FACTOR STRUCTURE, CORRELATIONS, AND MEAN DATA ON FORM A
OF THE BETA III VERSION OF
MULTIPLE AUDITORY PROCESSING ASSESSMENT (MAPA)

by

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ABSTRACT

In 1997, the Multiple Auditory Processing Assessment (MAPA) was studied by Domitz and Schow and found to be a comprehensive screening tool for APD. The purpose of this study was to see if several new tests factor favorably in their expected APD content areas since MAPA was revised to a Beta III version. It was also designed to provide test correlation data, to establish preliminary means and standard deviation normative data, and to consider the influence of self-report and co-morbidity. The battery was administered to 119 children in Idaho who ranged in age from 8 – 11 years.

Factor studies produced the following results. A monaural version of the Selective Auditory Attention Test (mSAAT) and a newly developed Speech in Noise for Children and Adults test (SINCA) loaded in the same factor assumed to be monaural separation/closure (MSC), dichotic digits (DD) and competing sentences (CS) loaded together in the same factor assumed to be binaural

integration/separation (BI/BS), and pitch patterns (PP) loaded with the Quicktap test (TAP) assumed to be auditory pattern/temporal ordering (APTO). Duration patterns (DP) and a random gap detection perception test (GAP) were also evaluated with inconsistent results.

The old and revised and new subtests correlated significantly with other tests within their factor content categories except for DP and GAP. Nineteen subjects participated in test/retest. Reliability correlations ranged from high for PP, DP, CS, TAP, DD and MSATT (overall), moderate for right and left mSAAT when the left and right ears were considered separately, and poor for GAP and SINCA.

Performance standards were established for all subtests. Based on test scores after GAP and DP scores were removed, and considering PP reversals as correct; 14 subjects (12% of the sample) met the 2 SD criteria and 48 subjects (40% of the sample) were found to meet 1 SD. Severity ranged from affecting one AP area to affecting all three.

Comparing parent/teacher report to the 14 most severe cases of APD identified by MAPA, 5 children were considered diagnositically identified with APD based on self report , co-morbidity with LD or other conditions, along with the MAPA scores. The other nine were considered at risk. Nine of another 18 judged to have difficulties by self-report could be explained with MAPA results as they were among those with more than 1 SD for MAPA scores. Three of the 14 children diagnosed with APD also had LD. Four more of the eleven with LD, one of which was receiving speech/language services (making 7 of 11), and the only child with ADHD, were all identified as at risk for APD.

CHAPTER I

Introduction

Auditory Processing Disorder (APD) is an information processing deficiency that is specific to the auditory modality. In April 2000, a conference (known as the Bruton Conference) was held at the University of Texas in which a group of leading audiologists reached a consensus on APD, and provided new direction. This statement helped frame issues that earlier had been discussed at a consensus conference sponsored, and later published in 1996, by the American Speech Language Hearing Association (ASHA). At the Bruton Conference they concluded that APD may be exacerbated in unfavorable acoustic environments and may be associated with difficulties in listening, speech understanding, language development, and learning. They also recommended that both behavioral tests and electrophysiological/acoustic tests and neuroimagery studies be used in diagnosing APD. Katz et al. (2002) disagreed with the use of electrophysiological/acoustic and neuroimaging tests for the general population because they felt that these measures were unrealistically expensive and time consuming. Also, previous research does not confirm that children with APD are significantly different in electrophysiological/acoustic measures from children who do not have APD, and little is known about imaging. Jerger and Musiek (2000) responded that the gold standard for APD should include electrophysiological measures. (p. 20) APD was recommended as a replacement for the older term, Central Auditory Processing Disorder (CAPD).

A four-test behavioral battery was recommended by Musiek and Chermak (1994) for diagnosing APD or CAPD. Following this protocol, Domitz and Schow (2000) proposed a battery of tests called the Multiple Auditory Processing Assessment (MAPA). The Beta I and II versions of MAPA included a monaural version of the Selective Auditory Attention Test (mSAAT), dichotic digits (DD), pitch patterns (PP), and competing sentences (CS). In their study, Domitz and Schow compared the MAPA to the SCAN, a test battery developed by Keith (1986) and used widely in the United States. The MAPA showed four factors in the areas defined by ASHA for what constitutes an APD, while the SCAN showed factors in only two of the ASHA areas. (Domitz & Schow, 2000, p.101).

Domitz and Schow (2000) gathered data in 1997 on 81 third grade children for this multiple-test battery. They concluded that “SCAN does not have high sensitivity for CAPD in relation to the MAPA…and all four tests [of MAPA] should be used for initial screening or preliminary diagnostic testing (Domitz & Schow, 2000, p.109).” The MAPA thus is thought to be a more comprehensive tool for identifying APD than the current, more widely used, SCAN. However, a ceiling effect was apparent for some of the older children on MAPA when it was later tested on fifth grade children (Shiffman, 1999).

The ceiling effect is not an uncommon occurrence. Similarly, in a Dutch study that was comprised of seven APD tests, when the distribution of the scores were examined, ceiling effects were found for older children and adults in the frequency (PP) and duration pattern (DP) subtests (Neijenhuis et al., 2001).

Jerger and Musiek (2000), reporting on the Bruton Conference and a consensus statement later promoted by the American Audiology Association (AAA), suggested that a gap-detection task and a duration pattern sequencing task be included as part of the minimal behavioral test battery. (p. 469 & 471)

Following the lead of Jerger and Musiek (2000), and based on the Bruton Conference where she was a participant, Chermak (2001) recommended a test battery that includes (1) *auditory pattern/temporal organization tasks* (APTO) such as PP, duration pattern (DP) and/or gap detection perception (GAP); (2) *binaural integration/separation tasks* (BI/BS) such as dichotic listening for digits, words, or sentences; and (3) *monaural separation closure tasks* (MSC) such as filtered/compressed speech, or speech in competition (Chermak, 2001, p. 16). It is upon this recommendation, and Bruton recommendations, that the current study was based.

The current MAPA has two BI/BS tasks already (DD and CS), one MSC task (mSAAT), and one APTO task (PP). In order to have at least two tests in each of the three behavioral test areas recommended at Bruton, the developers of MAPA (Schow et al., personal communication) decided to add to MAPA three more APTO tasks: a gap detection perception test (GAP), a duration patterns test (DP), and a QuickTap test (TAP) suggested by Charles I. Berlin (personal communication, October, 2002) hoping the new tests would load favorably with PP by factor analysis. In addition, a second MSC task was added; a newly developed test called Speech In Noise For Children and Adults (SINCA), with the hope it would load favorably with mSAAT. If the GAP, TAP and/or DP tasks factor under the same category as PP in the APTO area, and if the SINCA and mSAAT correspond in factor structure, alternative APTO and MSC tasks would then provide more flexibility for the clinician and make the overall test a more valid and comprehensive diagnostic APD tool. (See Table 1)

Accordingly, the MAPA was revised to a Beta III version which incorporated the following modifications:

1. Three tasks were added: a GAP subtest, a TAP subtest, and a DP subtest. It was hoped that at least one of these tests would factor favorably with the current PP subtest currently being used in the APTO area.
2. A MSC test was developed (Speech In Noise for Children and Adults – SINCA), to be factored against the current mSAAT. Speech in noise testing has been documented in APD test batteries (Schilder et al., 1994; Feldman et al., 1993; & Van Velzen et al., 1995).
3. In addition, three revisions have been made to earlier versions of MAPA to make it slightly more difficult. This was done to reduce the ceiling effect found in the original version (Shiffman, 1999) so that the test battery could be used for children and teens (8 – 18 years) and adults.
    a. The DD subtest was changed. The listener is required to repeat back three digits for each ear instead of two. Six digits have been used by other

professionals in the field (Neijenhuis et al., 2001).

b. The PP subtest was increased from three high/low tones, to four.

c. The total number of pitch pattern items was reduced to 20 items compared to the original 30. Statistical analysis on the Domitz and Schow data (1997) demonstrated a correlation of .92 between 15 and 30 items and .96 between 20 and 30 items. Thus, 20 items were determined to be sufficient.

d. The competing sentence task now requires the subject to repeat both sentences with one ear directed first, whereas before, they were only required to repeat back one sentence.

e. The pitch patterns and duration pattern tests are now a binaural rather than monaural task.

Table 1. A summary of the three content areas suggested by Chermak (2001) and the expected factor structure with the addition of four new subtests (*) to the original four MAPA subtests.

BI & BS Assesses: Auditory discrimination; & auditory decrements from competition	MSC Assesses: Auditory discrimination; auditory decrements from competition and degradation	APTO Assesses: Auditory discrimination; auditory pattern recognition; temporal aspects of audition
1. DD (BI task)	1. mSAAT	1. PP
2. CS (BS task)	* SINCA	* GAP
		* TAP
		* DP

Research Questions

This study was designed to answer the following research questions:

1. Factor Structure:
    a. Do GAP, TAP, or DP subtests factor and correlate with PP in a favorable way?
    b. Does SINCA factor and correlate favorably with mSAAT?
    c. Will the existing binaural tests (DD and CS) factor together as predicted.
2. Correlations:
    a. Using Pearson correlation coefficients, do the old and new subtests correlate significantly enough with other tests within their factor content categories so that the new Beta III version of the MAPA emerges as a more comprehensive central auditory processing diagnostic tool?
    b. Test/Retest: Do subjects demonstrate reliable mean scores (via Pearson r) and non-significantly different mean scores (via *t*-test) when comparing initial and a second administration of the battery.

3. Do mean scores and standard deviations(SD)produce reasonable normative data for identifying children with APD?
4. Do self-report scores and co-morbidity data correspond and compliment mean and SD data in an expected manner?

Note: Assumptions, limitations, and delimitations are stated in the literature review. A brief description of each test and its scoring procedure is included in Appendix F.

Acronym Key

AAA:	American Audiology Association
APD:	Auditory Processing Disorder
APTO:	Auditory pattern/temporal ordering
ASHA:	American Speech/Language/Hearing Association
BI:	Binaural Task - (Refers to Integration and Separation)
BS:	Binaural Separation
CAPD:	Central Auditory Processing Disorder
CS:	Competing Sentences
DD:	Dichotic Digits
DP:	Duration Patterns
GAP:	Gap Detection Perception
MAPA:	Multiple Auditory Processing Assessment
MSAAT:	Monaural Selective Auditory Attention Test
MSC:	Monaural Separation Closure
PP:	Pitch Patterns
TAP:	QuickTap Test as suggested by Charles I. Berlin, Ph.D.

CHAPTER II - Methodology

Research Design/Data Analysis

A correlational research design was employed to best determine the relationships and correlation coefficients between the various tests being expanded in the Beta III version of the MAPA. This study administered multiple tests that were thought to factor under presumed categories, and then factor analysis and Pearson correlations were used to statistically calculate the grouping and relationships between them.

Correlational studies are useful for determining relationships, assessing consistency, and making predictions (Ary et al, 2002, p. 359). In addition, the quantitative nature of correlations provide for objective results that can be more easily interpreted for this type of study, than can be provided by any other research design. The factor analysis procedure is capable of analyzing the intercorrelations among a large set of measures, and also assists in identifying a small number of common factors. Factors can be used to identify content areas within hypothetical constructs assumed to underlie different types of psychological measures; for example intelligence, aptitude, achievement, personality, and attitude. “Factor analysis indicates the extent to which tests or other instruments are measuring the same thing, enabling researchers to deal with a smaller number of [content areas within] constructs.” (p. 365) Scale-level factor analysis was used in this study and each subtest was considered independently.

The eight different tests of auditory processing that were administered (mSAAT, PP, DD, DP, CS, SINCA, GAP and TAP) constituted the independent variables. Performance outcomes of the participants on each test constituted the dependent variable.

Materials

The MAPA (Beta III Version) evaluates three diagnostic areas:(1) auditory pattern/temporal ordering (APTO), (2) competing/degraded monaural low redundancy listening (MSC), and (3) competing/degraded low redundancy binaural listening (BI/BS). To screen for problems with auditory processing in any of these areas, eight tests were developed and pre-recorded onto a compact disc (CD) by Auditec, a major supplier and developer of auditory tests in St. Louis, Missouri. All test contingencies, including relative presentation level, were accounted for in the recording. All tests are preceded by formal, recorded instructions and coincide with an answer sheet (See Appendix D for the answer sheet).

Procedures/Data Collection/Instrumentation

All children who returned forms were told that they could refuse participation later, despite parental consent. Every child, after completion of the test, was asked if he/she would be willing to undergo a second administration of the test in a week or two. All but one child agreed to be retested. Ten third grade and ten fifth graders were randomly selected by code number, to be retested after at least a week had passed. All testing was administered by graduate-level clinicians, a certified audiologist, or trained assistants. To increase the response rates, a selection of small gifts such as stickers/treats were offered when the children returned the parent consent forms. In addition, McDonald gift certificates were offered to the children after they completed testing.

