Analysis of Changes in Auditory Processing after Therapy

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Improving auditory processing disorders (APD) in children is a major concern. When a child diagnosed with APD is provided therapy, we want to know whether the treatments provided made significant changes. Often, the only "measure" of change is descriptive, subjective comments made by the therapist and parents observing the child. Sometimes, teacher input is used to help identify improvements have occurred.

Our profession demands that evidence based practices are provided for the client we serve. Yet, there is a lack of empirical data to indicate the efficacy of treatments for children with APD (ASHA, 2005; Bellis, 2011; Edell, Lucker, & Alderman, 2008; Geffner & Ross-Swain, 2012; Moore, 2006). Typically, authors of publications regarding treatments for APD describe the therapies and discuss sample cases to demonstrate improvements after treatments are provided, but they rarely use empirical, statistical analyses to prove that the changes are significant.

This lack of empirical data has led some researchers, such as DeBonis (2015), to state that the effectiveness of therapies for APD has not been established. DeBonis identifies that his review of the literature reveals very limited evidence to support APD treatments. This led DeBonis to question the whole notion of APD as a diagnosis in school-aged children. In contrast, Kaul and Lucker (2016a & b) provided a statistical analysis of 20 children with APD finding very significant changes after completing Buffalo Model based therapies. Thus, there are some publications proving that therapies can make significant changes in auditory processing in children.

The present study looked at a large group of children identified with APD seen by one author (CR) for APD therapy and evaluations. The study presents empirical, quantitative, statistical analyses of the effectiveness of treatment looking at the differences in post-treatment versus pre-treatment auditory processing test results for this large group of children.

Summary of the Methods Used

Participants

Subjects included 125 children ranging in age from five to sixteen years, with a mean age of 9.4 (standard deviation of 2.73) years. All participants had been assessed for APD and were identified as meeting the criteria for categories of APD based on The Buffalo Model (Katz & Fletcher, 2004): Decoding (Dec) (N = 114), Tolerance-Fading Memory (TFM) (N = 25), Integration (Int) (N = 30), Organization (Org) (N = 18). None of the children had hearing losses or any physical problems that would interfere with the therapies provided.

Diagnosis of APD was made via administration of the following tests: Speech in Noise (SIN) for each individual ear, the SSW test (only used the SSW total errors score for statistical analyses), the Phonemic Synthesis Test (PST) (quantitative analysis), NU-6 Filtered Words (FW) for each individual ear, and the Pitch Pattern Sequence Test (PPST).

Equipment and Treatment

Therapy was based on the Little Listeners Therapy (LLT) program. The LLT program typically consists of 15 to 20, 30-minute therapy sessions that consist of rhythm training with Interactive Metronome (IM) (www.interactivemetronome.com), Phonemic Synthesis Training, and "headphone" training with pre-recorded tracks for Auditory Figure Ground (speech-in-noise), Auditory Closure (Filtered Words, and Dichotic Listening (Dichotic Words). This headphone training was comprised of specific tracks from the Integrated Listening Systems' (iLS) (www.integratedlistening.com) Language Program recordings or using more difficult tracks that are custom recordings created by Little Listeners in 2016. Phonemic Synthesis Training focused on teaching participant to blend phonemes together to form whole words. Thus, in all, participants were provided with iLS listening and earphone training, IM, and Phonemic Synthesis Training.

Procedures

All children were initially seen for auditory processing testing to determine their specific APD problems. After completing therapy, the same auditory processing tests were re-administered. The changes in test scores were compared statistically.

The course of treatment was determined based on the child's age and assessment outcomes. The plan of therapy was individualized based on the specific needs and test results.

Analyses

Paired Sample t-tests were used to see if significant changes occurred for each of the APD tests used. Change varied in direction (positive or negative) depending on the tests used. For example, positive changes on FW indicated improvement in ability to process the distorted words; in contrast, negative changes on the SSW indicated a reduction in total errors made. Significance was determined via a two-tailed value for p less than 0.05 ($p<0.05$).

In addition to these measures of auditory processing, a special measure of timing for the IM program (part of the program) was completed. A reduction in timing revealed quicker responses and a negative change post-therapy versus pre-therapy. Again, $p<0.05$ was used for significance.

Results

Changes in APD Test Scores After Therapy

Results of the raw data (ranges, means, standard deviation) are presented in table 1. Results for each of the paired sample t-tests are presented in table 2. These tables reveal that all mean differences went in the direction of improvement. T-test results yielded highly significant findings $p < 0.000$ for all measures.

Table 1. Raw Data looking at each of the auditory processing and IM timing measures used. (N = 125)

Measure	Range	Mean	SD
SIN-RE pre	4-60%	27.3%	11.94%
SIN-RE post	0.12-36%	15.29%	5.47%
SIN-LE pre	0-76%	30.7%	13.98%
SIN-LE post	0.12-36%	15.29%	5.98%
SSW Total pre	4-64	25.4	14.98
SSW Total post	1-45	14.5	10.08
PST pre	1-38	18.4	6.00
PST post	11-50	21.8	5.15
FW-RE pre	14-100%	69.1%	17.51%
FW-RE post	16-100%	78.6%	13.47%
FW-LE pre	13-100%	67.6%	15.56%
FW-LE post	8-95%	75.5%	15.34%
PPST pre	0-100%	77.1%	23.54%
PPST post	30-100%	73.6%	20.36%
IM Timing pre	0-307.5msec	146.3msec	69.50msec
IM Timing post	0-259.3msec	77.3msec	48.62msec

