Auditory Processing Testing: In the Booth versus Outside the Booth

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Jay R. Lucker*

Abstract

Background: Many audiologists believe that auditory processing testing must be carried out in a soundproof booth. This expectation is especially a problem in places such as elementary schools. Research comparing pure-tone thresholds obtained in sound booths compared to quiet test environments outside of these booths does not support that belief. Auditory processing testing is generally carried out at above threshold levels, and therefore may be even less likely to require a soundproof booth. The present study was carried out to compare test results in soundproof booths versus quiet rooms.

Purpose: The purpose of this study was to determine whether auditory processing tests can be administered in a quiet test room rather than in the soundproof test suite. The outcomes would identify that audiologists can provide auditory processing testing for children under various test conditions including quiet rooms at their school.

Research Design: A battery of auditory processing tests was administered at a test level equivalent to 50 dB HL through headphones. The same equipment was used for testing in both locations.

Study Sample: Twenty participants identified with normal hearing were included in this study, ten having no auditory processing concerns and ten exhibiting auditory processing problems. All participants underwent a battery of tests, both inside the test booth and outside the booth in a quiet room. Order of testing (inside versus outside) was counterbalanced.

Data Collection and Analysis: Participants were first determined to have normal hearing thresholds for tones and speech. Auditory processing tests were recorded and presented from an HP EliteBook laptop computer with noise-canceling headphones attached to a y-cord that not only presented the test stimuli to the participants but also allowed monitor headphones to be worn by the evaluator. The same equipment was used inside as well as outside the booth.

Results: No differences were found for each auditory processing measure as a function of the test setting or the order in which testing was done, that is, in the booth or in the room.

Conclusions: Results from the present study indicate that one can obtain the same results on auditory processing tests, regardless of whether testing is completed in a soundproof booth or in a quiet test environment. Therefore, audiologists should not be required to test for auditory processing in a soundproof booth. This study shows that audiologists can conduct testing in a quiet room so long as the background noise is sufficiently controlled.

Key Words: auditory processing evaluations, sound-treated test suite, quiet test room

Abbreviations: ACPT = Auditory Continuous Performance Test; APDs = auditory processing disorders; MANOVA = multiple analysis of variance; PST = Phonemic Synthesis Test; SD = standard deviation; SLM = sound level meter; SRTs = speech reception thresholds; SSW = staggered spondaic word

INTRODUCTION

Audiologists are often asked to carry out measures of auditory processing in schools. Often, they respond that this cannot be done because the testing must be carried out in a soundproof booth. However, a review of the literature does not indicate that this is a requirement.

Bellis (n.d.) indicates that audiologists test children for suspected auditory processing disorders (APDs) in soundproof booths, but does not report that such testing must be done in these settings. Furthermore, she does

*Howard University, Washington, DC

Corresponding author: Jay Lucker, Howard University, Washington, DC 20059; E-mail: apddrj@gmail.com or apddrj@verizon.net

not provide a rationale as to why an audiologist evaluates auditory processing in a soundproof booth. In the 2005 Technical Report from the American Speech-Language-Hearing Association (ASHA, 2005a) and the ASHA Position Statement on the role of the audiologist in diagnosing APDs (ASHA, 2005b), there is a discussion about assessing one's auditory processing abilities. Neither report states that testing "must" be done in soundproof booths. Additionally, the AAA (2010) Clinical Practice Guidelines discuss various aspects of how audiologists should conduct auditory processing testing, but they also never state that the testing "must" be completed in a sound-treated suite.

The controversy over the use or nonuse of a soundproof booth for assessing auditory abilities led to two earlier studies that looked at whether we truly need a such a test booth to measure hearing thresholds. Maclennan-Smith et al (2013) looked at pure-tone threshold results obtained outside the test suite. They found that audiometric thresholds were similar when obtained outside the test booth compared with inside the test booth in ~95% of their participants. More recently, Margolis and Madsen (2015) also examined threshold testing conducted inside versus outside the booth and found no advantage to the use of a soundproof booth. They further state that testing when hearing loss is present involves testing at or above 25 dB HL such that the soundproof booth serves no advantage over a quiet test room for this population.

