to improve auditory attention (e.g., Ghaziri et al., 2013; Hajehforoush et al., 2018).

The other reason for the supremacy of NFT can be attributed to the individualistic nature of this method as opposed to the collective nature of TPR. That is, while the behavior of other students did not affect the behavior of each recipient of the NFT treatment, the behavior of each student in the TPR group was influenced by the behavior of other students. It should be noted that undesirable behaviors are usually observed among children with ADHD. Peer relationships among these children are often disrupted by peer rejection, negligence, or teasing (American Psychiatric Association, 2013). They may reveal substantial changes in mood within the very day or display excessive anger and irritability; they may have a tantrum (American Psychiatric Association, 2013).

Overall, since they suffer from diminished self-control, they may display difficult-to-manage behavior (American Psychiatric Association, 2013). Therefore, behaviors such as occasional temper tantrums, fierce rivalry, hostility, bullying, and rows among participants (i.e., verbal and physical aggression) frequently slowed down the speed of learning in the collective TPR group, issues not observed in the individualistic NFT group. Consequently, the TPR teacher had to tackle all these issues. And all these issues may explain, at least in part, the supremacy of NFT over TPR with respect to full attention and auditory attention.

Moreover, as regards RQ 3, the findings can be justified because while NFT is a successful method in improving visual attention (e.g., Ghadamgahi Sani et al., 2022; Ghaziri et al., 2013), there are also many studies indicating that gesture improves visual attention (e.g., Araya et al., 2016; Hamilton, 2017; Wakefield et al., 2018). Therefore, since gesture is one of the main techniques used in the TPR method, the effectiveness of TPR for improving visual attention is expected.

Furthermore, the findings are in line with one of the behavioral learning theories, which, according to Ryan and McDougall (2009), is suitable for children with ADHD, namely social learning theory and the benefits of observational learning proposed by Bandura (1977). According to Bandura (1977), when people are in any social group, models possessing engaging qualities are likely to attract greater attention than others. Therefore, the TPR teacher and students who carry out engaging orders can attract greater attention. Hence, it can be argued that while the collective nature of TPR sometimes deterred teaching and caused full attention and auditory attention in this group to lag behind those of the NFT group, it has, apparently, worked to the benefit of visual attention in the TPR group because of the benefits of observational learning. This issue can be supported by empirical studies supporting the positive effects of observational learning on visual attention (e.g., Koch et al., 2018; Yussen, 1974).

With respect to NFT within-group analyses, it can be argued that since neurofeedback is based on operant conditioning (Mirifar et al., 2022; Thompson & Thompson, 2021), the findings of these analyses can be explained by the role of operant conditioning in improving attention. There are studies indicating that attention can be trained by operant conditioning. For example, Silverstein et al. (2001) found that an operant conditioning technique known as shaping can improve attention in severely ill schizophrenia patients. Also, there are studies indicating operant training of the auditory evoked potential in man (e.g., Finley & Johnson, 1983; Rosenfeld et al., 1969). Moreover, Price et al. (2016) found that visual attention can be trained based on operant conditioning of eye gaze. Their study is relevant to the findings of this research because in each NFT session, the participants are involved in a kind of human-computer interface in which the eye gaze plays a prominent role.

Concerning TPR within-group analyses, it can be argued that since enactment and gesture are major techniques used in TPR, the findings of these analyses can be supported by studies indicating that these techniques lead to enhanced attention. In this regard, one can refer to studies conducted by Macedonia and Mueller (2016) and Wakefield et al. (2018). Moreover, the findings of this section can be further supported by the study conducted by Kováčiková and Reid (2018). Because their study indicated that TPR could be used as a mindfulness training tool to enhance mindful attention. Also, TPR's potential to improve auditory attention can be supported by the findings of the study conducted by Nagels et al. (2018). They found that accompanying gestures with speech increases auditory cortex activation. In addition, TPR's potential to improve visual attention can be supported by the findings of the study carried out by Araya et al. (2016) and Wakefield et al. (2018).

CONCLUSION AND IMPLICATIONS

This study aimed to investigate the comparative effects of NFT and TPR on ADHD young learners' attention. The findings of this study indicated that both TPR and NFT can improve ADHD young learners' attention, although NFT was found to be a more effective treatment as regards full attention and auditory attention.

One of the pedagogical implications of this study would be employing TPR in the educational system not only for teaching language but also for boosting attention. The other implication would concern training teachers to employ this method in their classes. At the same time, the limitations of the study should be taken into account. Both convenience sampling and small sample sizes used in this study are the sources of threats to validity (McEwan, 2020). Also, physical and psychological fluctuations of the participants undergoing measurement (especially those of children) should be taken into notice. For instance, lack of sleep, observing/having a row prior to the test, physical pain at the time of the test, anxiety caused by entering new places, meeting new people, or observing new measurement devices, etc. should be considered.

Moreover, it should be noted that the natures of the two treatments used in this study are different. That is, while NFT is an individualistic method, TPR is a collective method. The success or failure of collective methods depends on the participation of the whole group. In such methods, the unpunctuality of one student affects the whole class. The late attendance of some students in the TPR group slowed down the speed of learning. Furthermore, since undesirable behaviors are usually observed among most children with ADHD (American Psychiatric Association, 2013), difficult-to-manage behaviors frequently displayed among participants slowed down the speed of learning in the TPR group, an issue not observed in the NFT group.

Considering the limitations of this study, further interdisciplinary research is needed to thoroughly investigate the comparative effects of TPR and NFT on attention. Such interdisciplinary research is needed because the third millennium "era has brought about a growing understanding of the inadequacy of the findings of every discipline claiming to be standing on its own like an isolated island providing omniscient knowledge" (Maftoon & Taie, 2016, p. 41). Leaning issues, once monopolized by the field of education, are now being tackled by diverse disciplines such as psychology, medicine, nutrition, biology, pharmacology, and sports. In line with this study, triangulation of this research with different participants, e.g., young learners without ADHD, is recommended. Also, future research can explore the comparative effects of NFT and other language teaching methods on attention. Moreover, they can investigate the effects of different language teaching strategies on attention. In the same vein, the role of different types of feedback in increasing attention can be investigated. Finally, the comparative effects of TPR and other psychological therapies improving cognitive processes can be explored. In this regard, it is recommended that future research investigate cognitive remediation therapy (CRT), as it is specifically designed to improve attention, memory, and other executive functions (Franza et al., 2018).

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Masumeh Taie https://orcid.org/0000-0002-3933-8784

Reza Rostami https://orcid.org/0000-0001-9318-108X
Massood Yazdanimoghaddam https://orcid.org/0000-0002-1020-6569

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