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RESEARCH ARTICLE

Development and evaluation of the efficacy of Persian phonemic synthesis program in children with (central) auditory processing disorder: a single subject study

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Abstract

Background and Aim: Central auditory processing disorder (C)APD can affect academic, social and communicative status of its patients whether children or adults. One of the most important skills involved in these disorders is decoding. The rehabilitation method for the decoding deficit in Buffalo auditory processing model is the phonemic synthesis program (PSP). In this study, the Persian version of PSP was developed and then the efficacy of this method in the rehabilitation of Persian children with (C)APD was evaluated.

Methods: This study was conducted in two stages. At first, the Persian version of PSP was prepared in accordance with its English version. Then, a child with (C)APD according to the results of Persian versions of Phonemic Synthesis Test (P-PST) and staggered spondaic words (P-SSW) was rehabilitated with this method. The treatment was given to the patient three sessions a week, each session lasted 30 minutes. Data were analyzed using visual analysis and non-parametric tests.

Results: During the treatment phase, a significant improvement was seen in P-PST and P-SSW test results ($p<0.05$).

Conclusion: Based on the study results, the Persian version of PSP improves decoding, tolerance fading memory, and organization disorders.

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Introduction

(Central) auditory processing disorder or (C)APD is a central auditory nervous system disability in using auditory information [1]. ASHA (1996) defined central auditory processing as a set of mechanisms and processing that contribute in sound localization and lateralization, auditory discrimination, auditory pattern recognition, and auditory temporal processing such as intelligibility, masking, summation and temporal ordering, as well as auditory function in the presence of competing signals, and auditory function for degraded signal perception. Central auditory processing involves both verbal and non-verbal signals and has neurophysiologic and behavioral bases [2]. ASHA (2005) in its last report on (C)APD stated that it is a disability in processing auditory stimuli and although it may occur in association with other sensory disorders, it is not the result of involvement in other modalities [1].

The prevalence of (C)APD is reported to be 2% to 5% [3]. Inability in auditory processing can lead to language understanding disorder [1]. (C)APD can be due to central auditory nervous system (CANS) disorder [4] or an executive dysfunction necessary for motor response organization for reception, perception, and interpretation of auditory signal [5]. This ailment can be seen in children with speech-language impairments, developmental disabilities, attention deficits, or learning disabilities [6]. It may cause problems in communication, elementary education, self-confidence, and everyday activities [7]. Auditory processing models were proposed to help (C)APD classification, introducing tests, achieving proper results in determining disorder structure, and finally presenting appropriate treatments. Buffalo model is the most common and popular model. It consists of four categories: decoding, integration, organization, and tolerance fading memory (TFM) [7].

Decoding in Buffalo model is defined as fast and accurate speech perception at the phonemic level [7]. Moreover, it is the most prevalent (C)APD category [8]. Buffalo model mostly mentions evaluations of this category, too [8,9]. Decoding problem is the most common problem in patients who have communication and education difficulties. These patients have ambiguous or inaccurate phonemic information stored in their brains. In Buffalo model, there are six therapies all including phonemic synthesis. Katz introduced phonemic and Phonemic Synthesis Trainings (PST) as the main trainings in his model. The aim of PST is to gradually change patients' perception of phonemes and increase their ability to blend phonemes into words, so they can improve their decoding skill [7]. In addition to high efficacy, PST is simpler and more cost-effective than other decoding rehabilitations. Other PST characteristics are its resistant to peripheral hearing impairment, simplicity, and availability of the required equipment. It is applicable even in children with profound (C)APD, or in hearing-impaired subjects in different age groups with different cognitive status [7].

Although decoding is one of the main (C)APD categories, there has not been a Persian version of PST. The present study develops the Persian version of PST and then evaluate its efficacy in a Persian-speaking child with (C)APD.

Methods

This project conducted in two steps: step 1) developing the Persian version of PST, and step 2) evaluation of PST efficacy in an Iranian child with (C)APD.

