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Reliability, validity and acceptability of modified response formats of APD instruments for children using AAC

Allison Cara Soll
Washington University School of Medicine in St. Louis

Reliability, Validity and Acceptability of Modified Response Formats of APD Instruments for Children using AAC

by

Allison Cara Soll

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Approved by:
Kimberly Ott, M.S., CCC-A, Capstone Project Advisor
Krista Davidson, M.S., CCC-SLP, Second Reader

Abstract: A pilot study consisting of a parent questionnaire, four APD tests and an acceptability questionnaire were presented to normal hearing and cognitively developing children between the ages of 8-12 years. Responses to a standard and modified response format of the APD tests were obtained over two test sessions. Results indicated that the modified response formats of the four APD tests were acceptable, fairly reliable and three out of the four APD tests were valid.

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ABBREVIATIONS

AAC	Augmentative and Alternative Communication
ADD	Attention Deficit Disorder
ADHD	Attention Deficit Hyperactivity Disorder
APD	Auditory Processing Disorder
ASD	Autism Spectrum Disorder
CANS	Central Auditory Nervous System
CAPD	Central Auditory Processing Disorder
CD	Compact Disc
CNS	Central Nervous System
dB	Decibel
DDT	Dichotic Digits Test
DPT	Duration Pattern Test
GSI	Grason-Stadler, Inc.
HL	Hearing Level
Hz	Hertz
L	Left
MLD	Masking Level Difference
R	Right
SAAT	Selective Auditory Attention Test
SNR	Signal to Noise Ratio
VT	Ventriculoperitoneal
WNL	Within Normal Limits

INTRODUCTION

Auditory Processing Disorder (APD) also referred to as Central Auditory Processing Disorder (CAPD) has been defined in numerous ways (Bellis, T.J., 1996; Bellis, T.J. and Ferre J.M., 1999; Katz, J., Medwetsky, L. Burkard, R., Hood, L., 2009; Musiek, F.E., Chermak, G.D., 2007). The American Speech Language Hearing Association along with other professional groups believe there are two views of APD. The first view is based upon studies of subjects who have known lesions of the central auditory nervous system, which provide the procedural and theoretical "gold standard" for the diagnosis and management of APDs; thus, classifying an APD as a neurological disorder. The second view is that APD ought to be understood in reference to basic auditory processes using the bottom-up physiology and psychology of hearing in response to simple sounds, for example; tones and broadband noise (Moore, D.R. 2011).

Chermak and Musiek estimated the prevalence of CAPD in children in 1997. Their estimation revealed that 2%-3% of children have CAPD and of those children a 2:1 ratio was found comparing boys to girls. These children who have an APD may be easily inundated by auditory overload and may suffer greatly in the classroom. Some factors that may contribute to this overload are:

> "brevity of signal or signal components, fast rate of speaking, rapid presentation rate of new information, increased phonetic complexity (ex. consonant clusters, unstressed syllables, multiple syllables), increased acoustic/phonetic similarity among signals (ex. rhythm words, phonetically similar syllables), decreased word familiarity, increased length of decontextualized material, poor listening conditions (ex. background noise, distance from speaker, reverberation), temporal distortions (ex. time, rate), increased specificity of expected response, increasing task uncertainty (ex. open response sets) and demand for verbatim retention or recall" (Sloan, C. 1998; Freil-Patti, S. 1995).

These examples of auditory overload are very important to understand when providing support for a child in the educational settings. The key in determining the needs of these children is the APD assessment battery. The APD test battery gives audiologists and the management team the tools to determine the areas in which these children have difficulty; in order to create goals and treatment plans to help the child to be successful inside and outside the classroom. The APD test battery may vary; however, instruments used should include a low-pass filtered speech test, a dichotic speech test, a temporal pattern test and other tests (e.g. binaural fusion test, masking level difference test and rapid alternating speech tests) (Katz et al., 2009).