When one considers that all tests of auditory processing are typically conducted at levels well above 25 dB HL, this raises the question even more as to the need for using a soundproof booth when testing auditory processing abilities. However, there has been no research to support or refute this argument. Consequently, the following study was undertaken to investigate whether auditory processing test results will differ when the person is tested inside the soundproof booth versus in a quiet test room.

METHODS

Participants

Two groups of participants were included in the present investigation. Initially, the study examined auditory processing test findings inside versus outside the test booth. Ten people with no concerns of or histories of APDs, learning problems, cognitive deficits, communication difficulties, or other factors that might affect auditory processing test results were included as participants. After this initial investigation was completed, a question arose as to whether similar findings would be found for students referred for auditory processing testing with a history of learning problems, but no cognitive, physical, or other abnormalities. All students who were referred for such auditory processing testing were found to have language issues along with their learning disabilities, though psychological testing revealed normal cognitive abilities in both verbal and nonverbal areas. Thus, the present study examined findings from all 20 participants.

Non-APD Group

The initial investigation looked at auditory processing test results in ten participants who were reported as not having any intellectual, communicative, or learning problems. These ten participants were students majoring in communication sciences and disorders at Howard University in Washington, DC. The students were undergraduate majors ranging in age from 19 to 26 yr with a mean age of 24 (standard deviation [SD] = 0.82). Information regarding the lack of these problems was obtained from student reports as well as from review of the students' files that included information indicating that none of the students had student support services while in college, nor did they have indications of individual education plans or 504 Plans when they were in high school. These students had ≥ 3.0 GPA, were accepted into a very demanding major such as Communication Sciences and Disorders, and did not report any history of learning disabilities, attentional issues, or cognitive or other psychological factors; consequently, these students were considered free from factors that might affect auditory processing abilities. All participants signed informed consent forms and volunteered to participate in this research.

APD Group

The ten middle- and high-school students who comprised the APD group were students referred from a private school in the metropolitan DC area. These students all had individual education plans indicating normal cognitive abilities. They also had been identified with learning-related issues for a variety of reasons, including Other Health Impairments due to attention problems (attention-deficit hyperactivity disorder), speech-language impairments, or specific learning disabilities. These middle- and high-school students ranged in age from 12 to 18 yr with a mean age of 14.4 (SD = 1.90).

All students voluntarily agreed to participate in this investigation, with parents or legal guardians providing written consent for them to be involved in the testing that was completed at their school (in a quiet test room) as well as in a sound-treated suite in the audiology clinic at Howard University. Although the mean age differed between the non-APD and APD groups, since within participant comparisons were used for analyzing the data, each participant served as his/her own control. As such, age difference was not felt to affect the findings.

Equipment

To ensure the reliability of the test findings in and out of the soundproof booth, portable equipment was used.

Except for the audiometers that were used to assess hearing, all measures of auditory processing were obtained using the same equipment. For the hearing assessment, students in the university setting were tested via a GSI-61 audiometer (GSI, Eden Prairie, MN) with tones and speech (i.e., for speech reception thresholds [SRTs]) with stimuli delivered through TDH-50 headphones (Telephonics, Farmingdale, NY). For the students tested at the school, thresholds were measured via a MAICO MA-27 portable audiometer (MAICO Diagnostics, Eden Prairie, MN), which included TDH-50 headphones to deliver the tones and speech material. Before testing hearing thresholds and SRTs, ambient noise levels were measured in the quiet test room at the children's school, using a Quest Portable Sound Level Meter (SLM) 1200 (Quest Technologies Inc., Oconomowoc, WI). The ambient noise level in the test room was observed to be <40 dB SPL. All children were found to have hearing thresholds <15 dB HL as well as Type A tympanograms when each ear was assessed using an MAICO EasyTymp Tympanometer.