The following eight tests were rotated in their order of administration to control for threats of validity involving patient fatigue. Order remained the same while the starting place varied.

1. Monaural selective auditory attention test (MSC task)
2. Pitch patterns (APTO task)
3. Dichotic digits (BI task)
4. Competing sentences (BI task)
5. Duration patterns (Possible APTO task)
6. Speech in Noise for Children and Adults test (Possible new MSC task).
7. Gap detection (Possible APTO task)
8. Tap test (Possible APTO task)

The test battery took approximately 45 minutes to administer. This included time for the hearing, immittance, and otoacoustic screenings. Clinicians adhered to the pure-tone and tympanometry screening protocols established by ASHA.

Since all test instructions were pre-recorded on CD, clinicians were only responsible for monitoring the CD player, placing the headphones, and clarifying instructions as needed. The administering clinicians recorded each test based on subject response or non-response. Final tabulations were performed by the researcher for consistency, and were double checked for accuracy.

A MA 39 Maico portable audiometer and TDH-39 headphones, an Earscan immittance screener, and a portable EroScan Maico otoacoustic emissions screener was used to evaluate the subject's hearing and middle ear status. Portable Lenoxx Sound Model CD-87 compact digital audio disc players with digital Koss (UR15) or Optimus Nova-44 stereo headphones were used during APD testing. The administering clinicians used monitoring earbuds or headphones while conducting the testing. All equipment was calibrated following ANSI guidelines. Daily calibrations on the Immittance screener were conducted, as well as biological listening checks on the audiometer and CD players.

Validity and Reliability

The researcher took precautions to control the extent to which extraneous variables influenced the results during the testing period, and the extent that the test was free of measurement errors, sampling error, and bias.

1. To control against subject fatigue, children were offered a short break approximately halfway into the test battery or at additional times when the child appeared to be bored or tired. Breaks were offered only between subtests. Recess and lunch breaks

further offered breaks throughout testing. In addition, the starting place during test administration was varied while the test order remained the same.

2. Children who did not pass the hearing screening, had cognitive impairment (mild mental retardation or greater), or did not speak English as their first language, were excluded from APD testing.

3. Measurement error was controlled by providing training and instructions for scoring to each clinician prior to instrumentation. Clinicians were evaluated at least once during the research period by conducting an item-by-item analysis between two observers on a portion of the test. To minimize scoring differences, all final tabulations were double checked by the author. See Appendix F for a brief description of each test and the scoring procedures that were implemented. Procedural reliability was ensured by the presentation of all instructions and contingencies through the CD recording. Auditory processing tests were delivered to the subject at an approximate hearing level of 50 dB HL. Following the procedures of Domitz (1997) and Shiffman (1999), volume control of the CD player

was fixed at 75 dB SPL throughout testing to approximate the recommended 50 dB HL presentation level. To ensure delivery consistency, output through the headphone was verified using the Quest – 188 sound level meter while the monitoring headphones were connected.

4. While testing did not take place in a sound-proof booth, ambient noise levels for each quiet test area were measured and monitored and found to be within ASHA screening standards before any testing was performed.

5. Ten third graders and ten fifth-graders were randomly selected and underwent a second administration of the test battery with at least a one-week passage of time between administrations. This was to verify the consistency of test scores intra-individually and provide information about test stability (test-retest) over time.

6. Once the children received the instructions and demonstrated understanding of the tasks, testing resumed without stopping the CD or pausing between items. This protocol was designed to standardize the processing time for all children and to minimize error variance. There was one incident, however,

when a fire drill resulted in four children having immediate stoppage of the test for a short time. Upon returning to the test site, the children were reminded of the instructions, and testing proceeded where the test was paused. The score sheets were marked to indicate the incident.

7. The previously studied MAPA (albeit some subtests are now more difficult) was used to evaluate the new tests since the factor structure and major test parameters were already known.
8. An informal CD and audiometer equipment check was made by the administering clinician prior to each test session. The tympanometer was calibrated daily.
9. Split-half reliability for each test was measured by breaking each subtest down into odd/even numbers and comparing the correlation coefficients. This information will be used to improve the MAPA in a subsequent project, but will not be used for the purposes of this study.
10. The researcher consulted with two statisticians who were experienced in factor analysis and enlisted their participation in running the software and making interpretations.

CHAPTER III

Results and Discussion

To briefly summarize, the purpose of this study was to answer four research questions:

1. Factor Structure:
    a. Do GAP, TAP, or DP subtests factor and correlate with PP in a favorable way?
    b. Does SINCA factor and correlate favorably with mSAAT?
    c. Will the existing binaural tests (DD and CS) factor together as predicted.
2. Correlations:
    a. Using Pearson correlation coefficients, do the old and new subtests correlate significantly enough with other tests within their factor content categories so that the new Beta III version of the MAPA emerges as a more comprehensive central auditory processing diagnostic tool?
    b. Test/Retest: Do subjects demonstrate non-significantly different mean scores (via t-

test) and reliable mean scores (via Pearson r) when comparing initial and a second administration of the battery.

3. Do mean scores and associated SDs produce reasonable normative data for identifying children with APD?
4. Do self-report scores and co-morbidity data correspond and compliment mean and SD data in an expected manner?

Participants

Parent permission forms (see Appendix B) and an auditory behavior scale (see Appendix C) were delivered to four Idaho elementary schools in the Snake River District (school #1), Blackfoot District (school #2) and Pocatello District (#’s 3 and 4). The parent permission forms were developed and approved for distribution through the human subjects committee. The behavior scale was a twelve-item checklist based on the work of Shiffman (1999)and Chermak et al (1998). Teachers were asked to complete the same scale for each child participating in the study as a verification measure against parental report.

The principals and teachers of third and fifth-grade classrooms were contacted in advance and had agreed to participate. The schools and classrooms involved were a nonrandom-type convenience sample made up of all those available and willing to participate at the time.

All children in all classrooms where principals and teachers agreed to participate were given the opportunity to participate. No special consideration was given to factors such as academic performance or teacher recommendation.

The children were informed about the testing and were asked to have their parents sign the permission slips and fill out the questionnaire and return them to their teacher within a week. As an incentive for being tested, the children were told that they would receive $2.00 gift certificates to McDonalds, and in some cases more depending on the level of participation.

One hundred twenty-five (125) children returned forms and volunteered to be subjects. Participation was then dependent on the passing of a pure-tone hearing screening for both ears at 20 dB HL for the frequencies 1, 2 and 4 kHz. Children with type B tympanograms were eliminated unless they were also able to pass a more comprehensive hearing screening with the addition of frequencies 250 and 500 Hz. An electroacoustic otoacoustic emissions screening was performed on each child with the exception of a few subjects when the instrument was not available. This was done to verify behavioral results. The absence of emissions alone did not eliminate subjects. A *refer* was present on all ears that did not pass the screening and was also present on 4 of the ears that did. Four of the children could not pass the screening criteria in both ears and were eliminated from further testing.

Children were excluded due to a known diagnosis of cognitive impairment (mild mental retardation or worse) or other severe disability that could skew the results. According to Bellis (p.186), some professionals in the field require normal cognitive abilities before they will administer a central auditory evaluation, while others make a judgment as to whether the child can reliably complete the tasks required.

In this study, the district audiologists obtained student information and no children were found to have cognitive impairment (IQ < 70).

Children with a diagnosis of ADHD were not excluded from this study since they are part of the general population for which the Beta III Version of the MAPA may be used to screen for APD. One child met this criteria. Eleven children had a diagnosis of learning disability (LD): three received special services for math, writing, and reading; two for reading and writing only; and six were identified as LD but not receiving resource help at the time of testing, however, one was receiving speech and language services. One child was receiving outside help for reading difficulties. These children were not eliminated from the sample. (See Table 2) Six children were eliminated in all: two children diagnosed with limited English proficiency (LEP) and four who did not pass the minimal hearing screening criteria.

Table 2. Subjects included in the study: Eleven with LD, one with ADHD. Subjects are shown who were receiving special services in reading, writing, math, or speech/language.

LD	ADHD	SLP	Read	Write	Math
X					
X					
X					
X		X			
X			X	X	X
X			X	X	
X					
X			X	X	X
X			X	X	
X			X	X	X
X					
	X				
			X		

One hundred nineteen (119) children proceeded with APD testing. Fifty-five subjects came from school #1 (46.2% of the sample), forty-four subjects came from school #2 (37%), seventeen came from school #3 (14.3%), and three came from the fourth school (2.5%). Other children in these schools participated in a companion study. (See Table 3)

The total of 119 subjects were made up of 66 third-graders and 53 fifth-graders from 11 different classrooms (six 3rd grade and 5 5th grade) that represented a diverse socioeconomic status. Ages were represented by 23 eight-year-olds, 43 nine-year-olds, 24 ten-year-olds, and 29 eleven-year-olds. Gender consisted of 68 females and 51 males, somewhat unequal, but again related to convenience sampling and the researcher not having control over the number of consent forms that that would be returned. (See Table 4)

Table 3. A summary of the number of subjects from each of four schools, and their relative percentage compared to the total sample.

School	Number of Subjects	Percent of Sample
1	55	46.2 %
2	44	37.0 %
3	17	14.3 %
4	3	2.5 %
	Total 119	100 %

Table 4. A summary of the number and percentage of subjects as a function of grade and age. Gender is indicated with (*).

Grade	Age	Number of Subjects	Total by Grade	Percent of Subjects
3	8 Years	23	N = 66 3rd Grade	19.3 %
	9 Years	43		36.1%
5	10 Years	24	N = 53 5th Grade	20.2%
	11 Years	29		24.4%
*68 Females, 51 Males		119	119	100%

Noise Measurements

Testing was conducted in rooms that were within the acceptable noise criteria levels suggested by ASHA; which is 46 dB at 500 Hz, 49.5 dB at 1 kHz, 54.5 dB at 2 kHz, and 62 dB at 4 kHz (ASHA, 1997). Ambient noise was monitored using a Quest-188 sound level meter and rechecked when noise levels changed noticeably. At no time were measurements taken that exceeded ASHA guidelines.(See Table 5)

Table 5. Recorded noise measurements (in dB) for each school and test area compared to ASHA guidelines, 1997.

Hz	ASHA	School 1	School 2	School 3		School 4	
		Area 1	Area 1	Area 1	Area 2	Area 1	Area 2
500	46	33.6	39.0	39.5	34.6	37.9	33.6
1000	49.5	25.9	32.5	27.5	30.5	33.7	35.3
2000	54.5	21.6	27.0	21.6	25.3	33.7	32.6
4000	62	19.2	20.6	23.3	29.0	31.9	31.6

Factor Structure (Question 1)

The SPSS qualitative statistical analysis program was used to compute exploratory factor analysis on the data. Three factors with an eigenvalue greater than 1.0 (4.0, 1.5, 1.1) emerged using a maximum likelihood extraction method and a Promax with Kaiser normalization rotation. They are reported in Table 6. Factor I includes both mSAAT and SINCA and is thus considered the MSC factor. Factor II includes both CS and DD and is believed to be the binaural factor. Finally; TAP, PP, DP and GAP all factor together under what is believed to be the APTO area.

Table 6. Exploratory factor analysis using a maximum likelihood extraction method and a Promax with Kaiser normalization rotation method. Weightings <.25 are omitted.

TESTS	Factor I – (MSC)	Factor II – (BI/BS)	Factor III – (APTO)
1. MSAAT RE	**.75**		
MSAAT LE	**.51**		
2. SINCA RE	**-.67**		
SINCA LE	**-.57**		
3. CS RE		**1.0**	
CS LE		**.64**	
4. DD	.30	**.42**	.39
5. PP			**.61**
6. DP	.28		**.44**
7. TAP			**.75**
8. GAP			**-.29**

Dichotic digits showed up in all three categories at >.25 but the weighting was strongest along with competing sentences, the other binaural task. According to Nunnally, it is quite easy to find a set of items that measure multiple factors, as seems to be the case with DD. (p. 308) What is wanted is that we have clusters of items that have relatively higher correlations with one another but lower correlations with members of other clusters. Items with similar distributions tend to correlate more highly with one another than items with dissimilar distributions. (p. 318)

Exploratory factor analysis can be influenced by small data changes, and since this was found with our data, a second factor analysis was run using the same extraction and rotation method after two GAP outliers were removed from the data set (these two subjects could complete the task only at or beyond the greatest msec level). The resulting factors are provided in Table 7. Initial eigenvalues for the three factors were 4.0, 1.5, and 1.0 respectively.