The four APD test instruments included in this study are the Dichotic Digits Test (DDT), the Duration Pattern Test (DPT), the Masking Level Difference Test (MLD) and the Selective Auditory Attention Test (SAAT). All of these tests evaluate the Central Auditory Nervous System (CANS). The DDT is a test that is included under the category of binaural integration. Binaural integration is the "ability to properly respond to all competing signals directed to both ears" (Katz et al., 2009). Musiek, F.E. (1983) conducted a study using the DDT to develop normative data for subjects with normal hearing sensitivity (45 subjects ages 19-35), subjects with cochlear hearing loss (21 subjects with a mean age of 46.7 years) and subjects with Central Nervous System (CNS) lesions (21 subjects with mean age of 42.3 years). The results for the normal hearing subjects were analyzed statistically. A score of 90% or higher was considered to be within normal limits. Scores below 90% were considered abnormal. Results were considered to be within normal limits for subjects with cochlear hearing loss who received a score of 80% or greater (Musiek, 1983).

The DPT is a test that is included under the area of temporal processing. Temporal processing is defined as the "time-related aspects of an acoustic signal" (Bellis, T.J. 1996).

Musiek, F.E., Baran, J.A., Pinheiro, M.L., (1990) utilized the duration pattern recognition test to assess normal hearing subjects (50 subjects with mean age of 22.4 years), subjects with cochlear hearing loss (24 subjects with mean age of 48.1 years) and subjects with lesions involving but not limited to the auditory areas of the cerebrum (21 subjects with mean age of 33.3 years). The results of the tests were analyzed statistically. A score of greater than 70% was considered to be within normal limits (Musiek et al., 1990).

The MLD is an assessment that is included under the umbrella of binaural interaction tests as well as sound localization and lateralization. Sound localization and lateralization is the "ability to describe the location of a stimuli in relation to the position of one's head" (Katz et al., 2009). Wilson, R.H., Moncrieff, D.W., Townsend, E.A., Pillion, A.L., (2003) performed a study using the 500 Hz MLD to create a test protocol that could be easily administered in the clinic using an audio compact disc. Three tests were administered to 24-28 normal hearing listeners. The results indicated that the SpNo MLDs (signal p radians out-of-phase at the ears and noise in-phase at the ears) were ≥10dB for 95% of the listeners. These results created the norms for a 500 Hz MLD test (Wilson et al., 2003).

The SAAT is an assessment that evaluates an individual's ability to listen in noise. The test was created for use by various professions to identify those children who have selective auditory attention deficits that may hinder their academic achievement (Cherry, R.S., 1980). Three hundred and twenty one subjects between the ages of 55-107 months were tested to create norms for this instrument. The findings indicated that if a child scored below 88%, the child experienced greater than expected difficulty hearing in the presence of background noise (Cherry, 1980).

At this time all test instruments used for APD assessments require a verbal response from the test subject. This creates difficulty when testing children who are non-verbal. Many children who are non-verbal use Augmentative and Alternative Communication (AAC). Augmentative and Alternative Communication is a reference to a combination of technology and alternate response methods created to supplement spoken communication for people with limited language skills or speech (Wilkinson, K.M. and Hennig, S., 2007). Some populations of people who use AAC include those who have cerebral palsy, autism or intellectual impairments. Some examples of AAC include communication books and speech generating devices in which the person points or uses eye gaze to select the word or phrase they want to express. Currently, no known test instruments for APDs have been created for use with children who use AAC. Studies evaluating the use of AAC devices have accepted the test results of typically developing children. These results reveal the anticipated cognitive processing demands while restricting confounding variables related to physical and intellectual disabilities (Higginbotham, D.J., 1995). Higginbotham (1995) also recommended using typically developing children to study AAC devices to decrease the imposition on subjects with disabilities' energy and time while the important dimensions of research are attained.

Many AAC studies have been conducted on typically developing children. However, specific research has not been conducted on the topic of APDs for children who use AAC. Although research hasn't been performed on this specific population, some of the research that has been completed is important when examining AAC device usage for children who have APDs. For example, Smith, J.L, McCarthy, J.W. and Benigno, J.P. (2009) researched the effects of a high-tech AAC device on the duration and frequency of joint attention in infants without disabilities. Another study was conducted by Dropik, P.L. and Reichle, J., (2008) and examined

the relative skills of young children when participating in directed and group item scanning. These studies can be useful in determining how long a child may take when responding to certain stimuli.