For all auditory processing testing, the prerecorded tests were played from an HP EliteBook 8440p laptop computer (Hewlett Packard, Miami, FL). A y-cord was attached to the earphone output from the computer. One end of the y-cord was connected to Audio-Technica ATH ANC27 QuietPoint noise-canceling headphones (Audio-Technica, Stow, OH), while the other end of the y-cord was connected to a monitor headphone worn by the evaluator to monitor the output from the computer and hear the participants' verbal responses.

To set the computer's output to a level approximating normal conversational level, the 1000 Hz calibration tone from each auditory processing measure was measured using a Quest Portable SLM 1200. The microphone of the SLM was placed at the output on each earphone (measured one at a time) as the calibration tone was played, and the intensity level of the computer output was adjusted until a reading of 70 dB SPL was achieved for each ear phone.

This computer testing system was used for each participant for each of the auditory processing tests administered inside the test booth, as well as in the quiet test room. At the university, testing was conducted either in a double-walled IAC test booth (IAC Acoustics, North Aurora, IL) or in a quiet room inside the audiology clinic. In the test booth, the computer and earphones were placed in the participant's test room so that testing for auditory processing could be administered using the same equipment both inside and outside the test suite.

The battery of auditory processing tests used was based on the standard test battery used by author J.R.L. in evaluating auditory processing and is composed of tests that are typically used by many audiologists in the course of their auditory processing assessments. It should be noted that one measure, the Auditory Continuous Performance Test (ACPT), does not have norms for adolescents and adults. However, since only raw scores were used in the analyses of test performance, it was felt that this measure could be used. The battery of tests used is presented in Table 1.

Procedures

Each participant's hearing acuity was assessed under headphones for each ear separately by presenting pure tones at 250, 500, 1000, 2000, 4000, and 8000 Hz. This was followed by determining each participant's SRTs. All participants in this study were determined to have normal hearing acuity binaurally with no hearing thresholds exceeding 10 dB HL at any frequency.

After completing the hearing threshold measures, the participants were administered the auditory processing test battery in the order in which the tests are listed in Table 1. One half of the participants for each group completed the testing inside the test suite and then one to two weeks later in the quiet test room. The other half completed the initial testing in the quiet room, followed by testing inside the booth one to two weeks later.

All of the prerecorded auditory processing measures included test directions that the participants listened to before each test. The evaluator ensured that the recordings were functioning appropriately via the monitor earphones, while also being able to hear the

Table 1. List of Auditory Processing Measures Used in the Present Study

Test	Measure
SCAN-3:A*	Filtered words
	Auditory figure–ground 0
	Competing words–directed ear
	Competing sentences
	Time-compressed sentences
SSW Test†	RNC
	RC
	LC
	LNC
PST‡	
ACPT§	

Notes: The order of tests listed indicates the order in which the tests were administered in the battery. LC = left ear competing; LNC = left ear noncompeting; RC = right ear competing; RNC = right ear noncompeting; SSW = staggered spondaic word.

*For the SCAN-3:A, only the four core subtests were administered for this study, although some of the other measures were used in evaluating auditory processing in the students referred for such testing and found to have APDs.

†For the SSW, although the entire test was administered, very few middle- and high-school students, and none of the college students, revealed problems with the response biases, so they were not used in the analyses presented in the present study.

‡For the PST, only the total number correct was used in this study, since very few participants revealed response biases (i.e., qualitative analyses errors)

§For the ACPT, only the total number of errors were used in this study.

Table 2. Ranges, Means, and SDs for Each Auditory Processing Measure for the Two Participant Groups (Non-APD and APD)