PST development in the Persian language

Useful words for PST were selected based on their frequency of occurrence in the Persian language from frequency dictionary according to a written corpus of today Persian language that sorted the words from high frequent to low frequent words [10]. Then words were ordered based on their difficulties from phonemic frequency distribution list. At last, words with a high frequency of occurrence and easy phonemes were used for first lessons and words with lower frequency and more difficult phonemes were selected for the last lessons. For the first few lessons, another criterion for word selection was imagery. For the first three lessons, each word was represented by a proper image on a 9×10 cm card. For 15 lessons of PST, number of words in each individual session, number of phonemes in each word, number of repetition of each word in each lesson, and even similarity between consecutive words were considered and prepared like the English version of the training. In addition, completion level criteria were according to the English version of the training. Face validity and content validity were evaluated by 10 experts and their comments were applied. Then selected words for 15 lessons were distributed among 15 normal children aged 7 to 9 years. They were asked to describe the meaning of each word in a sentence. Five words were unfamiliar for children so they were substituted by suitable words. Finally, word lists for each lesson were prepared and score sheet for PST was adapted from the original version.

Single-subject study for the evaluation of PST efficacy

This research is a basic and practical interventional single-subject study. A patient was selected and entered into the basic phase of the study (A). Then she was put under the training phase (B) and at the end of each session, her performance was checked. As a definite program does not exist for screening and diagnosis of (C)APD in Iran, we used available sampling method and our inclusion criteria were as follows: aged 7-9 years, normal peripheral hearing, right-handedness based on Edinburgh questionnaire, (C)APD with decoding difficulty. Exclusion criteria were as follows: not cooperating in the baseline phase or training phase and parents' unwilling to continue participation.

Hananeh was a 9-year-old girl (third grade of elementary school) living in Tehran, Iran. The chief complaints of her parents were her spelling, reading, memory difficulty, and sensitivity to loud sounds. She had a late response, history of chronic otitis media and communication difficulty. She asked "what?" repeatedly and showed severe speech articulation with nasal speech. She showed many phonemic errors and articulation problems in history taking. She also had low self-confidence, isolation, and verbal communication problem. She had problem with following instructions and late speech emergence based on parents' report.

Hananeh has been under speech therapy due to her academic problems for two years. Her speech therapy continued during PST. She had simultaneous occupational therapy for one year, play therapy for three months when she was five, and cognitive therapy in first six months of her third grade. She was still on the speech and cognitive therapy during PST. She was receiving private teaching after school hours due to her academic problems. She had no progress based on teachers' report. She showed spelling problems including phonemic omission, substitution, and poor handwriting.

Hananeh entered into the basic phase after first evaluations and checking the inclusion criteria. In the training phase, PST was used for correcting phonemic engrams. Three weeks after completion of training program, the patient was tested again. In general, six evaluations were performed during the study including Persian staggered spondaic words (P-SSW) and P-PST, also phonemic error analysis (PEA) form was completed. Therefore results were analyzed for P-SSW, P-PST, and PEA.

As her performance was good at first lessons, therapy was started from session 5. Words were presented phoneme by phoneme and she had to blend them in her mind and make up that word and say it out loud. Her score in each session was recorded. Each session had two signs. One, dashed line which the area above it is called target area. If her performance was below the target area, it was assumed that her performance is poor and we cannot jump to the next lesson yet. Therefore that lesson must be repeated and if it was necessary, compensation strategies were used. The second sign was two dark line above and below a row. This area is called completion level and when her scores were above completion level, that lesson was completed and the next one would start. When the child had many errors or it took a long time for her to reach a completion level, compensation strategies were used.

Word chart is the most useful and effective compensation strategy for correcting errors. In this strategy, at first a piece of paper was divided into four parts from the width and then was folded from the middle. So the paper would make four two-pieces parts. Then in each row, original word and the wrong word that the child repeated, were written. The paper was folded in a way that only one row of the words was visible. Those two words were spelled phoneme by phoneme and she had to point to the presented word. If she made a mistake, this process would be repeated. If it was necessary, the word was first shown to the child and then it was spelled. Then this process is performed for the second pair and so on. At last, the entire

Table 1. The patient's quantitative scores of the Persian staggered spondaic words test in the first session of baseline phase and the last session of follow-up stage

	Quantitative scores								
	C	LE	RE	Rev	Total	LNC	LC	RC	RNC
Before treatment	31	22	27.5	7	24.75	25	19	31	24
After treatment	1	0.5	0	0	0.25	0	1	0	0

C; condition, LE; left ear, RE; right ear, Rev; reversal, LNC; left non-competing, LC; left competing, RC; right competing, RNC; right non-competing

page was opened and all eight words were presented simultaneously in front of the child and words were spelled randomly. Child had to point to the right word. To make sure that child is not pointing by chance, each word might be presented several times consecutively in a row.