In this case, DD showed up strongest with Factor III whereas it was showing up across the board but strongest with Factor II before. In addition, the GAP test showed up as loading strongest with Factor I instead of Factor III. This problem with GAP, plus others, suggested it might need to be removed.

A third analysis (Table 8) was run after removing all of the GAP data and while using right and left DD scores rather than a total DD score. A principle axis extraction method and a Promax with Kaiser normalization rotation method was used. Initial eigenvalues for the three factors were 4.2, 1.6 and 1.1 respectively. This showed expected weightings for DD but DP then loaded slightly more with the MSC tests than with the APTO area.

Table 7. Exploratory factor analysis using a maximum likelihood extraction method and a Promax with Kaiser normalization rotation method after removing two GAP outliers. Weightings <.25 are omitted.

TESTS	Factor I – (MSC)	Factor II – (BI/BS)	Factor III – (APTO)
1. MSAAT RE	**.71**		
MSAAT LE	**.54**		
2. SINCA RE	**-.66**		
SINCA LE	**-.59**		
3. CS RE		**.94**	
CS LE		**.65**	
4. DD		.36	**.51 ***
5. PP			**.67**
6. DP	.30		**.46**
7. TAP			**.75**
8. GAP	**-.29 ***		

Table 8. Exploratory factor analysis using a principal axis extraction method and a Promax with Kaiser normalization rotation method after the GAP data was removed. Weightings <.25 are omitted.

TESTS	Factor I – (MSC)	Factor II – (BI/BS)	Factor III – (APTO)
1. MSAAT RE	**.68**		
MSAAT LE	**.55**		
2. SINCA RE	**-.70**		
SINCA LE	**-.71**		
3. CS RE	.30	**.56**	
CS LE	.33	**.59**	
4. DD		Right **.70** Left **.82**	
5. PP			**.51**
6. DP	**.42***		.36
7. TAP			**.87**

From multiple factor analyses, depending on the extraction and rotation methods used, some differences in loadings are evident. The previous MAPA tests (MSAAT, CS, DD, and PP) factored in these factor results largely according to expectations and into the monaural, binaural, and APTO areas. Dichotic digits was not as consistent as the others and did show unexpected factor loadings, at times. Of the four new subtests, DP and GAP were the least consistent while TAP and SINCA factored beautifully within the expected areas. Three different ways of showing the factor results were presented because all of them have informational value.

Given the above stated factor results, DP and GAP were removed from analysis and two more factor analyses were run on the remaining six subtests (mSAAT, SINCA, CS, DD, PP, and TAP). First, factor results include those for right and left ear scores shown separately, and then the factors on total scores for each test (combining right and left ears for mSAAT, SINCA, and CS) are shown.

Initial eigenvalues for the three factors in Table 9 were 3.5, 1.4 and .95 respectively. Initial eigenvalues for the three factors in Table 10 were 2.68, 1.19, and .76 respectively. Eigenvalues under 1.0 are shown because of the presumed factor structure. This is not standard protocol but justified in a case like this (Kim & Mueller, 1978; Rummel, 1970; Tabiachnick & Fiddel, 1996) from Letter to the Editor (Schow et al., 2002).

Table 9. Exploratory factor analysis using a principal axis extraction extraction method and a Promax with Kaiser normalization rotation method after removing GAP and DP subtests. Weightings <.25 are omitted.

TESTS	Factor I – (MSC)	Factor II – (BI/BS)	Factor III – (APTO)
1. MSAAT RE	**.68**		
MSAAT LE	**.55**		
2. SINCA RE	**-.70**		
SINCA LE	**-.56**		
3. CS RE		**.84**	
CS LE		**.72**	
4. DD	-.29	**.48**	.37
5. PP			**.54**
6. TAP			**.80**

Table 10. Exploratory factor analysis using a principal axis extraction extraction method and a Promax with Kaiser normalization rotation method after removing GAP and DP subtests. Weightings <.25 are omitted.

TESTS	Factor I – (MSC)	Factor II – (BI/BS)	Factor III – (APTO)
MSAAT	**.74**		
SINCA	**-.72**		
CS	.35	**.65**	
DD	.25	**.67**	
PP			**.74**
TAP			**.50**

As Tables 9 and 10 illustrate, when GAP and DP data are removed from analysis, the remaining six subtests factor nicely within their expected content areas: MSATT/SINCA into MSC, CS/DD into BI/BS, and PP/TAP into APTO even though eigenvalues less than one were included. Dichotic digits overlaps with another Auditory Processing (AP) task as was seen before, but loads strongest, where it should, along with competing sentences.

Correlations (Question 2)

Each of the eight subtests were correlated against each other. The findings are presented in Table 11. The three groups of highlights represent those tests that are expected to correlate favorably together by category, i.e., MSC, Binaural, and APTO. The stars indicate the significance of correlations based on the .05 (*) and .01 (**) 2-tailed level.

A correlation coefficient indicates the size and direction of a relationship. Highly reliable correlations (closer to 1.0) suggest that persons generally have similar scores when retaking the test. Low correlations (closer to .00) suggest that the variables are less related and higher variability can be expected upon retest.

The question of how high a coefficient must be to be considered good is not easy to answer. In general, it’s a comparative matter. A coefficient of .50 might be acceptable if it’s the only test available to predict a given criterion and it could be inadequate if other tests are available with higher coefficients. Airasian and Gay suggest one way to look at correlations: below plus or minus .35, not related; between plus or minus .35 to .65, moderately related; and higher than plus or minus .65, highly related. In Table 11, items bolded meet correlation expectations at the plus or minus moderate, .35, level or higher.

Table 11. Pearson correlations for the eight subtests. (**=correlation is significant at the .01 level; *=correlation is significant at the .05 level). Three groups of highlights represent tests expected to correlate favorably. Bolds represent tests that meet +/- .35 criteria.

TESTS	**MSAAT Right**	**MSAAT Left**	**SINCA Right**	**SINCA Left**	**CS Right**	**CS Left**	**DD**	**TAP**	**PP**	**DP**	**GAP**
MSAAT Right	1.00										
MSAAT Left	**.42 ** **	1.00									
SINCA Right	**-.54 ** **	**-.40 ** **	1.00								
SINCA Left	-.24 **	**-.36 ** **	**.46 ** **	1.00							
CS Right	.25 **	.33 **	**-.45 ** **	-.27 **	1.00						
CS Left	.28 **	**.38 ** **	-.32 **	-.27 **	**.65 ** **	1.00					
DD	.01	.10	-.16	.00	**.42 ** **	**.38 ** **	1.00				
TAP	.07	.32 **	-.29 **	-.00	.28 **	.28 **	**.35 ** **	1.00			
PP	.24 **	**.35 ** **	-.32 **	-.29 **	**.39 ** **	.29 **	**.39 ** **	**.46 ** **	1.00		
DP	.32 **	**.39 ** **	**-.39 ** **	**-.40 ** **	**.47 ** **	**.41 ** **	.33 **	**.42 ** **	**.52 ** **	1.00	
GAP	-.04	-.08	.06	.09	-.02	-.15	.02	-.20 *	-.14	-.17	1.00
	Highlights Above MSC				Highlights Above Binaural (BI/BS)			Highlights Above APTO			

Using a criteria of +/- .35, all tests correlate favorably against tests within their respective categories except SINCA left with MSAAT Right (which is still significantly correlated at the .01 level), and GAP against all other temporal tests.

These findings support the factor analysis results that indicated GAP does not factor well with the other temporal tests in the battery. Even though DD showed weightings across categories in factor analysis, nevertheless, correlations with competing sentences in the binaural category are reasonably strong. Duration patterns and GAP were the most inconsistent by factor analysis, and similarly, DP appears to correlate in all three categories and GAP does not correlate favorably with any of the other subtests. In addition, CS Left has higher correlations with MSATT left than we might expect (.38), and SINCA right appears to have more in common with CS right (.45). Although PP correlates best, as expected, within the APTO area, it also correlates nearly as well with MSAAT Left, CS Right, and DD in the two other content areas. As Nunnally says, it is quite easy to find a set of items that measures multiple factors (p. 308).

Test/Retest Reliability

Good test/retest reliability has historically been difficult to establish when assessing for APD, due to changes in alertness, cognitive status, and compensation strategies (Chermak & Musiek, 1997). Cacase and McFarland (1995) encouraged researchers to give the necessary attention to test reliability and to change factors that have resulted in poor reliability in the past. Reliability is expressed numerically, usually as a reliability coefficient. Reliability is crucial in test development, however, a reliable test is not always valid. For this reason, the careful validity measures taken by the researcher and described in the methods section became an important precursor to the question of test/retest reliability. These measures included such things as providing breaks and test rotation to guard against subject fatigue effects, eliminating children from consideration who had cognitive involvement or English as a second language issues, conducting daily listen checks and calibration checks (where appropriate) on the equipment, providing training instructions to the administering clinicians, etc.

Twenty children were randomly selected to undergo a second administration of the test battery (ten 3rd graders and ten 5th graders). Nineteen were tested as one 5th grader was absent on the day of testing.

All children were tested in the same test rooms, under similar conditions, and with a passage of time of at least one week and up to ten days (mean 8.5 days). Compared to the mean test/retest time for SCAN-C of 6.5 days (Keith, 1986), this is believed to be a reasonable amount of time between administrations.

The same measures were taken during retest to ensure ideal and as close to identical testing conditions as possible. For example, a fan was covered, the school intercom was turned off, doors were shut during testing, dividers were used to reduce distraction, etc.

Pearson correlations for the test and retest subtests are summarized in Table 12. Composite scores were calculated for CS, mSAAT, and SINCA by combining the right and left ear scores. Scores on the individual tests were also considered separately and are included.

Table 12. Pearson correlations listed from high to low, between test and retest for the Beta III version of the MAPA for 19 subjects (ten 3rd graders and nine 5th graders).

Test/Retest	Correlation	Interpretation (Airasian/Gay Recommendation)
PP	.91	HIGHLY RELATED
DP	.90	
CS Overall	.86	
CS Left	.82	
CS Right	.79	
TAP	.77	
DD Total	.73	
MSAAT Overall	.67	
MSAAT Right	.62	MODERATELY RELATED
MSATT Left	.59	
SINCA Left	.30 *	NOT RELATED
GAP	.29	
SINCA Right	.20 *	
SINCA Overall	.11	

*Note. SINCA test/retest improved after removing half the items and doubling the remainder (left .50, right .53). Moderate correlations can probably be achieved by this strategy, but further data are needed to verify this.

In this study the concern was how dependable or stable is the Beta III version of the MAPA. How consistently will there be similar results upon administration of the same subtests, to the same subject, under similar circumstances, after a passage of time? The more confidence there is that the scores obtained the first time can be obtained again, then the more reliable a test is believed to be. Higher reliability indicates minimum error variance (Airasian & Gay, 2000).

It may be noted that test/retest reliability has a close relationship with equivalence reliability. Equivalence reliability is being considered separately, in a companion study, by Laurie Conlin at Idaho State University.

Reliability correlations between test and retest ranged from *excellent* for PP and DP, to *poor* for GAP and SINCA. Using the criteria suggested by Airasian & Gay previously stated (not related below +/- .35, moderately related +/- .35 to .65, and highly related greater than +/- .65), PP, DP, CS, TAP, DD and MSAAT (overall) had high test/retest correlations. When the right and left ears were considered separately, MSATT had moderate test/retest correlations. GAP and SINCA had poor correlations.

It should be noted that when half of the items were removed from SINCA and the remainder doubled, the test/retest correlation for the left was .50 and for the right was .53. SINCA will be revised and retested on another group of children in a subsequent study. Thus, SINCA test/retest shows promise of improvement and correlations will be revisited following test revisions.

GAP also needs more work but on this study it was in part removed due to poor test-retest correlations.

The means for each test and retest were also considered individually. (See Table 13) All groups in Table 13 demonstrated slight improvement on test/retest mean scores except DP. The difference on DP was very slight. Otherwise there appears to be a modest learning effect for all scores, which is not unexpected. A paired t-test on the means for all children (N=19) showed a significant difference where the learning effect appears to be greatest, i.e., at the .05 level for DD and PP and at the .01 level for mSAAT and CS.

Table 13. Test/retest mean scores for the eight subtests administered to 19 children. Bolded items are indicative of slightly lower retest scores. +Paired t-test for all children only. *Indicates sig at $p<0.05$. **Indicates sig at $p<.01$.