Other research has been conducted by Thistle, J.J. and Wilkinson, K. (2009) and examined the variation in reaction time of finding a line drawing when the background was colored as opposed to color drawn inside the picture. This study is important to note that when choosing symbols, children identify more quickly with drawings that have the inside colored as opposed to color in the background. An additional study by Fitzgerald, M.M., Sposato, B., Politano, P., Hetling, J. and O'Neill, W. (2009) compared the speed and accuracy of messages constructed using three infrared head-controlled mouse emulators on an AAC device in three different light conditions. This study is beneficial when testing children to make certain the lighting in the room is ideal for the best performance of the AAC user. The purpose of the current study is to use AAC to test children for an APD, which may take into account some of the goals of past and present research on AAC but creates a different rationale (focus of eye gaze for testing children, creation of test plates based on color cues and response time in different lighting conditions) (Fitzgerald et al., 2009).

Children who use AAC are unable to be screened or tested for APDs because there are no standardized assessment tools that allow for responses to be offered via an AAC system. Many teachers and therapists who write and implement goals and objectives for these students need assessment information, particularly in the area of communication, to develop appropriate goals and treatment plans for their students. This pilot study will investigate a means to assess children who use AAC who may have an APD.

METHODS

Participants

Fifteen subjects were recruited from the Volunteers for Health registry with advertisements, email blasts, flyers and Facebook posts. Letters and flyers were used to recruit from the Belleville Area Special Services Cooperative in Belleville, IL (BASSC), Washington University School of Medicine Pediatric physician's offices, Central Institute for the Deaf and the Washington University School of Medicine listserv. Inclusion criteria required subjects to be between the ages of 8-12 years of age with normal hearing sensitivity, at least average cognitive function, and age appropriate overall development. Exclusion criteria included subjects who were outside the age range of 8-12 years, or who did not have normal hearing sensitivity bilaterally (both ears). Subjects who were not developing typically according to developmental norms, did not have at least average cognitive function, or were suspected of having APD were not included in this study. This research study was approved by Washington University School of Medicine Institutional Review Board.

Methods

Each subject and his/her parents were given the informed consent agreement to review and sign before the test session began. Once the subject agreed to participate in the study, otoscopy was performed bilaterally to make sure cerumen was not blocking the ear canal. A hearing screening and APD testing were administered in a single walled soundproof booth. Each subject wore Telephonics TDH-50P circumaural headphones to hear the stimuli. A hearing screening using a Grason-Stadler, Inc. (GSI) 61 audiometer was administered at 20 dB HL from 250Hz-8000Hz to ensure that each subject had normal peripheral hearing. Tympanometry was

performed to ensure the subject's middle ears were functioning normally using the GSI-33 Module Ear Analyzer. Both the audiometer and the tympanometer were calibrated on July 19, 2011. The CD player that was used to present the stimuli via an audio compact disc was a Sony CDP-591.

While these screenings were conducted, a closed set questionnaire was given to the parents of the potential test subject to make certain the child was not suspected of having an APD or other learning disabilities. The questionnaire was compiled from three different questionnaires from familyeducation.com, Raviv Practice London AP Questionnaire and wvsha.org. This questionnaire consisted of seventeen questions (See Appendix A). The use of this questionnaire helped to identify factors that may have influenced the validity and reliability of subjects responses therefore disqualifying them as test candidates.

Each subject that passed the hearing screening, otoscopy, tympanometry and parent questionnaire was assigned into one of two groups – the Standard Response Group or the Modified Response group. The two groups were matched for age and gender. Eight subjects, who were referred to as the standard group, underwent the APD test battery using the standard response format, and approximately one to two weeks later the subjects took the same test battery using the modified version response format. Seven subjects, who were referred to as the modified group, took the version of the test instrument with the modified response format two times, approximately two weeks apart. This provided data for statistical analysis of reliability and validity. The tests were spaced one week to two weeks apart to ensure that the subject did not recollect the stimuli included in the tests.

The subjects in the **Standard Response Group**, were asked to complete the following tests which lasted approximately 30 minutes altogether:

Dichotic Digits Test (DDT) – This test was recorded by the Veterans Affairs (VA) Medical Center. The DDT used was a single pairs test. This is a test in which the subject heard two numbers (1-10) at the same time, one in each ear. Before the test was performed each test session, the test CD was calibrated to the audiometer. This test was administered at 50 dB HL. The subject was asked to repeat both numbers that he/she heard, to be counted as correct. The subject was presented with 20 pairs.