Results

The present study was performed to develop the Persian version of PST and evaluate its efficacy in an Persian-speaking Iranian child with (C)APD. After development, its face and content validity were tested. For testing content validity index (CVI), the chosen words were distributed among 10 experts and they made comments based on a Likert-type qualitative scale (absolutely appropriate, partially appropriate, and absolutely inappropriate). CVI was found to be 90.56%. Content validity ratio (CVR) based on Lawshe method was 77%-95%. For face validity, participants had to score each word based on a 5-point Likert-type scale. Impact score for all words was higher than 1.5.

1) Comparison of Hananeh's evaluations before and after training

In Tables 1 to 3, the results of the baseline and the last session evaluations were compared. As it is seen in Tables 1 and 2, the results of P-SSW and in Table 3 the results of P-PST show the child's performance improvement. Table 3 shows phonemic error reduction after training.

2) Single-subject study analysis

a) Analysis based on ascending-descending line

The most appropriate aligned line was drawn for left competing (LC), right competing (RC), left noncompeting (LNC), right noncompeting (RNC) conditions from the baseline phase to training phase. In RNC, RC, LNC, and LC conditions in the baseline phase, 33% of dots were below the line but after training 100%, 83%, 66%, and 50% of dots were below the line, respectively. In total, right ear, left ear, and condition scores in the baseline phase, 33% of dots were below the line and after training 83%, 100%, 100%, and 83% were below the line.

With regard to organization (ORG), decoding

Table 2. The patient's qualitative scores of the Persian staggered spondaic words test in the first session of baseline phase and the last session of follow-up stage

	Qualitative scores									
	TTW	Sm	P	Q	BTB	Sm-2	IW	QR	XX	X
Before treatment	3	1	7	1	3	7	2	8	4	9
After treatment	0	0	0	1	0	0	0	0	0	1

TTW; tongue twister, Sm; smush, P; preservation, Q; quick, BTB; back to back, IW; intrusive word, QR; quiet rehearsal, XX; extreme delay, X; delay

Table 3. The patient's scores of the Persian Phonemic Synthesis Test and phonemic errors analysis in the first session of baseline phase and the last session of follow-up phase

	Phonemic Synthesis Test scores										Phonemic errors analysis scores			
	1st	P	Rev	NF	QR	Q	XX	X	Qual	Quant	Total	Added	Omissions	Substitutions
Before treatment	9	11	0	11	8	7	0	0	0	0	112	18	53	41
After treatment	0	0	0	0	0	0	0	1	23	24	3	1	1	1

1st; 1st phoneme omission, P; preservation, Rev; reversal, NF; non fused, QR; quiet rehearsal, Q; quick, XX; extreme delay, X; delay, Qual; qualitative, Quant; quantitative

(DEC) and tolerance fading memory (TFM) indices in the baseline phase (based on P-SSW), 33% of dots were below the line and after training 100%, 66%, and 100% of dots were below it. Regarding the qualitative indices of PST for DEC errors and TFM errors in the baseline phase, 33% and 50% of dots were below the line and after training 100% and 83% of dots were below the line. With regard to the quantitative (Quant) and qualitative (Qual) scores in the baseline phase, 33% of dots were below the line and after training 100% of dots were below it. Regarding the PEA in the baseline phase, 50% of dots were below the line for substitution (SUB), omission (OMI) and addition (ADD) but after training 100%, 66% and 83% of dots were below the line, respectively. With regard to total errors in the baseline phase, 33% of dots were below the line and after training 83% were below it.

b) C-statistic analysis

The results of C-statistic are summarized and presented in Tables 4 to 7. P-PST, P-SSW, and PEA showed significant improvement after training ($p<0.05$).

c) Efficacy study based on two standard deviations band method

Based on the results of P-SSW, P-PST, and PEA, her errors and scores were 2SD out of normal limits, so the training was significant and effective.

d) Efficacy evaluation based on nonoverlapping data

In P-SSW, her best performance (lowest level of error) in the baseline phase was 23, 29, 17, and 22 for RNC, RC, LC and LNC, respectively. The percentages of data under the horizontal line was 83%, 66%, 50% and 66%. For total, right ear (RE), left ear (LE), and condition (C) scores in the baseline phase, there were 23, 26,

Table 4. C-statistics analysis for the patient's scores of the Persian staggered spondaic words test