TEST	8 – 9 Years (3rd Grade) N=10		10 – 11 Years (5th Grade) N=9		+All Children N=19	
	TEST	RETEST	TEST	RETEST	TEST	RETEST
MSAAT	21.9	26.7	25.1	28.7	23.4	27.6**
SINCA	5.2	4.5	3.7	2.6	4.4	3.6
CS	23.2	25.7	26.6	31.4	24.8	28.4**
DD	74.5	75.9	77.6	90.3	76.0	82.7*
GAP	12.5	9.2	16.1	8.8	14.2	9.0
PP	7.8	8.9	10.6	12.6	9.1	10.6*
DP	**5.8**	**5.2**	10.6	11.8	8.1	8.3
TAP	20.0	20.9	20.3	22.7	20.3	21.7

Means and Standard Deviations (Question 3)

Table 14 represents the mean raw scores and respective SDs for the eight subtests that were administered to the subjects in this study. The information is presented for each individual age category and also for the overall sample where N=119.

Table 14. Mean raw scores and respective SDs for the eight individual subtests administered to 119 children from 8 – 11 years.

TEST (Left/Right Ear)	X & SD	Age 8 N = 23	Age 9 N = 43	Age 10 N = 24	Age 11 N = 29	Total N = 119
1. MSAAT RE	X SD	11.1 2.7	11.3 3.3	12.3 3.4	13.2 2.8	11.9 3.2
MSAAT LE	X SD	10.8 2.7	11.4 2.7	11.9 2.7	12.3 2.5	11.6 2.7
MSAAT	X SD	21.9 4.5	22.7 5.4	24.3 4.9	25.5 4.1	23.5 5.0
2. SINCA RE	X SD	5.3 2.6	**5.8** 3.1	**3.5** 3.1	**3.9** 2.8	4.8 3.1
SINCA LE	X SD	5.6 2.5	4.8 2.3	4.1 2.0	3.8 2.1	4.6 2.3
SINCA	X SD	5.4 2.1	5.3 2.4	**3.8** 2.4	**3.9** 1.8	4.7 2.3
3. CS RE	X SD	11.4 3.2	12.6 4.5	13.9 3.8	14.4 3.9	13.1 4.1
CS LE	X SD	9.8 4.1	12.2 4.1	13.9 4.2	15.0 3.8	12.7 4.4
CS	X SD	21.3 6.6	24.7 7.7	27.8 7.4	29.4 6.8	25.8 7.7
4. DD	X SD	71.7 13.6	72.0 14.6	79.7 17.6	81.6 13.5	75.8 15.3
5. PP	X SD	9.5 5.5	11.1 5.5	13.2 5.7	**11.8** 5.8	11.4 5.9
6. DP	X SD	5.9 4.4	7.6 4.4	11.6 4.8	12.0 4.9	9.2 5.4
7. TAP	X SD	22.2 5.1	**22.0** 5.1	24.9 3.4	**22.1** 5.3	22.6 4.9
8. GAP	X SD	**11.0** 5.2	**12.9** 7.0	**10.1** 3.7	**11.1** **11.0**	11.5 7.4

Means and SDs for mSAAT, CS, DD, and DP all show improvement as expected with increasing age, however, some inconsistencies were found for SINCA, PP, TAP and GAP. Why this occurs is unknown but may be related to an insufficient N or because the tests may not be strongly age dependent. The size of the sample influences both the representativeness of the sample itself and the statistical analysis of the data (Airasian & Gay, p. 134). The researcher, therefore, considering these inconsistencies, collapsed the information into two age groups: 8–9 years and 10–11 years (Table 15). This removed the inconsistencies so that preliminary norms could more reliably be established. With this adjustment, all mean scores are now better for the older children.

Table 15. Mean raw scores and respective SDs for the eight individual subtests administered to 119 children for 8-9 yr and 10-11 yr groups.

TEST (Left/Right Ear)	X & SD	8 - 9 Years (3rd grade) N = 66	10 – 11 Years (5th grade) N = 53	Total N = 119
1. MSAAT RE	X SD	11.2 3.1	12.8 3.1	11.9 3.2
MSAAT LE	X SD	11.2 2.7	12.1 2.6	11.6 2.7
MSAAT	X SD	22.4 5.1	24.9 4.5	23.5 5.0
2. SINCA RE	X SD	5.6 3.0	3.7 2.9	4.8 3.1
SINCA LE	X SD	5.1 2.4	3.9 2.1	4.6 2.3
SINCA	X SD	5.4 2.3	3.8 2.1	4.7 2.3
3. CS RE	X SD	12.2 4.1	14.2 3.8	13.1 4.1
CS LE	X SD	11.4 4.2	14.5 4.0	12.7 4.4
CS	X SD	23.5 7.5	28.7 7.1	25.8 7.7
4. DD	X SD	71.9 14.2	80.7 15.3	75.8 15.3
5. PP N = 47 W/O Rev	X SD	10.6 6.0	12.4 5.7	11.4 5.9
PP N = 72 W/Rev.	X SD	12.0 5.5	13.2 4.9	12.6 5.2
6. DP	X SD	7.0 4.9	11.8 4.8	9.2 5.4
7. TAP	X SD	22.0 5.1	23.3 4.7	22.6 4.9
8. GAP	X SD	12.2 6.4	10.6 8.4	11.5 7.4

Table 16 provides performance standards (norms) based on subject performance one and two SDs below the mean for the current study. Scores for PP and DP were so low that it was impossible to find all 2 SD cutoffs, so means and SDs were calculated for the 72 children for whom reversals were noted while scoring the PP and DP subtests. The problem with PP was resolved with reversals scoring so that all 2 SD cutoffs could be defined. Performance standards with reversals are included in the table for PP, but not for DP, because the small number of reversals for DP did not change the DP cutoff problem. Since DP and GAP will likely be removed from the battery, this DP problem is not a major concern.

Table 17 shows the number of children down more than 1 SD or 2 SD on APD tests based on the current study (Domitz, 1997 & Shiffman, 1999). The table indicates that 48 subjects (40% of the sample) were found to be down more than 1 SD on at least 1 subtest for APD and 14 subjects (11.8% of the sample) were down more than 2 SD based on such a strategy. These were the final calculations after GAP and DP tests were removed from consideration.

Table 16. Performance standards (norms) at 1 and 2 SDs below the mean for the current study.

TEST (Left/Right Ear)	X & SD's	3rd Grade 8–9 Years N = 66	5th Grade 10-11 Years N = 53	Total N = 119
1. MSAAT RE	X	11.2	12.8	11.9
	1 SD	8.1	9.7	8.6
	2 SD	5.0	6.8	5.6
MSAAT LE	X	11.2	12.1	11.6
	1 SD	8.5	9.5	8.9
	2 SD	5.8	7.0	6.1
MSAAT	X	22.4	24.9	23.5
	1 SD	17.4	20.4	18.6
	2 SD	12.3	16.0	13.6
2. SINCA RE	X	5.6	3.7	4.8
	1 SD	8.6	6.7	7.8
	2 SD	11.5	9.6	10.9
SINCA LE	X	5.1	3.9	4.6
	1 SD	7.5	6.0	6.9
	2 SD	9.8	8.0	9.2
SINCA	X	5.4	3.8	4.7
	1 SD	7.6	5.9	7.0
	2 SD	9.9	7.9	9.3
3. CS RE	X	12.2	14.2	13.1
	1 SD	8.1	10.4	9.0
	2 SD	4.0	6.6	4.9
CS LE	X	11.4	14.5	12.7
	1 SD	7.1	10.5	8.4
	2 SD	2.9	6.6	4.0
CS	X	23.5	28.7	25.8
	1 SD	16.0	21.6	18.1
	2 SD	8.6	14.6	10.4
4. DD	X	71.9	80.7	75.8
	1 SD	57.8	65.4	60.6
	2 SD	43.6	50.1	45.3
5.PP (w/o Rev) N = 47	X	10.6	12.4	11.4
	1 SD	4.6	6.7	5.5
	2 SD		1.0	0
5. PP (Reversals) N = 72	X	12.0	13.2	12.6
	1 SD	6.5	8.3	7.4
	2 SD	1.0	3.4	2.2
6. DP	X	7.0	11.8	9.2
	1 SD	2.1	7.0	3.8
	2 SD		2.2	
7. TAP	X	22.0	23.3	22.6
	1 SD	17.0	18.7	17.7
	2 SD	11.9	14.0	12.8
8. GAP	X	12.2	10.6	11.5
	1 SD	18.6	19.0	18.9
	2 SD	25.0	27.4	26.3

Table 17. Number of children down more than 1 SD or 2 SD based on the six subtests (GAP and DP removed) for the current study on at least one subtest.

# of SD	N	% of Sample
1	48	40%
2	14	11.8%

Table 18 is a breakdown that shows the number and percentage of subjects, by age category, who had difficulty with each subtest and scored below 1 or 2 SDs on any given subtest.

Table 18. Number of children by age in years, and percentage of the sample who scored outside the mean by 1 and 2 SDs on each test.

TEST	SD	8–9 Years (3rd Grade) N=66	%	10-11 Years (5th Grade) N=53	%	All Subjects N=119	%
MSAAT	1 2	6 3	9.0 4.5	9 1	17.0 1.9	15 4	26 6.4
SINCA	1 2	8 2	12.1 3.0	6 2	11.3 3.8	14 4	23.4 6.8
CS	1 2	11 0	16.7 0	7 1	13.2 1.9	18 1	29.9 1.9
DD	1 2	11 0	16.7 0	8 1	15.0 1.9	19 1	31.7 1.9
PP	1 2	13	19.7	7 2	13.2 3.8	20 2	16.8 1.7
DP	1 2	15	22.7	11 1	21.0 1.9	26 1	21.8 1.0
TAP	1 2	9 2	13.6 3.0	2 3	3.8 5.7	11 5	17.4 8.7
GAP	1 2	6 1	9.0 1.5	1 1	1.9 1.9	7 2	10.9 3.4

When considering all tasks in their content areas (MSC, BI, and APTO), but after GAP and DP were removed from consideration, the breakdown in Table 19 suggests that all three APD test areas are relatively equal in difficulty.

Table 19. A summary of the total population for this study who scored more than one and two SDs below the mean in the MSC, APTO, and BI/BS content areas of auditory processing. APTO, here, does not include GAP and DP.

CONTENT AREA	SD	N	% of Sample
MSC (MSAAT/SINCA)	1 2	28 6	23.5 5.0
APTO (PP/TAP)	1 2	26 6	21.8 5.0
BI/BS (CS/DD)	1 2	32 2	26.9 2.0

The percentage for both the 1 SD (40%) and 2 SD (11.8%) populations are high. Typically, cut-offs at 1 SD below the mean results in sample percentages of about 16 percent and cut-offs at 2 SDs below the mean result in sample percentages of about 2.5% (Airasian, p. 444). However, in this case, we were considering six subtests in three different APD areas, and so a higher number is expected since different children could have problems only on one of these different tests and increase the overall number identified. If everyone had a problem in all three areas, then 2.5% and 16% cut-off’s might apply, but several have problems in only one area. (See Table 20)

It seems the criteria for 1 SD or 2 SD, considering the above, needs to be adjusted in the case of a multiple battery, even though these current cut-offs are used widely in the field (Chermak, personal communication, March 2003). Whatever the strategy, further testing and consideration of other sources could be considered to confirm the tentative diagnosis and reduce the numbers by requiring multiple areas of difficulty (McFadden, 1996).

The lower-scoring 14 subjects representing 11.8 percent of the sample, who are below 2 SDs in at least one area will be discussed in terms of APD diagnosis. Their severity ranged from affecting one AP area to all three, and were based on 6 different subtests (two in each content area). One or two stars were assigned to represent degree of involvement based on SDs. If the subject scored more than 1 SD below the mean on a given test, 1 star was assigned. Two stars were assigned for those tests whose scores fell more than 2 SDs below the mean. Based on SD cut-offs for one or more tests, it is reasonable to think of APD severity in terms of how many areas are affected and the degree (1 SD or 2 SD) of difficulty.

Table 20 is a representation of the 14 children, the number of areas affected, the severity of the problem represented by stars, and a suggested diagnosis. Four children were affected in one content area, five were affected in two content areas, and five were affected in all three areas. The descriptors *minimal, moderate*, and *serious* APD were assigned based on the number of content areas affected.

Fourteen children (12%) seems to be a reasonable number to identify for this sample, and supports the current battery of six test areas and the mean and SD data as used in Table 16 to identify the 14 children.

Table 20. A representation of the 14 subjects who scored below 2 SD on at least one APD subtest, the number of areas affected and severity level, and a suggested diagnosis. One star was assigned for each of the six subtests whose score was more than one SD below the mean. Two stars were assigned for each subtest whose score was more than two SD below the mean.