Duration Pattern Test (DPT) – This test was recorded by the VA Medical Center. Before the test was performed each test session, the test CD was calibrated to the audiometer. The DPT was presented to the subject monaurally. The subject heard three tones, two tones of one duration and one tone of another duration (eg. Long Short Long, Long Short Short, Short Short Long.) The short duration was 250 msec, the long duration was 500 msec, and the interstimulus interval was 200msec. The tones were presented at 50 dB HL at 1000Hz. The subject was asked to respond by saying the order in which the tones were presented. Each ear was presented with 30 patterns of stimuli. The pattern was marked correct if the subject repeated the order accurately.

Masking Level Difference Test (MLD) – This test was recorded by Auditec of St. Louis, MO. This test was presented to test subjects as a series of short noise bursts in one ear that lasts for 3 seconds, while the other ear received a 500 Hz tone burst. The tone bursts were intermittent. The noise bursts varied in phase. The noise bursts and tones were presented at 50 dB HL. Before the test was performed each test session the test CD

was calibrated to the audiometer. The subject had to indicate whether or not he/she heard the 500Hz tone. Thirty-three stimuli were presented to the subject. The stimulus was counted correct if the subject stated he/she heard the 500Hz tone when it was actually presented.

Selective Auditory Attention Test (SAAT) – This test was recorded by Auditec of St. Louis, MO. This test contained monosyllabic words that were phonemically similar. The monosyllabic words were presented at 50 dB HL through the speaker with background noise consisting of a semantic distracter, presented at 0 dB SNR through the same speaker. The SAAT CD was calibrated in the soundfield to ensure the presentation level was at 50 dB HL with the background noise presented at 0 dB SNR. The subject was asked to point to the correct symbol of the word he/she heard from a set of six choices. The symbol pages were created by Mayer Johnson's Boardmaker program and consisted of colored symbols that matched the monosyllabic words that were being presented. The six words were phonemically similar, which made the test difficult for the test subject to identify which symbol was correct. Fifty items were presented for this test.

If the subject was in the **Modified Response Group**, he/she completed the above listed tests in approximately 30 minutes. The subject listened to the recordings and provided responses by pointing to the symbols (pictures), which the subject thought represented the correct answer. For all of these tests the subject was encouraged to take a guess if he/she were unsure of the correct answer. The subject was asked to turn the pages themselves, according to the test that was being administered. The subject wore circumaural headphones, and the presentation levels and the scoring methods were the same as for the standard response. The difference between the two test groups was the standard response group's test required verbal response; whereas the

modified response group's test provided for non-verbal responses by allowing the subject to point to the correct picture.

The modified response symbol pages were designed using Mayer Johnson's Boardmaker. Boardmaker is a design program that assists in making and adapting curriculum and communication material for students who need symbols (www.mayer-johnson.com). For the purpose of this capstone, the colored pictures were printed on white paper and the subject pointed to what he/she believed was the correct symbol. Responses for the four tests were on the Boardmaker symbol pages as follows (Appendix B-E): Each response for the question in the DDT was represented by numbers 1-10 (See Appendix B). The DPT responses were represented symbolically with pictures of one short bar with the word short above the bar and one long bar with the word long above the bar. The other eight boxes were left blank for consistency with the layout of the other symbol pages in the battery (See Appendix C). The MLD test response page consisted of 10 boxes with one box designated for "yes" and another for "no." The other 8 boxes were left blank to be consistent with the layout of the other test response pages in the battery (See Appendix D). The SAAT responses were represented by 6 symbols on a page per test item. The other 4 boxes were left blank for consistency with the layout of the other test pages in the battery (See Appendix E).

The last item of the test session was the administration of a questionnaire, which was given to all children who used the modified test response format. The questionnaire was composed of six questions written by the principal investigator. The questions explored the acceptability of the modified response format (See Appendix F). The principal investigator questioned the subjects and recorded their answers. The subject was told he/she could skip any question if the subject preferred not to answer it.

All subjects returned for a second test session to take the modified response format of the APD test battery approximately one to two weeks later. This provided data to determine validity and reliability of the test battery.

RESULTS

Six females and two males participated in the "standard response group," their ages ranged from 8-11 years (mean of 10 years old). Six females and one male participated in the "modified response group" and their ages ranged from 9-11 years (mean of 9.7 years old) (Table 1). Only four subjects from the "modified response group" participated in the second test session due to scheduling. The results from subjects 1105-1107 were used in determining the parent questionnaire, validity of the tests, reliability of the tests and acceptability questionnaire. The data for subjects 1105-1107 did not contribute to the trends for normalizing the four APD tests.