	RNC	RC	LC	LNC	Total	RE	LE	C
Baseline								
z	0.83	0.73	0	−0.77	0.72	1.29	−0.84	0.73
p	0.40	0.45	1	0.440	0.469	0.195	0.398	0.45
Baseline and treatment								
z	3.18	3.18	2.29	2.29	3.12	3.22	2.88	3.10
p	0.001	0.001	0.022	0.002	0.001	0.001	0.003	0.001

RNC; right non-competing, RC; right competing, LC; left competing, LNC; left non-competing, RE; right ear, LE; left ear, C; condition

Table 5. C-statistics analysis for the patient's scores of the Persian staggered spondaic words test based on Buffalo sub-categories

	DEC	TFM	Rev
Baseline			
z	−0.52	0.57	−1.21
p	0.603	0.563	0.223
Baseline and treatment			
z	3.06	2.74	2.81
p	0.002	0.006	0.004

DEC; decoding, TFM; tolerance fading memory, Rev; reversal

20, and 29 errors, respectively. The percentages of the findings under the horizontal line were 66%, 83%, 66% and 83%, respectively. For ORG, DEC and TFM scores in the baseline phase, her best performances were 6, 35, and 5 respectively and the percentages of findings below the horizontal line were 100%, 66%, and 66% respectively. In P-PST, the lowest errors for DEC and TFM in the baseline phase were 29 and 15, respectively and the percentages of findings below the horizontal line was 83 in both. The best Qual and Quant scores in the baseline phase were 1 and 0, respectively, and the percentages of the findings above the horizontal line was 66% for both.

The lowest errors for SUB, OMI, ADD, and total in the baseline phase were 40, 48, 17, and 112, respectively and the percentages of findings below horizontal line for SUB, OMI, and ADD were 66% and for total was 83%.

e) Efficacy evaluation based on percentages of all nonoverlapping data (PAND)

With regard to P-SSW in RNC, RC, LC, and LNC, the number of nonoverlapping points was 1, 2, 2, and 0, respectively. So all percentages of nonoverlapping data (PND) were 91%, 83%, 83%, and 100%, respectively. For reversal (REV), DEC and TFM errors, the number of nonoverlapping points were the same and the total percentage of nonoverlapping data was 91%. Regarding P-PST, DEC, TFM and Quant and Qual score, the number of nonoverlapping points were 1, 1, 2, and 2 respectively and the total percentage of nonoverlapping data were 91% for DEC and TFM and 83% for Quant and Qual scores.

Regarding the SUB, OMI, ADD and total errors in PEA, the number of nonoverlapping points were 0, 2, 1, and 0 and a total percentage of nonoverlapping data were 100%, 83%, 9%, and 100%, respectively.

f) Visual evaluation of Hananeh's performance

One method for efficacy evaluation in the single-subject study is monitoring patients' performance changes in the baseline, training and follow-up phase. Hananeh's performances are summarized in Fig. 1A-F. As it is seen, there was a significant decrease in the number of errors after training. In addition, there was no return of indices to the baseline phase in the follow-up phase.

Discussion

This study was conducted to develop P-PST and evaluate its efficacy in Persian-speaking children with (C)APD. Ascending-descending line, C-statistic, two standard deviation band method, PND, and PAND analysis were used. In the first stage of the study (PST development), face validity and content validity ratio showed that selected words were appropriate to evaluate the central auditory system. For studying CVI,

Table 6. C-statistics analysis for the patient's scores of the Persian-Phonemic Synthesis Test

	Quant	Qual	DEC	TFM
Baseline				
z	−0.59	0	−1.66	−0.36
p	0.554	1	0.961	0.712
Baseline and treatment				
z	3.21	3.12	3.25	2.93
p	0.001	0.001	0.001	0.003

Quant; quantitative, Qual; qualitative, DEC; decoding, TFM; tolerance fading memory

Table 7. C-statistics analysis for the patient's scores of the phonemic error analysis form

	Substitutions	Omissions	Added	Total
Baseline				
z	0.73	1.17	−0.27	1.34
p	0.459	0.239	0.783	0.179
Baseline and treatment				
z	3.18	3.20	2.88	3.25
p	0.001	0.001	0.001	0.001

Waltz and Bausell method was used [11]. Words were distributed among 10 experts to have their comments based on a qualitative Likert-type scale (highly relevant, somewhat rlevant, and not relevant). In the end, CVI was 90.56% that means the chosen words had high content validity for PST. Lawshe maintained that CVI larger than 0.62 is an acceptable criterion [12]. CVR in this study based on Lawshe method was 77%-95%. For face validity, the participants were asked to score words on a 5-point Likert-type scale. Impact score above 1.5 was indicative of acceptable face validity. Impact score for all words was above 1.5 so the face validity was acceptable.