Areas Affected	Severity/Stars	N	Diagnosis
1	** (2)	3	Minimal APD (4 cases)
1	*** (3)	1	
2	*** (3)	3	Moderate APD (5 cases)
2	**** (4)	1	
2	****** (6)	1	
3	***** (5)	1	Serious APD (5 cases)
3	****** (6)	3	
3	******* (7)	1	
		N = 14	

Scale of Auditory Behaviors/Co-morbidity (Question 4)

In order to determine the status of the subject’s performance compared to teacher and parent report, the auditory behavior questionnaire was examined. (See Appendix C) This scale is a lickert scale with five choices per item. A response of “1” indicates that the child *frequently* exhibits the behavior. A response of “2” means *often*, “3” means *sometimes*, “4” means *seldom*, and “5” means *never*. The child’s scores are added for a possibility of 60 points which is the best possible score.

Table 21 illustrates the means and SDs found for the scale of auditory behaviors as completed by some, but not all, of the parents and teachers for the current 119 subjects and also for others that were collected for use in a companion study. Approximately 1 or 1.5 SDs (<35 and <30 points), were used to indicate levels of concern. If the self report scales are used to compare with behavioral testing results, there is a way to collate and corroborate all the findings.

Table 21: Mean and SDs for parent and teacher responses to the scale of auditory behavior questionnaires. 1.0 and 1.5 SD are represented and may be considered levels of concern.

	Behavior Scale	
	Parent N = 117	Teacher N = 120
3rd Graders (8 – 9 Years)	X 45.6 SD 9.6	X 43.5 SD 10.7
5th Graders (10 – 11 Years)	X 46.8 SD 11.5	X 47.4 SD 9.6
Total	X 46.1 SD 10.4 Concern 1 35(~1 SD) Concern 1.5 30(~1.5 SD)	X 45.3 SD 10.3 Concern 1 35 (~1 SD) Concern 1.5 30 (~1.5 SD)

Table 22 shows the 14 children diagnosed with APD by severity (minimal, moderate, serious), and the corresponding parent/teacher self-report ratings for those who had a questionnaire available.

Table 22. Shows the 14 children diagnosed with APD by severity (minimal, moderate, serious), gender, and the corresponding parent/teacher self-report ratings. (*) means *at risk*; (**) means *diagnosed*.

Code # Gender (N=14)	APD Severity	Co-morbid Issues	P Score	T Score	Dx
76 (F)	Minimal	No		56	*
87 (F)		LD/Read/Write/Math			**
95 (F)		No	55	58	*
105 (F)		No	**19**	**28**	**
1 (F)	Moderate	No	42	40	*
33 (F)		No	48	48	*
42 (F)		No	53	48	*
91 (F)		No		48	*
129 (F)		No		44	*
3 (M)	Serious	No	54	**34**	**
58 (F)		No			*
65 (F)		LD/Read/Write/Math		**34**	**
74 (F)		LD/Read/Write	**29**	**30**	**
75 (F)		No	60	49	*

Using parent/teacher report of 35 or poorer plus requiring at least 2 SD, then with the 14 most severe cases identified by MAPA, 4 of the children would have been identified (if you count those with co-morbidity issues such as LD, then there are 5). This appears promising. The remaining 9 children chould be considered *at risk* based on MAPA results, but parent/teacher reports suggest no immediate need for treatment.

According to parent/teacher scores alone, 18 other children (with scores at or below 35) were exhibiting auditory difficulties at home or in the classroom. Half of these could be identified if used together with MAPA results, as 9 of these children were among those with test scores on at least one subtest below 1 SD from the mean. An explanation for auditory difficulties for the remaining 9 children will apparently then need to be sought beyond APD as a contributing factor.

There were 12 children [11 LD (1 receiving speech/language services), 1 ADHD] with co-morbidity issues in the sample. Three of these with LD were identified in the group of 14 who scored below 2 SD on MAPA. Five more of the twelve (4 LD, 1 ADHD) were among those in the 1 SD MAPA. The remaining four did not show up in either the 1 SD or 2 SD MAPA groups but 3 were among those in the self-report concern groups. So, only one child of 12 was not picked up in some part of the APD testing, but four do not seem to have auditory issues measurable on MAPA.

The strategy suggested based on this could be to *diagnose* 5 APD cases based on at least 2 SD plus at least one concern level on self report (4) or co-morbidity (1). *At risk* could be assigned for the 9 others who meet the 2 SD on MAPA but do not meet the self-report concern level, or do not have co-morbidity issues (9). *At risk* could also be assigned if self-report is at a concern level and there is at least 1 SD on one or more MAPA scores (9 more).

This would produce, in this sample of 119, 5 with *diagnosis*, 9 more *at risk* based on MAPA of 2 SD and no co-morbidity or self-report issues, and 9 as *at risk* based on MAPA of 1 SD and a self-report concern level. This is a total of 23 *diagnosed* or at risk. Even more could be considered *at risk* if multi-area/multi-star, or co-mormidity plus 1 SD MAPA scores were included.

Table 23 summarizes the different scenarios that have been suggested above for determining an *at risk* or *diagnosis* for APD.

Table 23. A summary of suggested at risk and *diagnosis* scenerios and the breakdown of findings for this study.

	2 SD MAPA	1 SD MAPA	Co-morbid Issues	Self Report	Multi/area, Multi/Star (1 SD/2 SD Combos)
(1)	X		X		
Diagnosis (4)	X			X	
	X		X	X	
(9)	X				
		X	X		
At Risk (9)		X		X	
		X	X	X	
Total 23					X

There are some sobering facts that create some concern about this diagnostic strategy. Of the five diagnosed with APD in this sample; 1 was male, 4 were female. Of the 14 in the 2 SD MAPA group; 1 was male, 13 were female. On the remaining *at risk* group of 9 identified by 1 SD and self report; 6 were male, 3 were female. Of the 23 total then; 7 were male, 16 were female. While the sample contained more females (57%), it is puzzling to consider why so few males were identified given the usual higher prevalence of males experiencing APD as compared to females.

It should be noted that 3 children would have been identified based on GAP or DP and thus may be overlooked when those tests are eliminated. These children are discussed below.

The first child scored 2 SDs below the mean on GAP and had a diagnosis of LD. No parent report was provided but the teacher report score was 35. This child scored below 1 SD on PP and DD, so would have been identified as a child *at risk* since the concern 1 teacher score and 1 SD on MAPA subtests would meet the *at risk* criterion suggested above. The auditory behavior score as completed by the teacher was a good indication of how the child also performed for two of the APD content areas (PP:APTO and DD:BI/BS).

The second child scored 2 SDs below the mean on DP and had a parent report score of 29. This child scored below 1 SD on DD, so also would have been labeled *at risk* based on parent report (concern 1.5) as matched with a 1 SD MAPA subtest result. Again, the auditory behavior score as completed by the parent was a good indication of how the child also performed in one of the three APD content areas (DD:BI/BS).

The third child scored 2 SDs below the mean on DP and had a teacher report score of 56. Given the auditory behavioral scale alone, this child would not have been considered a concern 1 or 1.5. This child did, however, score below 1 SD on both mSAAT and CS in the MSC and BI/BS

APD content areas. Perhaps 2 area/2 star severity children should be considered *at risk* in which this child would not be lost to follow-up even if DP is not retained within MAPA.

Elimination of the three children based on DP and GAP scores alone then, need not result in overlooking a child with APD concerns based on this sample. All three were among those that would show up in a concern group if self-report and 1 SD on a MAPA subtest were to trigger *at risk* and if 2 area/2 star MAPA results also triggered *at risks*.

It is important to note that the need for multi-disciplinary identification/diagnosis has been met in this approach through the use of speech/language and psychological diagnosis (LD/ADHD) and parental and teacher report along with audiological testing. The findings would also need to be confirmed in an IET process within the schools.

Summary and Conclusions

Factor Analysis

The researcher set out to answer several questions regarding the factor structure of the Beta III version of MAPA. To answer these, multiple factor analyses were considered. Of the 4 new subtests, DP and GAP were the least consistent and for them, factor results varied depending on the extraction method and normalization rotation selected. TAP and SINCA consistently factored beautifully within their expected content areas and DD consistently overlapped across areas. The GAP and DP data were removed from consideration and the remaining six subtests were again evaluated. TAP factored and correlated with PP in a favorable way; SINCA factored and correlated favorably with mSAAT; and the existing binaural tests (DD and CS) factored together as predicted.

Correlations

Pearson correlations on the old, revised, and new subtests were run to answer questions among tests and regarding test/retest. Using a criteria of +/- .35, all tests correlated favorably within their respective categories except SINCA left with mSAAT right and GAP against all other temporal areas. These findings regarding GAP supported factor analysis results. While DD showed weightings across categories in factor analysis, correlations with competing sentences in the binaural category were strong. Correlations for DP loaded in all three content areas, similar to the inconsistencies found by factor analysis. Higher correlations than expected were found between CS left and mSAAT left; SINCA right and CS right; and between PP as compared to mSAAT left, CS right, and DD.

The old and new subtests correlated significantly with other tests within their factor content categories except for DP and GAP. Based on all of the above, it is believed that the new Beta III version of the MAPA will emerge as a more comprehensive APD diagnostic tool and will work best if GAP and DP are removed from the battery.

Nineteen subjects underwent a second administration of the test battery. Reliability correlations ranged from high for PP, DP, CS, TAP, DD and MSAAT (overall), moderate for right and left mSAAT when the left and right ears were considered separately, and poor for GAP and SINCA. It was noted that when half of the items were removed from SINCA and doubled, the test/retest correlations show promise of improvement. This will be revisited in a subsequent study.

Mean scores for were slightly higher for all children on all tests except DP for third graders only.

Means and Standard Deviations

When means and SDs were considered by the four age groups; mSAAT, CS, DD and DP all showed improvement as expected with increasing age while SINCA, PP, TAP, and GAP did not. The information was therefore collapsed into two age groups (8 – 9 years and 10 – 1l years). This resolved the inconsistencies. Performance standards were established for all subtests, however, DP and PP scores were too low without counting reversals to establish a 2 SD cut-off in some or all cases. By counting the reversals, this problem was resolved for PP but not for DP and the normative data was changed for PP to include reversals as correct. Since DP will likely be removed from the battery based on factor analysis and correlation results, this problem was not considered a major concern.

Based on test scores after GAP and DP scores were removed, and considering PP reversals as correct, 14 subjects (12% of the sample) met the 2 SD criteria and 48 subjects (40% of the sample) were found to meet 1 SD criteria. Severity ranged from affecting one AP area to affecting all three, and descriptors minimal, moderate, and serious APD severity were assigned based on the number of areas affected.

Mean scores and associated SDs produced reasonable normative data for identifying children with APD in all content areas (except DP) once PP reversals were counted as correct.

Self-Report and Co-morbidity

Comparing parent/teacher report to the 14 most severe cases of APD identified by MAPA, 5 of the 14 children had self-reports or co-morbidity and could be diagnosed with APD and recommended for treatment. Considering the self-report alone, 18 other children were subjectively judged to be exhibiting difficulties at home and/or in the classroom. Nine could be explained with MAPA, as they were among those below 1 SD on MAPA, resulting in a total of 23 either *at risk* or *diagnosed* with APD. (See Table 23) The other nine concerns on self-report apparently do not have APD based on MAPA testing and need to have explanations for their lower parent/teacher scores sought elsewhere.

Regarding co-morbidity, 12 children in the sample had LD (with and without speech/language issues) or ADHD. Three of these were among the 14 with 2 SD on MAPA. Five more of the 12 with co-morbidity issues were among these 9 in the 1 SD MAPA plus self-report group. The remaining four did not show up in either the *at risk* or the *diagnosed* group.

Those with self-report and co-morbidity issues and no MAPA problems probably shouldn't be considered as having APD. Those with 1 SD on MAPA and co-morbidity should perhaps be considered *at risk* but were not a factor in this study, nor were multi-area/multi-star MAPA cases. However, one child identified by DP would be lost to follow-up without a multi-area/multi-star *at risk* group.

In conclusion, it appears that self-report scores and co-morbidity data correspond and compliment the mean and SD data for APD in a reasonably consistent manner. The final conclusions about how we use these various factors for diagnosis will probably require more study.

Appendix A

Review of the Literature

Research Questions

As stated, this study had four questions:

1. Factor Structure:
    a. Do GAP, TAP, or DP subtests factor and correlate with PP in a favorable way?
    b. Does SINCA factor and correlate favorably with mSAAT?
    c. Will the existing binaural tests (DD and CS) factor together as predicted.
2. Correlations:
    a. Using Pearson correlation coefficients, do the old and new subtests correlate significantly enough with other tests within their factor content categories so that the new Beta III version of the MAPA emerges as a more comprehensive central auditory processing diagnostic tool?
    b. Test/Retest: Do subjects demonstrate reliable mean scores (via Pearson r) and non-significantly different mean scores (via t-

test) when comparing initial and a second administration of the battery.

3. Do mean scores and associated standard deviations produce reasonable normative data for identifying children with APD?
4. Do self-report scores and co-morbidity data correspond and compliment mean and standard deviation data in an expected manner?