Measure	Group	Location	Range	Mean	SD
Word recognition in quiet					
Right ear	Non-APD	Inside	all 100%	100%	0.00
		Outside	96–100%	98.8%	1.93
Left ear		Inside	96–100%	99.6%	1.26
		Outside	96–100%	98.8%	1.93
Right ear	APD	Inside	96–100%	98.8%	2.70
		Outside	92–100%	98.0%	2.83
Left ear		Inside	92–100%	98.0%	2.83
		Outside	92–100%	98.0%	2.83
SCAN-3:A					
FW	Non-APD	Inside	27–38	34.2	3.94
		Outside	30–38	34.5	2.68
	APD	Inside	18–34	24.8	4.78
		Outside	15–34	24.8	5.63
AFG 0	Non-APD	Inside	30–36	33.9	1.86
		Outside	32–37	34.4	1.65
	APD	Inside	26–39	33.3	3.80
		Outside	28–38	34.7	3.23
CW	Non-APD	Inside	41–60	52.2	6.39
		Outside	44–60	52.7	6.38
	APD	Inside	34–53	42.6	5.93
		Outside	33–52	43.1	5.99
CS	Non-APD	Inside	65–70	68.5	1.51
		Outside	67–70	69.0	1.33
	APD	Inside	24–70	47.9	15.23
		Outside	25–70	47.7	15.53
TCS	Non-APD	Inside	59–60	59.8	0.42
		Outside	58–60	59.5	0.71
	APD	Inside	7–51	28.5	17.17
		Outside	9–50	28.5	16.32
SSW test					
RNC	Non-APD	Inside	0–1	0.50	0.53
		Outside	0–1	0.40	0.52
	APD	Inside	0–8	2.70	2.67
		Outside	0–10	2.80	3.39
RC	Non-APD	Inside	0–2	0.70	0.82
		Outside	0–2	0.50	0.71
	APD	Inside	1–18	5.90	6.37
		Outside	0–21	6.30	7.42
LC	Non-APD	Inside	0–3	0.80	1.32
		Outside	0–4	0.80	0.92
	APD	Inside	2–32	10.3	8.41
		Outside	3–26	9.90	6.76
LNC	Non-APD	Inside	0 for all	0.0	0.00
		Outside	0 for all	0.0	0.00
	APD	Inside	0–13	4.0	4.57
		Outside	0–11	3.6	4.14
PST total score	Non-APD	Inside	23–25	24.6	0.70
		Outside	24–25	24.8	0.42
	APD	Inside	7–23	16.9	5.32
		Outside	10–23	17.4	4.30
ACPT total score	Non-APD	Inside	0–2	0.5	0.97
		Outside	0–3	0.4	0.70
	APD	Inside	1–13	6.5	3.66
		Outside	0–12	6.2	3.46

Note: AFG 0 = auditory figure-ground 0; CS = competing sentences; CW = competing words–directed ear; FW = filtered words; LC = left ear competing; LNC = left ear noncompeting; RC = right ear competing; TCS = time-compressed sentences.

participant's responses. Each test item was scored according to standard procedures. For the ACPT, the only change relative to the standard procedure was that participants were asked to tap or knock on the handrest of the chair in which they were sitting rather than raising their thumbs. This was done because author J.R.L. has found that for individuals with attentional issues, they often waver their hands and thumbs so that it is not certain whether they are responding to the target stimuli or merely waving their hand. However, tapping or knocking on something is not a behavior that listeners typically do unless they are responding specifically to the target stimulus on the ACPT.

Data Analyses

Only the raw data (either number of items correct for SCAN-3:A and Phonemic Synthesis Test [PST] or the number of errors for the SSW and ACPT) were used in analyzing the results in the present study. The data were then examined regarding the range of scores, mean values, and SDs obtained. Results were analyzed via a multiple analysis of variance (MANOVA), the independent variables being the location of testing (inside the booth versus in the quiet room or outside the booth), and the order of location (inside–outside versus outside–inside). The analysis of order was completed to evaluate whether a learning effect might have led to any differences that might have occurred. That is, it is possible that the second time that the participants completed the APD measures, they performed better because of a learning effect. Thus, analysis of the order of location helped determine whether any learning effect influenced the test findings.

RESULTS

Results for each of the measures for the two groups of participants are presented in Table 2. Review of this table indicates that the mean values for each measure as a function of test setting did not appear to differ when considering the two groups. Thus, it was decided to look at whether any significant differences occurred when comparing (a) the two test locations (inside versus outside the test suite), (b) the order of testing (which location was used first), and (c) the interactions between the variables of group and location as well as group and order of testing. Significant findings would indicate whether there were differences based on the location of testing as well as any possible learning effect based on the order in which the testing occurred (first inside the test suite versus first in the quiet test room). Additionally, the interactions between group and these variables of location and test order would indicate whether results differed between the two groups (APD versus non-APD). To investigate these differences, a MANOVA was calculated. Table 3 presents the results of these analyses.