In the present study, disorder severity was evaluated by a number of phonemic errors. Katz suggested that the number of errors in Buffalo model is a good index for determining disorder severity. Disorder severity based on Katz [7] is presented in Table 8. Based on this table, the subject in the present study had severe (C)APD. Katz after introducing Buffalo model, showed that left posterior middle temporal lobe defect can lead to DEC involvement [13]. The subject in the present study had DEC involvement, so it is assumed that she has a left posterior middle temporal lobe defect. As it is seen in 1 to 3 descriptive Tables, all indices of P-SSW and P-PST showed improvements after training and in the follow-up phase there was no return of her complaints and problems. This shows that training effects were permanent. Olive and Franco suggested that in addition to visual analysis of the performance change graph, several analytic statistics should be used in the single-subject study [14]. Lenz suggested that in order to decrease error occurrence rate in the single-subject study, several analytic approaches should be used in training efficacy evaluation [15]. Noorbakhsh and Ottenbacher. commented that to achieve comprehensive conclusion in treatment efficacy evaluations, several analytic methods have to be used [16]. In this study ascending-descending line, C-statistic, two standard deviation band method, PND and PAND analysis were used.

Scruggs and Mastropieri [17] as well as Lenz mentioned that PND is vulnerable to floor and ceiling effect in the baseline phase and this may lead to underestimation of the training. He added that PAND analysis is more cautious and accurate that PND [15]. So in cases that there is a floor or ceiling effect in PND, we can use PAND instead. PND and PAND are interpreted based on Scruggs and Mastropieri findings that are summarized in Table 9. This table shows the relationship between PND and PAND findings and training efficacy [17,18].

Hananeh showed significant improvement in four scores of P-SSW. In the baseline phase, there was no spontaneous improvement based on C-statistic. With regard to RNC, RC, LC and LNC scores, the percentages of total nonoverlapping data were 91%, 83%, 83%, and 100%, respectively indicating a definite improvement