Research Design

Correlational studies are useful for determining relationships, assessing consistency, and making predictions (Ary et al, 2002, p. 359). In addition, the quantitative nature of correlations provide for objective results that can be more easily interpreted for this type of study, than can be provided by any other research design. The factor analysis procedure is capable of analyzing the intercorrelations among a large set of measures, and also assists in identifying a small number of common factors. Factors can be used to identify content areas within hypothetical constructs assumed to underlie different types of psychological measures; for example intelligence, aptitude, achievement, personality, and attitude. “Factor analysis indicates the extent to which tests or other instruments are measuring the same thing, enabling researchers to deal with a smaller number of [content areas within] constructs.” (p. 365) The construct APD is an abstraction that cannot be observed directly. To measure this, it is broken down into content areas, the subtests proposed, and we identify the scores within these areas on various tests. Airasian and Gay pointed out that “You cannot see a construct, you can only observe its effect” (p. 168),

The literature points out an important conceptual difference between scale-level analysis versus item-level analysis. Scale-level analysis considers a subtest whereas item-level analysis considers the items individually within the subtest. Nunnally (1994) does not support item-level analysis as this leads one to conclude that the set of items being tested are multidimensional when in fact they are unidimensional. (p. 317) Scale-level factor analysis was used in this study and each subtest was considered independently. Correlational research designs best determine the relationships and correlation coefficients between the various tests being expanded in the Beta III version of the MAPA.

Ary, Jacobs, & Razavieh (2002) state that correlational research “investigates the extent to which the variables are related and the direction of the relationship...[so that it] relates two (or more) variable measures from the same group of subjects." (p. 354)

Factor analysis can be used to determine the structure of the entire newly revised Beta III version of the MAPA to help us better make sense of the large number of variables and group them into smaller clusters called factors. From this, we are able to derive factors by finding groups of variables that were highly correlated among each other, but lowly with other variables.

The literature will review the following related content areas: (a) APD definition controversy, (b) prevalence and causes of APD, (c) symptoms and assessment and how the current MAPA compares to expert recommendation, (d) reliability and validity issues, (e) a discussion regarding multi-disciplinary assessment, and (f) the need for more research and the collection of local normative data. Finally, the assumptions, limitations, and delimitations of the study will be outlined.

APD Definition Controversy

The literature in general is in basic agreement, as Schow and Chermak (1999) state that: "Central auditory processing disorders (CAPDs) are among the most challenging disorders facing the school audiologist and other professionals concerned with identification and rehabilitation of auditory disorders.” (p. 137) However, there has been some disagreement as to what constitutes the complete definition of CAPD, now renamed, APD.

In 1996, The American Speech Language Hearing Association (ASHA) task force issued a technical report listing six behaviors that characterize auditory processing, and defined CAPD as a deficiency in any one or more of the following areas:

> Central auditory processes are the auditory system mechanisms and processes responsible for the following behavioral phenomena:
>
> 1. Sound localization and lateralization.
> 2. Auditory discrimination.
> 3. Auditory pattern recognition.
> 4. Temporal aspects of audition, including (a) temporal resolution, (b) temporal masking, (c) temporal integration, and (d) temporal ordering.
> 5. Auditory performance decrements with competing acoustic signals.
> 6. Auditory performance decrements with degraded acoustic signals. (p. 41)

Later, Schow et al (2000) proposed a revision of the ASHA definition based on factor analysis on the MAPA tests they recommended for making an APD diagnosis. They stated:

> Although this [ASHA] definition was specific and useful, the relationship between processing phenomena and test measures was left somewhat unresolved in that only five behavioral auditory procedures were listed to measure the six areas in question. Further, the five auditory measures did not correspond in a simple way to the behavioral processes listed. (p. 63)

They pointed out that ASHA defined six characteristics of APD, but only offered five objective ways to measure these six areas. In addition, based on research data they had collected (Schow & Chermak, 1999; Domitz & Schow, 2000), among the five suggested ways to test for APD, they found that only four tests which were commonly used showed separate factors, and these only represented three of the ASHA areas (temporal, monaural, and binaural areas with localization, discrimination and patterns folded into those three). Schow et al, 2000, proposed a change in names given to the processes and closely synchronized naming of the behavioral auditory test measures.

Measurable behavioral processes:

1. Auditory Pattern/temporal ordering (APTO).

2. Monaural separation/closure (as required in low redundancy listening due to competition or degradation).
3. Binaural separation (directed listening and reporting of one or both ears in a precise order).
4. Binaural integration (non-directed listening and reporting of both ears).

Behavioral auditory test measures:

1. Auditory pattern/temporal ordering (APTO) tasks (e.g., pitch patterns).
2. Monaural separation/closure (MSC) tasks (e.g., SCAN – auditory figure ground, SCAN – filtered word, or monaural Selective Auditory Attention Test mSAAT).
3. Binaural separation (BS) tasks (e.g., competing sentence).
4. Binaural integration (BI) tasks (e.g., dichotic digits). (p. 67)

They noted the possibility of 3 and 4, the two binaural areas being folded into one, because the correlation between these two was a .7 on the MAPA battery.

It is on the basis of this definition, and upon these recommended auditory test measures, that the current study will base its findings with the two binaural areas folded into one. It should be noted that those within ASHA have not revised the characteristics of what constitutes an APD nor changed the recommendations for testing, but the Schow et al. recommendation has not been challenged by them either. A task force is currently in place to make a new statement and an official at ASHA reported recently to Schow that terms suggested within the Schow et al. document are being used in the new AHSA statement (personal communication, 2003).

In 2000, a group of 14 senior scientists and clinicians held a conference in Dallas, to reach a consensus regarding APD issues (Chermak, 2001, p.10). In support of a change, but criticizing the fact that there were few in attendance who actually worked with APD children on a daily basis, Katz et al. (2002) issued the following statement: “We recommend that another consensus conference be developed, that includes educational audiologists as well as researchers and clinicians from related professions who assess/treat children with APD every day in schools and clinics.” (p. 17)

Central Auditory Processing Disorder (CAPD) is now known in the field as Auditory Processing Disorder (APD). The new acronym, APD, emphasizes the interaction of disorders at both the peripheral and central sites along the auditory pathway (Jerger & Musiek, 2000, p.468), rather than central deficits exclusively. Auditory processing is commonly referred to as what we do with what we hear (Katz, 1992), but it is not a label for one specific condition. Rather, it is a description for a heterogeneous group of functional deficits (ASHA, 1996, p.41) in areas that are not modality specific, such as with attention, learning, motivation, and decision making processes that often coexist with APD. Among the most common co-morbid diagnoses associated with APD are Learning Disability and Attention Deficit Hyperactivity Disorder (Chermak, 2001, p.12).

Diagnosis is important in case problems need to be (1) treated medically, (2) for awareness reasons that may have an influence on the improvement of attitudes, (3) to improve student performance (academic planning), (4) to reduce the tendency to shop around for treatments that may not work, (5) to reduce fear/stress effects, etc. (Schow, personal communication, 2002).

Prevalence/Causes of APD

The prevalence of APD in children has been estimated to be as low as two to three percent, with a 2:1 ratio between boys and girls (Chermak & Musiek, 1997, p.22). It may even be as high as ten to twenty percent according to some reports for older adults (Cooper & Gates, 1991) and based on Domitz and Schow’s data in school children (1997).

The cause is speculative but the majority of cases are thought to be neuromorphologic, meaning the result of underdeveloped or misplaced cells in the left cerebral hemisphere and the auditory region of the corpus collosum (the area connecting the left and right hemispheres of the brain). Other possible causes are thought to be due to such things as delayed maturation of the central auditory nervous system (CANS), neurologic disorders, trauma, and neuro-degenerative diseases (Musiek, Gollegly, & Ross, 1985, p.253). Musiek has suggested classifying APD into three categories: delayed, disordered, and specfic site of lesion. According to Domitz and Schow (2000), there are three main categories for people with APD: neurologic, delayed maturation of the CNS, and developmental anomalies.

Symptoms/Assessment/MAPA

Individuals with APD characteristically have difficulty comprehending spoken language in competing noise, may frequently ask for repetitions of words or sentences, have trouble paying attention, may misunderstand messages, and/or find it difficult to localize sound (Chermak & Musiek, 1997, p.3). Further, they may present with related deficits in auditory memory, phonologic awareness, reading, and academic achievement (Jerger & Musiek, 2000, p.468).

Since APD patients share a number of behavior patterns in varying degrees, diagnostic tools must have the ability to assess a variety of problems manifested by the disorder so that appropriate diagnostic testing can be recommended and intervention strategies implemented if necessary. One of the most commonly used tools for measuring APD is the SCAN, and more lately the SCAN-A for adolescents/adults and the new version of SCAN, called the SCAN-C. Various versions of SCAN are the most comprehensive, fully normed, specifically designed and most used tool currently being used in the audiology profession (Keith, 1986).

However, in 1995, Chermak et al. found that the Selective Auditory Attention Test (SAAT) identified a larger number of children than SCAN as being at risk for APD, and claimed that it had better agreement with parental report than SCAN. (p.30)

Jerger and Musiek (2000), reporting on the Bruton Conference, suggested that a gap-detection task in which a short silent gap inserted in a burst of broad-band noise, should be included in a direct screening test procedure. (p. 469) In response to this statement, however, an

American Academy of Audiology (2002) statement said that, “despite the importance placed on the gap detection test, we found no broadband noise procedure to be commercially available” (p. 17). Jerger and Musiek also suggest that a duration pattern sequencing task be part of the minimal test battery. (p. 471) Further, they point out that “Gap detection samples temporal processing, a key dimension of speech processing” (p. 469).

Recently, Chermak, also a participant at the Bruton Conference, summarized Bruton and recommended an APD behavioral test battery that includes:

> “at least one measure from each of the following categories: (1) temporal processing (e.g., pitch duration pattern perception, gap detection); (2) binaural integration (e.g., dichotic listening for digits, words, or sentences); and (3) monaural low-redundancy speech recognition (e.g., filtered or compressed speech, speech in competition” (Chermak 2001, p.16).

The previous Beta II version of the MAPA included the following behavioral tests: a temporal processing subtest (pitch patterns), two binaural subtests (dichotic digits and competing sentences), and a monaural low-redundancy speech recognition subtest (mSAAT). The current study is designed to determine if four additional tests found within MAPA Beta III will factor favorably in the same three categories as the existing tests.

Bellis (2002) suggests that children with a known diagnosis of attention deficit/hyperactivity disorder AD/HD should be required to be receiving medical treatment and have their symptoms under control to be included in the study. “Significant cognitive, language, or related difficulties such as those that occur with mental retardation, autism, AD/HD, or other disorders may indicate that an APD evaluation is not necessary or cannot be performed” (p. 166).

Others do not agree with Bellis and simply note the co-morbidity and the need to track other conditions if they exist along with APD (Domitz & Schow, 2000).

Reliability/Validity

Why have more than one test within each content area? First, multiple test options will be valuable for children needing follow-up from time to time. It would not matter if ‘test learning’ takes place since an alternate test that factors under the same category (eg. pitch patterns test and gap detection could be used and still be testing the same area equivalently). Also useful and valuable are equivalent forms A and B of the same subtest. This is being explored in a companion study. In addition, multiple tests could be used as a verification measure against the other, if the child does not do well on one particular subtest, another test could be used to validate the results. If a child has particular difficulty recognizing or identifying the differences between high and low pitches, it may be that describing the difference between long and short tones, or long and short periods of time, is less daunting. Either of these tests would be an acceptable alternative if they factor favorably within the same factor as the current pitch pattern test. Furthermore, failing two tests in one area will be a stronger diagnostic finding than failing only one.

Multi-disciplinary Assessment

The literature emphasizes that APD is “not a label for a unitary disease entity, but rather a description of functional deficits” (Chermak, 2001, p. 10). Further, Silman et al (2000) states that: “All auditory tasks, from pure-tone perception to spoken language processing, are influenced by higher-level, non-modality-specific factors such as attention, learning, motivation, and decision processes.” (p. 57)

This complicates the diagnosis of APD, and recommendations are provided throughout the literature regarding the importance of multi-disciplinary assessment before a diagnosis is made. Chermak (2001) states:

> Multidisciplinary assessment and comprehensive intervention are necessary for APD given the overlapping symptomatology across these diverse clinical populations and the range of listening and learning deficits associated with APD…comprehensive assessment is necessary for the accurate differential diagnosis of APD from other look-alike disorders, most notably ADHD and language processing disorders. (p. 12)

Bellis (2002), another APD specialist, explains the importance of early identification and how an accurate diagnosis of APD is essential in determining what the appropriate treatment should be. (p. 163) She further documents case after case of how appropriate and early intervention has proven to have significant effects on academic performance. Providing the opportunity for reliable results across multiple subtests will certainly be helpful if the subtests themselves are valid and factor favorably. This study will determine if this is so.