Table 2. Paired Sample t-tests comparing post- versus pre- treatment auditory processing and timing (for IM) measures. (df = 124)

Measure	Mean Difference (SD)	t	p	Cohen's d
SIN-RE	-15.1 (-10.83)	-13.259	0.000*	-2.795**
SIN-LE	-17.4 (-13.28)	-12.440	0.000*	-2.637**
SSW Total	-12.9 (-8.50)	-15.192	0.000*	-3.185**
PST	7.0 (4.20)	11.694	0.000*	3.341**
FW-RE	17.0 (11.86)	10.651	0.000*	2.899**
FW-LE	14.9 (15.68)	7.090	0.000*	1.912**
PPST	22.5 (19.38)	4.780	0.000*	2.390**
IM Timing	-69.2 (51.19)	-13.451	0.000*	-2.718**

*significant at $p<0.05$ **Greater than One Standard Deviation (Very Large)

To determine how much improvement was made, Cohen's d was calculated for each measure used. This statistical method looks at the number of standard deviations that have changed between the post-treatment versus pre-treatment raw scores. Cohen's d is viewed as a measure of the "size" of the change known as the effect size. Effect sizes of 1.000 or greater reveal improvement of one standard deviation or more. From review of Table 2, the effect size changes were all around or above 2 standard deviations. Thus, the effect size analyses revealed very significant improvements in all measures.

To look further at the changes made, the data were re-analyzed looking at whether results were normal (value of 1) or below normal (value of 0) for each measure used. These values were statistically analyzed via Chi-Square tests. Table 3 presents results of these Chi-Square statistical measures.

Table 3. Chi-Square analyses looking at changes post-therapy versus pre-therapy for all auditory processing tests based on whether the participants' performance fell within age level norms or not. (for all measures df = 1)

Measure	Chi-Square	p
SIN-RE	94.363	0.000*
SIN-LE	75.823	0.000*
SSW Total	52.734	0.000*
PST	5.843	0.016*
FW-RE	19.345	0.000*
FW-LE	25.412	0.000*
PPST	6.709	0.010*

*significant at $p<0.05$

Review of table 3 indicates that the Chi-Square analyses revealed significant findings for all measures ($p = 0.000$). As such, both analyses (using raw scores and age level normative data) indicated that after receiving the treatments provided, this group of participants revealed significant improvements in their auditory processing abilities.

Were Changes Related to the Specific APD Category?

Another question investigated was whether the changes were related to the category of APD. To see if type of disorder was a factor, a correlation between the post-treatment test findings and the specific APD categories was completed. Table 5 presents results of these correlation analyses.

Table 4. Correlation analyses comparing the various categories of APD and each measure of APD and IM Timing on post-treatment results.

Category	Measure	r	p
Decoding	SPIN-RE	0.123	0.191
	SPIN-LE	0.028	0.764
	SSW	0.046	0.628
	PST	-0.062	0.509
	FWNU6-RE	-0.100	0.344
	FWNU6-LE	0.004	0.967
	PPST	0.048	0.856
	IM Timing	0.123	0.231
TFM	SPIN-RE	0.016	0.868
	SPIN-LE	-0.030	0.746
	SSW	0.037	0.696
	PST	0.151	0.104
	FWNU6-RE	0.177	0.090
	FWNU6-LE	0.188	0.076
	PPST	0.409	0.091
	IM Timing	0.016	0.875
Integration	SPIN-RE	-0.111	0.234
	SPIN-LE	0.050	0.597
	SSW	0.109	0.254
	PST	-0.184	0.047*
	FWNU6-RE	-0.212	0.042*
	FWNU6-LE	-0.116	0.275
	PPST	0.171	0.497
	IM Timing	-0.036	0.725
Organization	SPIN-RE	-0.002	0.979

SPIN-LE	0.082	0.382
SSW	0.111	0.242
PST	-0.163	0.080
FWNU6-RE	-0.139	0.184
FWNU6-LE	0.028	0.795
PPST	-0.052	0.838
IM Timing	-0.063	0.539

*Significant $p<0.05$

Review of this table indicates that there were no significant correlations between improvements in APD and IM Timing on post-treatment measures compared with the specific category of APD identified for participants except for participants identified with Integration type APD and only for two measures. These two tests were PST and FW only for the right ear. Overall, the findings indicate that significant improvements in auditory processing can be found in all areas of auditory processing regardless of the category of APD found.

Conclusions

Results of the present investigation revealed that significant improvements in auditory processing abilities occurred for participants who completed the therapies used in the present study. Findings revealed significant improvements whether raw scores or age level norms were used as well as indicated that the category of APD was not a factor associated with improvement.

These results are similar to those found by Kaul and Lucker (2016a & b) who found significant improvements in auditory processing using a Buffalo Model approach to treatment. Both studies also revealed significant effect size changes after completing the therapies provided.

The conclusions from the present study are that the use of iLS and the LLT headphone training along with IM therapy can significantly improve auditory processing skills in children from five to seventeen years of age. This study is presently under review for publication in one of our professional journals. Additional information is provided in that expanded document. It is hoped that more empirical studies will be completed so that professionals can have the evidence base they need to support the use of therapies for children with APD problems.

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