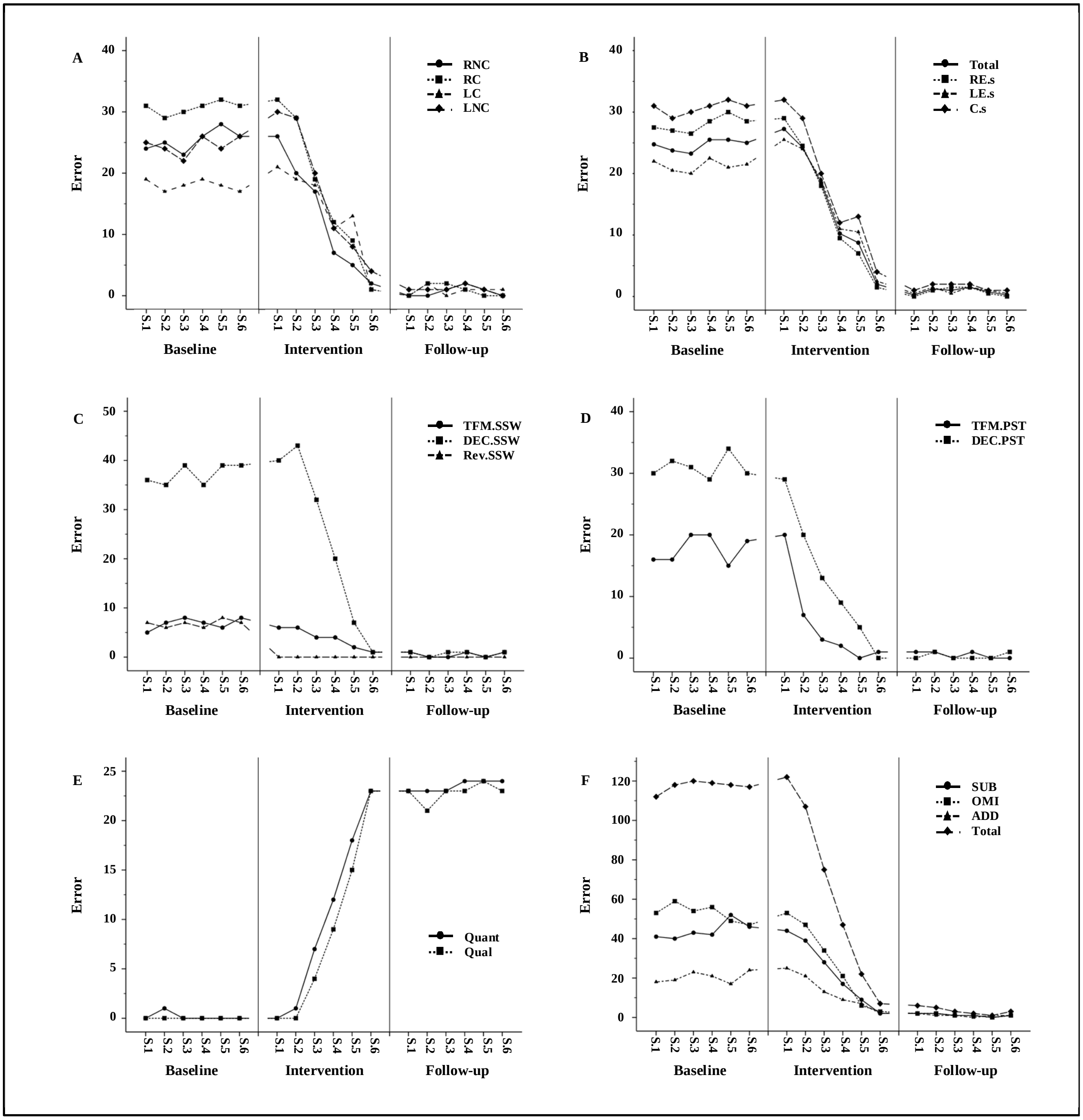

Fig.1. The trend of changes in the patient's A) scores in four main condition of P-SSW, B) scores of P-SSW, C) behavioral indices of decoding, tolerance fading memory and organization based on P-SSW scores, D) behavioral indices of decoding, tolerance fading memory and organization based on P-PST scores, E) qualitative and quantitative scores of the P-PST, and F) phonemic errors based on the P-PEA in the baseline, treatment, and follow up sessions. RNC; right non-competing, RC; right competing, LC; left competing, LNC; left non-competing; S; session, RE.s; right ear score, LE.s; left ear score, C.s; condition score, TFM; tolerance fading memory, DEC; decoding, Rev; reversal, SSW; staggered spondaic words, PST; Phonemic Synthesis Test, Quant; quantitative, Qual; qualitative, SUB; substitution, OMI; omission, ADD; addition.

Table 8. Determining severity of central auditory processing disorders based on the phonemic error analysis form

Severity of APD	Number of phonemic errors
Mild	20-48
Moderate	49-62
Severe	63-153

APD; auditory processing disorder

in all four conditions. RE, LE and total scores showed strong training effects and condition score showed proper training effects as well. Regarding the qualitative errors in DEC, TFM and ORG subcategories, training had very strong effects. Regarding the P-PST indices, PAND was 83% for quantitative and qualitative scores which is indicative of effective training based on Table 9. In these two scores, her performance improvement was not significant in the baseline phase and after training the improvement was significantly based on C-statistic. Training effect for Buffalo subcategories in P-PST was 91% that is very strong and agrees with qualitative P-PST score improvement.

Phonemic error analysis (PEA) showed strong training effects in SUB, ADD, and total indices and proper training effects in OMI. After three weeks since the completion of training, all baseline evaluations were done again and the probability of disorder recurrence was tested. In all indices, training effects were permanent so it can be concluded that PST correctly works on the defective area and its effects are maintained after training. In other words, it can modify inaccurate phonemic engrams in the left posterior middle temporal lobe because the central auditory system is plastic. The plasticity and flexibility were permanent and howed the durability of training effects.

Katz investigated PST efficiency in a field study on 54 children and showed that there was a significant improvement following training. One of his findings was that the number of lessons' repetition for reaching to the completion level was higher in the first few sessions sessions. The child first shows a peak of errors that increase the length of training but in the second half of training sessions, this peak starts to decline fast. This steep reduction can be seen in a number of errors and increment of lesson completion. This finding is in agreement with the present study [7].