Otoscopic examination results (Table 2) revealed that subject 0003 had non-occluding cerumen in her left ear canal; otherwise all other subjects' ear canals were clear of cerumen. The subjects' audiometric screening results were within normal limits bilaterally. Tympanometric results revealed normal middle ear movement bilaterally except for subject 1104 who presented with a hypercompliant tympanogram for her right ear.

The results of the parent questionnaire (Table 3) revealed that subject 1103 had ADHD or ADD and took 1mg of Intuniv the day of testing. No other parents indicated their children had a learning disability, an anxiety disorder, a bipolar disorder, Aspergers Syndrome, dyslexia, a hearing impairment, an Autism Spectrum Disorder (ASD) or a cognitive impairment. Subject 0002 took 25 mg of Benadryl daily for allergies, subject 0004 took Motrin daily and an Epipen as needed for allergic reactions, and subject 0005 took a Multivitamins daily.

Subject 1104 was in occupational, physical and developmental therapy before the age of three. Subject 1104 has an Individualized Education Plan (IEP) for a speech articulation disorder, specifically for the /r/ sound. All subjects were enrolled in grades 3rd through 6th at

public or private schools. All subjects received grades between A+'s-C's. None of the children previously received phonological awareness training. Subject 1104's performance in school excelled in the past two years, therefore she was placed into an all gifted program. No other subjects' school performance had changed in the past two years. Subject 1103 received reading intervention services when he was in first and second grade, however no other subjects received reading intervention. All subjects read at or above grade level (Table 3).

Table 4 specifically reveals the results from the parent questionnaire question #13. The parents responded to situations in which their children had difficulty.

All subjects' primary language used in the home was English. Subject 0005 spoke Filipino (Tagalog) and subject 1102 spoke French as well as English. Subject 0003 and 1104 both had middle ear infections and were treated with pressure equalizing (PE) tubes as toddlers. No other subjects exhibited a history of middle ear infections.

Statistical Analysis Software (SAS) was utilized to analyze the subjects' data from the standardized and modified response formats of the four APD tests. Table 6 shows the Pearson Correlation used to determine the reliability of the subjects' responses between the first and second test session of each subject. The Pearson Correlation is a number between -1 and 1 that measures the degree of association between two variables. Results revealed a correlation of 0.522 for the Dichotic Digits (DD) test with a confidence interval of 0.0621 to 0.982. The confidence interval for the Duration Pattern Test (DPT) for the right ear was 0.741 to 1.000 and a correlation of 0.88. The correlation for the Duration Pattern Test (DPT) for the left ear was 0.821 and had a confidence interval of 0.698 to 0.944. The confidence interval for the Masking Level Difference (MLD) test was 0.357 to 0.966 and the correlation was 0.662. The correlation

for the Selective Auditory Attention Test (SAAT) was 0.735 and the confidence interval was 0.450 to 1.000. These results reveal that the DPT for the right ear was the most reliable with the MLD revealing the least reliable results. It is important to note that these test results were not considered 100% reliable due to the fact that they did not obtain a Pearson correlation of 1.0.

The next set of the subjects' data was analyzed using a t-test to determine the mean by comparing the modified response group's results to the standard response group's results. A t-test evaluates whether the means of two groups are statistically different from each other, thus determining the validity of the tests. The results were considered statistically significant if the p-value was less than .05, which meant that the test was not valid. Table 7 displays the results from the DD test. The mean of the modified response group was 19.786 and the standard response group's mean was 19.813, revealing an insignificant p-value of 0.866. The modified response group's mean for the DPT for the right ear was 16.357 and the mean for the standard response group was 23.375, producing a significant p-value of 0.003. The DPT for the left ear's modified response group's mean was 14.714 and the standard response group's mean was 20.938, resulting in a significant p-value of 0.002. The MLD mean value for the modified response group was 9.143 and the mean for the standard response group was 9.000, revealing an insignificant p-value of 0.91. The modified response group for the SAAT had a mean of 38.357 and the standard response group's mean for the SAAT was 39.563, which resulted in an insignificant p-value of 0.519.