Need for Research and Local Normative Data

Musiek et al. (1982) strongly recommended that norms for APD testing be collected in “your own area” (pp. 251-257). Then Jerger and Musiek (2002) further agreed that:

> One way to decide whether an individual is not normal on a particular dimension is to compare his/her performance with the range of performance of “normal” persons…normative data allow(s) you to make the not unreasonable assumption that the test scores will be normally distributed, to compute the SD, and to set a fail criterion at some outcome score which encompasses a large portion of the distribution. (p. 20) Two SDs is the bottom of the distribution often used as fail criteria (Domitz & Schow, 2000).

The current study will establish normative data for the MAPA on children between eight and eleven years of age in local elementary schools from third to fifth grade. This is in response to ASHA’s (1996) acknowledgement of the need for more research to clarify a number of unresolved theoretical issues and clinical practice questions regarding APD. Two in particular are stated as follows:

1. Develop minimal test batteries of physiological and behavioral measures necessary and sufficient

for identification and assessment of central auditory processing disorders.

2. Establish guidelines for the identification of children at risk for central auditory processing disorders. (p. 50)

Assumptions

For the purpose of this study, the researcher has assumed the following:

1. That children in fifth grade (ages ten and eleven years) will perform better as compared to children in the third grade (ages eight and nine years). The MAPA test is thought to be age-specific, and has not been used to produce tentative norms for children under eight years of age.
2. That the changes made to the current design and scoring of the mSAAT test, the dichotic digits test, and the pitch patterns test to make them slightly more difficult because of an existing ceiling effect, will not have a significant effect on test outcomes and factor structure for children in the third and fifth grade.

3. That the Beta III version of the MAPA is indeed valid as prior testing on Beta I and Beta II suggest.
4. That the Bruton definition for APD, and guidelines for behavioral tests in three areas as summarized by Chermak (2002) are accurate and complete.
5. That APD can be thoroughly and confidently measured using behavioral tests that are monaural, binaural, and temporal ordering tasks such as those provided on the MAPA.

Limitations of the Study

For purposes of this study, the researcher acknowledges the following limitations:

1. Test administration will take longer than it normally would, and fatigue may be a factor for some children.
2. Time of day may influence performance. Teacher cooperation is unknown and time availability may be limited.

3. Children who do not pass tonal hearing screenings will be eliminated from participating further in the testing.
4. Children in third and fifth grade classrooms will be selected based on the socioeconomic diversity of the schools chosen and will be tested without consideration given to factors such as academic performance or teacher recommendation.
5. Conditions may not be ideal, however, every attempt will be made to provide a quiet environment suitable for testing.

Delimitations of the Study

The delimitations of this study are based on the confined range and population of children who will be tested.

1. The population is restricted to a limited number of third and fifth grade elementary classrooms in Idaho.
2. Not all schools in Idaho will be represented.
3. Private schools will be excluded from the study.

Appendix B

Idaho State University
Human Subjects Committee

Informed Consent Form for Non-Medical Research

PARENTAL CONSENT TO PARTICIPATE IN RESEARCH

Auditory Processing Testing

Child's Name ______________________ Code # __________

Your child is invited to participate in a research project sponsored by the Audiology Program at Idaho State University. Your child has been asked to participate in this research because of his/her age and grade level in school. Several hundred students in Washington, Utah and Idaho are being asked to participate in this study. Your child's participation in this research project is voluntary. Please read the information below before signing the consent form.

1. **PURPOSE OF THE STUDY**
The purpose of this study is to gather normative data for an auditory processing test. Auditory processing helps us understand the information we hear. Central auditory processing disorder (APD) refers to an impairment of this auditory ability. The test that is being developed is the revised Multiple Auditory Processing Assessment (MAPA). When the test is marketed there may be some modest monetary benefit to the researchers, but the benefit to children who have APD is what motivates this project.

2. **PROCEDURES**
If you agree to your child's participation in this study, he/she would be asked to do the following things:

1.Have hearing screened using tones.
2.Have middle ear pressure and function checked.
3.Have the inner ear screened for appropriate function.
4.Take the auditory exam, Beta III MAPA.

The entire process should take approximately 35 minutes and will not be repeated except for a few volunteers who will take the test twice to check the reliability of the testing instrument. Some students will take the auditory exam in two sessions with both sessions about 30 minutes.

3. **POTENTIAL RISKS AND DISCOMFORTS**
The testing will take place during the school day. If you choose to allow your child to participate, he/she will be missing possible instruction time in the classroom. However, every effort will be made to accommodate your child and your child's teacher. In addition, the school district audiologist/special educator will need to consult your child's cumulative file and teacher for information regarding other conditions which may be confused with or complicate the interpretation of auditory findings. The research procedures should involve nothing more strenuous than repeating a few words and numbers and thus will involve minimal risks.

4. **ANTICIPATED BENEFITS TO SUBJECTS**
If your child exhibits difficulty with central auditory processing tasks, he/she will be referred to the school audiologist who will be able to provide support and information for you and your child.

You have the right to refuse participation in this research study and so does your child.

5. **ANTICIPATED BENEFITS TO SOCIETY**
Children who have an auditory processing disorder may struggle with academic performance and exhibit inappropriate social behaviors. Some of these children withdraw socially and may have diminished self-esteem. In the classroom, these children may "act out", have difficulty in groups, struggle with reading,

spelling, and speech sounds, or they may appear to be daydreaming through class. All of these behaviors impact academic and social development. For this reason, it is important to have valid testing measures.

7. **PAYMENT FOR PARTICIPATION**
You or your child will not be paid for participation in the study except for a small gift which will be awarded after they return the permission form and complete the test. Participation is strictly voluntary.

8. **FINANCIAL OBLIGATIONS**
You will not be billed for any of the procedures involved in the research project.

10. **PRIVACY AND CONFIDENTIALITY**
The only people who will know of the results of the testing data will be members of the research team and the school audiologist. No information about your child, or provided by your child during the research, will be disclosed to others without your written permission. When the results of the research are published or discussed in conferences, no information will be included that would reveal your child's identity. Each test will be coded to ensure confidentiality for your child.

11. **PARTICIPATION AND WITHDRAWAL**
Your child's participation in this research is VOLUNTARY. Your child will be asked to assent to the test procedures before any testing is done. If you choose not to allow your child to participate, that will not affect your relationship with Idaho State University, or your right to receive services (for you or your child) at Idaho State University to which you are otherwise entitled. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without prejudice to your future at Idaho State University. If you have any questions, please call the project supervisor, Dr. Ronald Schow, at 282-3495.

15. **RIGHTS OF RESEARCH SUBJECTS**
You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have any questions regarding your rights as a research subject, you may contact the Human Subjects Committee office at 282- 3811 or by writing to the Human Subjects Committee at Idaho State University, Box 8116.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE
I have read (or someone has read to me) the information provided above.

BY SIGNING THIS FORM, I WILLINGLY AGREE TO ALLOW MY CHILD TO PARTICIPATE IN THE RESEARCH IT DESCRIBES.

____ ____________
Signature of Research Subject (or parent of subject) Date

Check here if you do not want the school audiologist to receive this information.

Appendix C

SCALE OF AUDITORY BEHAVIORS

Please rate each item by circling a number that best fits the behavior of the child you are rating. At the top of the column of numbers there is a term indicating the frequency with which the behavior is observed. Please consider these terms carefully when rating each possible behavior. A child may or may not display one or more of these behaviors. A high or low rating in one or more of the areas does not indicate any particular pattern. If you are undecided about the rating of an item, use your best judgment.

Name:_________________________ Age:_____ Grade:_____ Today's date:_____________

Teacher:_________________________ School: ________________ Score: ______________
(Informant)

Freq	Often	Sometimes	Seldom	Never	ITEMS
1	2	3	4	5	Difficulty hearing or understanding in background noise
1	2	3	4	5	Misunderstands, especially with rapid or muffled speech
1	2	3	4	5	Difficulty following oral instructions
1	2	3	4	5	Difficulty in discriminating and identifying speech sounds
1	2	3	4	5	Inconsistent responses to auditory information
1	2	3	4	5	Poor listening skills
1	2	3	4	5	Asks for things to be repeated
1	2	3	4	5	Easily distracted
1	2	3	4	5	Learning or academic difficulties
1	2	3	4	5	Short attention span
1	2	3	4	5	Daydreams, inattentive
1	2	3	4	5	Disorganized

Appendix D

Letter to Schools Requesting Permission to Test

March 14, 2003

To: Participating elementary schools

We are graduate students in Audiology at ISU. We would like to give you some preliminary information about what we hope to do and how the school children will be involved.

Background and Purpose

The purpose of our study is to gather normative data for an auditory processing test. Auditory processing helps us understand the information we hear. Auditory processing disorders (APDs) are not disorders of the organs of hearing. Rather, they are impairments of how the brain processes auditory information. Children who have an auditory processing disorder may struggle with academic performance and exhibit inappropriate social behaviors. Some of these children withdraw socially and may have diminished self-esteem. In the classroom, these children may “act out”, have difficulty in groups, struggle with reading, spelling, and speech sounds, or they may appear to be daydreaming through class. All of these behaviors impact academic and social development. For this reason, it is important to have valid testing measures to identify these children.

The governing body for audiologists, the American Speech Language Hearing Association (ASHA), has suggested guidelines for screening and evaluating (APDs). Currently there is not a standard testing tool that meets all of the guidelines and is accepted by all professionals in the field of audiology. In 1997, Domitz and Schow, from ISU, conducted a study using the Pocatello schools to research and compile a number of subtests into one test battery. This test was named the Multiple Auditory Processing Assessment (MAPA). The MAPA attempts to incorporate more of the guidelines than any other single test used at this time. The MAPA was found to be a valid tool for screening APD; however, a ceiling effect was occurring on several of the subtests. These subtests were too easy for many of the older children. Recently, the MAPA has been revised. It is now more difficult and includes another form (There is a form A and B now.). We also have additional tests that we would like to incorporate into the MAPA battery that are believed to test the areas suggested by the ASHA guidelines according to current literature.

Project 1 (Laurie Conlin) is to establish equivalency between forms A and B of the revised MAPA. The research questions to be answered are as follows: Will the two forms be equivalent? Will the revised tests eliminate the ceiling effect while retaining their validity?

Project 2 (Sherry Summers) is to determine if newly proposed subtests correlate favorably with the existing MAPA subtests.

Method

Approximately 200 children ages 8-12 will be asked to participate in this study. We will test students in the third and fifth grades from Idaho elementary schools. The school audiologist supports this project.

The children in the study will not be paid for participation except for a small gift which will be awarded after they return the permission form and complete the test. The children will be asked to do the following thkngs.

1. Have hearing screened using tones.
2. Have middle ear pressure and function checked.
3. Have the inner ear screened for appropriate function.
4. Take the auditory exam, Beta III MAPA.

The entire process should take approximately 35 minutes and will not be repeated except for a few volunteers who will take the test twice to check the reliability of the testing instrument. Some students will take the auditory exam in two sessions with both sessions about 30 minutes.

We would like to begin as soon as possible and have testing complete before April 14. This time frame is convenient for the school district audiologist who lends her support to the project.

If you have any questions and would like to meet with us, we can be reached by email or telephone. During the day, we are generally at the audiology building on campus and a message can be left with the secretary at 282-3495. Our major professor, Dr. Ron Schow can also be reached at this number.