Table 3. Results of MANOVA Comparing the Two Test Locations (Inside the Booth vs. Outside the Booth) and the Order for Testing (In/Out vs. Out/In) for the Group as a Whole and the Interaction Effects of Group by Location and Group by Order of Testing

Analysis/Comparison	Measure	*F* value	*p* value
Inside vs. outside the booth (for group as a whole)	FW	0.010	0.919
	AFG 0	0.235	0.631
	CW	0.059	0.810
	CS	0.002	0.967
	TCS	0.001	0.970
	RNC	0.000	1.000
	RC	0.004	0.950
	LC	0.029	0.866
	LNC	0.038	0.847
	PST	0.092	0.763
	ACPT	0.073	0.789
Order of testing (for group as a whole)	FW	0.029	0.866
	AFG 0	0.142	0.709
	CW	0.190	0.666
	CS	0.824	0.371
	TCS	0.491	0.489
	RNC	0.075	0.786
	RC	1.784	0.191
	LC	1.035	0.317
	LNC	0.151	0.700
	PST	0.017	0.897
	ACPT	0.018	0.894
Interaction of group by location of testing	FW	0.010	0.919
	AFG 0	0.003	0.957
	CW	0.000	1.000
	CS	0.010	0.923
	TCS	0.001	0.970
	RNC	0.019	0.892
	RC	0.036	0.850
	LC	0.003	0.955
	LNC	0.038	0.847
	PST	0.017	0.897
	ACPT	0.164	0.689
Interaction of group by order of testing	FW	0.010	0.919
	AFG 0	0.073	0.789
	CW	0.009	0.923
	CS	0.679	0.416
	TCS	0.329	0.570
	RNC	0.168	0.684
	RC	1.460	0.236
	LC	0.626	0.435
	LNC	0.151	0.700
	PST	0.092	0.763
	ACPT	0.073	0.789

Notes: The df for all measures was 1. AFG 0 = auditory figure-ground 0; CS = competing sentences; CW = competing words–directed ear; FW = filtered words; LC = left ear competing; LNC = left ear non-competing; RC = right ear competing; RNC = right ear non-competing; TCS = time-compressed sentences.
For all values, $p > 0.05$, not significant.

Review of the MANOVA indicates no significant differences between the two testing locations and for the order in which the testing was done (i.e., in the booth or not and which test condition was the initial condition). Additionally, no significant interactions were found for location by order. Furthermore, no significant interactions were found for group (APD versus non-APD) by location or by order.

The results of the present study support the conclusion that one should not expect to find differences in auditory processing test results whether the persons being tested are evaluated in or out of the test booth, with the caveat that noise levels are sufficiently low and have been assessed before administration of hearing and auditory processing testing.

CONCLUSIONS

Results of the present study support the findings regarding pure-tone threshold and SRT measures mentioned earlier (Maclennan-Smith et al, 2013; Margolis and Madsen, 2015). That is, there is no rationale to support that auditory processing testing must be completed in a soundproof booth so long as factors such as those discussed in the present study are taken into consideration. As Margolis and Madsen stated, when testing is done well above threshold, there is no advantage to using a soundproof booth. Furthermore, these authors found that hearing thresholds were no different inside versus outside the booth. In the present study, the earphones used were noise-canceling headphones, which helped to reduce outside noise from entering the ears and interfering with the auditory processing testing. Furthermore, in the present study as well as that of Margolis and Madsen, the measures completed outside the booth were done in quiet test environments. When the findings of the present study are considered, it is reasonable to state that auditory processing testing can reliably be done in quiet rooms in school buildings as long as background noise issues are minimal and addressed. This will allow students to easily be evaluated for auditory processing problems when such problems are suspected. Therefore, as long as care is taken to use a quiet test room and noise-reducing headphones, there should be no difference in the auditory processing results obtained if we were to compare test results of the same students obtained in a soundproof booth.

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