There has not been any study on both phonemic synthesis program (PSP) and phonemic training efficacy. Katz in 2009 studied a group of children who were under PSP and phonemic training program (PTP). He evaluated PST and PEA before and after training. He reported that after an average of 12.8 sessions, the scores ncreased 7 point on average. They pointed that at the end of training, 31% of the patients had no error or only one error. Qualitative score improvement was from 14 errors on average before training to 5 errors after training that is indicative of effective therapy [7]. The findings of the present study are in agreement with Katz study. Katz studied phonemic errors too and showed 45% improvements after training [7]. The present study not only agrees with Katz

Table 9. Interpretation of percentage of non-overlapping data and percentage of all non-overlapping data results

Training status	Percent of non-overlapping results
Complete/definite treatment	Score over 90%
Appropriate treatment	Score 70-90%
Treatment is available but it should be used cautiously	Score 50-70%
No treatment	Score below 50%

study but also supports higher efficacy of the program comapred to Katz study results.

Conclusion

This single-subject study was conducted to evaluate Phonemic Synthesis Test (PST) efficacy in a Persian speaking child with (C)APD and showed that this training is absolutely suitable for these children, especially for decoding (DEC) subcategory.

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Conflict of Interest

The authors declare that they have no conflict of interest.

REFERENCES

1. American Speech-Language-Hearing Association. (central) auditory processing disorders [Technical Report]. 2005. Available from www.asha.org/policy.
2. American Speech-Language-Hearing Association. Central auditory processing: current status of research and implications for clinical practice [Technical Report]. 1996. Available from www.asha.org/policy.
3. Geffner D. Central auditory processing disorders: definition, description and behaviors. In: Geffner D, Ross-Swain D, editor. Auditory processing disorders: assessment, management and treatment. 1st ed. San Diego: Plural Publishing; 2007. p. 25-48.
4. Keith R. Central auditory and language disorders: strategies for use with children. Houston: College-Hill Press; 1981.
5. Rees N. Saying more than we know: is auditory processing disorder a meaningful concept? In: R Keith, editor. Central auditory and language disorders in children. Houston: College-Hill; 1981. p. 94-120.
6. Bellis TJ. Assesment and management of central auditory processing disorders in the educational setting: from science to practice. 1st ed. Clifton Park, NY: Cengage Learning; 1996.
7. Katz J. Therapy for auditory processing disorders: simple effective procedures. Denver, CO: Educational Audiology Association; 2009.
8. Katz J. Classification of auditory processing disorders. In: Katz J, Stecker NA, Henderson D, editors. Central auditory processing: a transdisciplinary view. St. Louis, MO: Mosby; 1992. p. 81-91.
9. Katz J. Phonemic training and phonemic synthesis programs. In: Geffner DS, Ross-Swain D, editors. Auditory processing disorders: assessment, management and treatment. 1st ed. San Diego: Plural Publishing; 2007. p. 255-65.
10. Bijankhan M, Mohseni M. Frequency dictionary according to a written corpus of today Persian language. 1st ed. Tehran: University of Tehran Press; 2012.
11. Waltz CF, Bausell RB. Nursing research: design, statistics, and computer analysis. Philadelphia: F. A. Davis; 1981.
12. Lawshe CH. A quantitative approach to content validity. Personnel psychology. 1975;28(4):563-75. doi: 10.1111/j.1744-6570.1975.tb01393.x
13. Katz J. The SSW test: an interim report. J Speech Hear Disord. 1968;33(2):132-46. doi: 10.1044/jshd.3302.132
14. Olive ML, Franco JH. (Effect) size matters: and so does the calculation. Behav Anal Today. 2008;9(1):5-10. doi: 10.1037/h0100642
15. Lenz AS. Calculating effect size in single-case research: a comparison of nonoverlap methods. Meas Eval Couns Dev. 2013;46(1):64-73. doi: 10.1177/0748175612456401
16. Nourbakhsh MR, Ottenbacher KJ. The statistical analysis of single-subject data: a comparative examination. Phys Ther. 1994;74(8):768-76.
17. Scruggs TE, Mastropieri MA. How to summarize single participant research: Ideas and applications. Exceptionality. 2001;9(4):227-44. doi: 10.1207/S15327035EX0904_5
18. Scruggs TE, Mastropieri MA. Summarizing single-subject research. Issues and applications. Behav Modif. 1998;22(3):221-42. doi: 10.1177/01454455980223001