Sincerely,

Laurie Conlin
478-4518
laurieconlin@yahoo.com

Sherry Summers
232-6734
scottandsherry@eudoramail.com

Appendix E

MAPA Beta III—Form A

Date ________ Date of Birth ___________ Age _______ Gender _____ Child's code # _________

Handed _______ Comments ____ Examiner _______________

	500	1000	2000	4000	OAE	Pressure	Volume	Compliance
Right								
Left								

instructions (3)

mSAAT NC-R (4)

please	_______
great	_______
sled	_______
pants	_______
rat	_______
TOTAL	_______

mSAAT NC-L (5)

bad	_______
such	_______
need	_______
five	_______
rag	_______
TOTAL	_______

instructions (6)

mSAAT-C-R (7)

school	_______
ball	_______
smoke	_______
floor	_______
fox	_______
hat	_______
pan	_______
bread	_______
neck	_______
stair	_______
eye	_______
knee	_______
street	_______
wing	_______
mouse	_______
shirt	_______
gun	_______
bus	_______
train	_______
arm	_______
chick	_______
crib	_______
wheel	_______
straw	_______
pail	_______
TOTAL	_____/25

instructions (8)

mSAAT-C-L (9)

broom	_______
bowl	_______
coat	_______
door	_______
socks	_______
flag	_______
fan	_______
red	_______
desk	_______
bear	_______
pie	_______
tea	_______
meat	_______
string	_______
clown	_______
church	_______
thumb	_______
rug	_______
cake	_______
barn	_______
stick	_______
ship	_______
seal	_______
dog	_______
nail	_______
TOTAL	_____/25

instructions (10)

PP-binaural (11)

LHHH	_______
HHLL	_______
LHLL	_______
HHLH	_______
HHHL	_______
LHHL	_______
HLLL	_______
LLLH	_______
HLHH	_______
LLHH	_______
HLHL	_______
LHLH	_______
HLLH	_______
LLHL	_______
HHHL	_______
LLLH	_______
HLHH	_______
HHLL	_______
HHLH	_______
LHHH	_______
TOTAL	_____/20

instructions (12)

DD-binaural (13)

Right	Left		
352	186	____	_____
418	625	____	_____
219	548	____	_____
254	631	____	_____
548	263	____	_____
419	326	____	_____
381	694	____	_____
296	138	____	_____
961	483	____	_____
924	581	____	_____

Directed left ear first (14)

Left	Right		
253	869	____	_____
849	526	____	_____
912	845	____	_____
352	146	____	_____
815	392	____	_____
914	653	____	_____
194	632	____	_____
562	839	____	_____
946	128	____	_____
429	685	____	_____

Total ______/120 any order
Total ______/60 right first
Total ______/60 left first

instructions (15)

CS-Right first (16) Circle L or R of correct sentences

1. R The caboose is always last.
   L This is a long freight train.
2. R Recess is my favorite time.
   L I don't like to go to school either.
3. R Put gas in the tank.
   L My car is very fast.
4. R I do not like to eat dinner alone.
   L They say candy is bad for your teeth.
5. R That scratch may get infected.
   L Put a clean bandage on that cut.
6. R I saw it when it was a play.
   L That movie was on TV.
7. R There are lions and tigers in the zoo
   L I saw lots of different kinds of animals
8. R Don't forget your father's birthday.
   L My sister has a new boyfriend.
9. R I had to take a nap.
   L He is only resting.
10. R He's off for Easter week.
    L I had a wonderful Christmas.
11. R Visit your grandmother on Sunday.
    L Make sure you call your brother this week
12. R Summer is finally here.
    L The sun is finally shining.
13. R Did your boss give you a raise?
    L Do you have to take many business trips?
14. R Goldfish are easy to keep.
    L That dog likes to run.
15. R He doesn't like his new boss.
    L Make sure you get to work on time.

Total _______/30

Note: sentences must be exact to be scored as correct.

MAPA Beta III—Form A continued
instructions (17) circle L or R of correct sentences

CS-Left ear first (18)

1.	L	It was a long ride by car.
	R	I thought we would never get there.
2.	L	He went to the South on his vacation.
	R	I get two weeks off in the summer.
3.	L	Make sure you deposit that check.
	R	I need to borrow five dollars.
4.	L	I put the letter in the mailbox.
	R	You must write to her more often.
5.	L	He drank all of the milk.
	R	I like my coffee black.
6.	L	When did your dog get sick?
	R	Do you want to buy that cute puppy?
7.	L	He was very late to class yesterday.
	R	I went to the cafeteria at noon.
8.	L	The airplane flew very low.
	R	The jet took off smoothly.
9.	L	I have the best teacher in school.
	R	He was a student here before me.
10.	L	I saw the funny clown.
	R	The circus was very good.
11.	L	What's your address?
	R	They bought a new house.
12.	L	I never saw a bear.
	R	Cats have whiskers.
13.	L	How many of your brothers live at home?
	R	How long have your parents been married?
14.	L	She has a fever.
	R	See your doctor.
15.	L	How much snow fell?
	R	Has it started raining?
16.	L	Don't play your radio that loud.
	R	Their last song was a big hit.

Total _______/32 Total______/30 w/o 16
Note: the sentences must be exact to be scored as correct

instructions (21)
SINCA circle all words correctly repeated

Right (22)

+20	dish	teach	pinch	pink	_______
+16	bead	bath	tree	shop	_______
+12	five	rat	mouth	box	_______
+8	fed	such	need	hunt	_______
+4	ride	class	hit	scab	_______
+0	great	smile	pond	sled	_______

TOTAL # right _____/24
Score 22 – TOTAL # right= _______SNR

Total # right (excluding +20 words) _____/20
Score 18 – Total # right= _______ SNR

instructions (23)
Left (24)

+20	hot	please	few	cart	_______
+16	bad	pants	slip	law	_______
+12	ways	thank	fold	bus	_______
+8	slice	rag	put	did	_______
+4	take	beef	neck	suit	_______
+0	turn	darn	laugh	clamp	_______

TOTAL # right _____/24
Score 22 – TOTAL # right= _______SNR

Total # right (excluding +20 words) ______/20
Score 18 – Total # right= _______ SNR

Instructions (19)
DP-binaural (20)

LSSS	_______
SSLL	_______
LSLL	_______
SSLS	_______
SSSL	_______
LSSL	_______
SLLL	_______
LLLS	_______
SLSS	_______
LLSS	_______
SLSL	_______
LSLS	_______
SLLS	_______
LLSL	_______
SSSL	_______
LLLS	_______
SLSS	_______
SSLL	_______
SSLS	_______
LSSS	_______
Total	_______/20

instructions (25)
Gap Detection test (26)
practice __ __
items __ __ __ __ __ __ __ __ __
5 10 40 15 20 2 30 0 25

lowest msec gap detected (i.e. lowest number w/2) ___

instructions (27)
Tap test (28-29)
1. _______ practice
2. _______ practice
3. _______
4. _______
5. _______

prompt with "think back and tell me how many you heard" if they answer with anything other than a number

Total for 3, 4, 5 _______/30

Appendix F

Brief Description of Each Test

Monaural selective auditory attention test: This test, SAAT, was a binaural test developed by Cherry in 1980. The test requires the individual to listen for the primary stimulus (words selected from the Word Intelligibility by Picture Identification or WIPI list) which is embedded in competing background noise. The earlier MAPAs (Beta I and II) and the current revision of the MAPA (Beta III) uses a monaural version of this test with both the stimulus and the competing noise presented to the same ear. Thus, in these test batteries, the test is referred to as mSAAT.

Pitch patterns: This test, PP, was introduced by Pinhiero in 1977. It randomly introduces high and low pitches in a three-tone series which the subject is asked to identify. Although it is becoming more common to allow the subject to hum, sing, or manually point up and down for their responses, for the purposes of this study, the subjects were instructed to verbalize. Several children, however, chose to sing their responses or point (high/low) in conjunction with their verbalizations for a multi-mode response, and this was not discouraged. In addition, because this test has been prone to the ceiling effect (Shiffman, 1999 & Neijenhuis, 2000), a four-tone sequence was used. Reversals were scored as incorrect for N=47 (G. Chermak, personal communication, March 6, 2003 & Musiek et al, 1982), but as correct for N=72 because scores were too low to obtain two SD cut-offs. Norms are provided separately.

Dichotic digits: The DD test was introduced by Musiek in 1983. Four numbers are usually simultaneously presented to the listener, two in each ear. The subject is required to repeat all four numbers aloud. A more difficult version of the DD test was used for this study in which number triplets are presented to each ear as has been done by other researchers (Neijenhuis, 2000). The subject is requested to repeat items from the right ear first, then from the left, as recommended by Moncrieff and Musiek (2002). We scored three ways for this study, all involving binaural type scoring; right ear/left ear/and total scores but did not score ears separately as done on MAPA Beta I and II. There was no penalty for within ear order reversals on right and left or for order at all on the total scoring. Data were entered for the total number correct.

Competing Sentences: The Willeford Competing Sentences Test (CS), introduced in 1985, presents two sentences, one to the right ear and one to the left ear, concurrently. It was designed to assess the maturation of the auditory systems and identify delays in maturation or damage to the central auditory pathways. In the earlier MAPA, the subject only repeated the left or right ear sentences as directed. In his early work on competing sentences, Willeford mentioned the possibility of testing the patients’ ability to repeat both sentences. He said that in this case, both sentences should be presented at the same testing level of 50 dB HL (Willeford, within Katz text). The current study instructed the subject to repeat both sentences. They were directed to repeat either the right or the left ear first (personal communication, Chermak, 2002). Sentences had to be repeated exactly to be considered, except for what appeared to be true articulation errors. Although recall was directed to one ear first, the subjects were not penalized if they reversed the order of the sentences as they repeated them.

Duration patterns: This test randomly introduces short and long tones binaurally in a four-tone series. The subject is instructed to repeat back the series in the order that the tones were presented. This task is believed to be an APTO task similar to the high/low PP task. Reversals were scored as incorrect in this study (G. Chermak, personal communication).

Speech in Noise for Children and Adults test: The test requires the individual to listen for the primary stimulus (words selected from the Word Intelligibility by Picture Identification or WIPI list) which is embedded in competing background noise. The signal to noise ratio reduces more and more until the target and competing signals are presented at the same levels. A signal to noise ratio is computed for the subject based on the number of words scored correctly.

Gap detection: The purpose of the Random Gap Detection Test (RGDT), according to Robert W. Keith (2001) is to identify temporal disorders of the auditory system related to phonologic processing deficits, problems of auditory discrimination, receptive language and reading. The RGDT is designed to measure temporal resolution through determination of the smallest time interval (in msec) between two closely approximated stimuli. The listener attends to a series of stimuli presented in pairs while the silent interval between each pair changes in duration. The listener reports whether the stimulus heard was one tone, or two. The gap detection threshold is the stimulus interval at which the stimuli are heard as two rather than one. The RGDT is a revision of the Auditory Fusion Test-Revised (AFT-R) (McCroskey and Keith, 1996). The RGDT is viewed as a test of temporal integrity at the level of the cortex.

The RGDT involves a number of smaller tests involving multiple frequencies where the gap thresholds are averaged. Our study considered only the final subtest, the click stimuli of 230 uSec duration followed by inter-stimulus intervals of 0 to 40 msec that are presented in random order. The stimulus pairs are recorded with a 4.5 second interval to allow for subject response. The clicks were derived from a one msec. compression (positive) section of white noise. The stimuli were adjusted employing Samplitude Cakewalk software on a Compaq computer at the studios of *AUDiTEC*™ of St. Louis (Keith, 2001).

The gap detection threshold is defined as the gap interval at which the subject consistently identifies two tones at a specific inter-pulse interval. The random GAP test was scored by determining the lowest millisecond at which the subject was able to detect a tonal gap. This method yielded inconsistencies for some children, so all tests were re-scored to require that the child show two consistent responses at the area closest to threshold. A normal gap detection threshold for both tones and clicks is considered to be between 2 and 20 msec, however, no normative data have been reported for click gap thresholds to date (Keith, 2001).

Tap test: The QuickTap test was suggested by Charles I. Berlin, Ph. D. This test is thought to test gap detection, pattern recognition and working memory in one quick step. A series of tapping sounds are presented with one every 120-150 msec. After each of three series of taps are presented, the listener is instructed to think back and describe what they heard. The total of the test taps added amounts to thirty. For this study, the subject received a raw score based on the sum of their three responses.

Appendix G

Acronym Key

AAA:	American Audiology Association
APD:	Auditory Processing Disorder
APTO:	Auditory pattern/temporal ordering
ASHA:	American Speech Language and Hearing Association
BI:	Binaural Integration
BS:	Binaural Separation
CAPD:	Central Auditory Processing Disorder
CS:	Competing Sentences
DD:	Dichotic Digits
DP:	Duration Patterns
GDP:	Gap Detection Perception
MAPA:	Multiple Auditory Processing Assessment
MSAAT:	Monaural Version of Selective Auditory Attention Test
MSC:	Monaural Separation Closure
PP:	Pitch Patterns
TAP:	QuickTap Test as suggested by Charles I. Berlin, Ph.D.

Appendix H

A Bonus on Handedness

Although this section does not pertain to the research questions of this study, part-way through the data collection process the researcher began collecting data on handedness. Out of 89 children for whom this information was obtained, 79 were right-handed (89% of the sample) and 10 were left-handed (11% of the sample).

The following table shows the mean APTO scores for left vs. right-handers. It was found, that there was a trend for left-handers (N=10) to score slightly better in all temporal areas than right-handers (N=79). The information reported here is not related to the research questions of this study, however, it may be useful for future studies or for general information.

Mean APTO scores for left vs. right handers.

Temporal Tasks APTO	Right- Handers N=79	Left-Handers N=10
PP	11.1	14.3
DP	9.7	11.1
TAP	22.9	24.1
GAP	12.2	7.7

Appendix I

Raw Data

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