The trend for the normative data was analyzed by averaging the modified response data from the 12 subjects. The results were subjectively analyzed due to the small number of subjects. Results for the DD test revealed a mean of 19.92 with a standard deviation of +/-.29 will be considered normal. Results for the DPT R revealed a mean of 21.55 with a standard

deviation of +/- 4.70 will be considered normal. . Results for the DPT L revealed a mean of 19.7 with a standard deviation of +/- 5.63 will be considered normal. Results for the MLD test revealed a mean of 8.83 with a standard deviation of +/- 2 will be considered normal. Results for the SAAT test revealed a mean of 40.08 with a standard deviation of +/-2.64 (74%) will be considered normal.

Subjects 1105, 1106 and 1107 did not return for the second test session. According to the newly established trends for the normative data, all subjects were within the normal range for the dichotic digits test receiving either 19 or 20 correct. For the duration pattern test for the right ear, subjects 1102,1103,1105,1106 and 1107 received scores below average (17) for the first test session. Subjects 1102 and 1103 also scored below average (17) for the second test session for the DPT for the right ear. Results for the duration pattern test for the left ear revealed that subjects 1103, 1104 and 1107 received scores below average (14). The subjects that received scores below average (14) for the second test session for the DPT for the left ear were 1102, 1103 and 1104. The subjects that received a score of less than 6 dB MLD for the first test session of the masking level difference test were 0005. The second test session's results for the MLD resulted in all subjects scoring within the normal range of 6 dB MLD or greater. Subjects 0003, 1102, 1103 and 1106 received scores below average (less than 74%) for the SAAT for the first test session. The results for the second test session for the SAAT revealed that subjects 1102 scored below average (less than 74%).

The results from the acceptability questionnaire interviews revealed that 11 subjects recognized all of the pictures (symbols). Thirteen subjects felt the pictures (symbols) appropriately matched the words. Thirteen subjects thought they had enough time to respond to the questions. Three subjects felt the DPT was confusing, one subject thought the MLD test was

confusing and three subjects believed the SAAT was confusing. Fourteen subjects did not find it difficult to turn the pages. One subject commented that the SAAT was difficult because they could not hear the word while the man was telling the story.

DISCUSSION

The parent questionnaire was a useful tool for identifying information about the test subjects. It was difficult to determine if the peculiarities the parents noted were due to age, personality, situation or attention. It could not be concluded from the parent questionnaire whether or not their children may have an APD. It is also important to understand that typical children display a variety of differences.

The results for the trends of the APD tests used in this test battery would not have been an accurate comparison to the norms that were referenced in the introduction by Musiek (1983), Musiek et al. (1990), Wilson et al. (2003) and Cherry (1980) due to age differences. These subjects displayed difficulty with the APD tests, which appeared evident in the results. Some subjects were below the average range on each test. All of these children are considered to have at least average cognitive function and typical development; however, it is important to note that they still displayed difficulty with a few of these APD tests. This might be due to misunderstanding of the instructions, time allotted to respond to the stimuli, or attention to the task.

The trend for the results from the Pearson correlation indicated that the APD tests were not reliable from one test session to another. This could be due to having compared the standardized response format test and the modified response format from the first test session to the modified response format test from the second test session. Also, the unreliability could be due to the time difference the test sessions were conducted, the subject's understanding of the tasks, the subject's attention during the test session, and time allotted for each response.

The trend of the results of the t-tests for the DD test, the MLD test and the SAAT did not yield significant results at the p=.05 level, meaning that the tests were valid. These results show that the modified response format group's results were comparable to the standard response format group's results. Thus, the modified response format for the three tests (DD, MLD and SAAT) could be an assessment tool for children who use AAC in determining an APD.

The trend for the results of the DPT for the right ear and DPT for the left ear yielded significant results when comparing the modified response group's results to the standard response group's results at the p=.05 level. Some reasons for this could be that the ages of the subjects in the modified response group were slightly younger than those in the standard response group. Duration pattern testing is a temporal processing test, specifically temporal ordering. It is very important in the perception of speech. Four things affect temporal ordering ability: the amount of training, how the sequences are presented (continuously or simultaneously), the number of stimuli and the task the subject must perform (Shinn, J.B. 2003). The standard response format for the DPT required verbal responses however, the child had to point to the correct responses for the modified response format test. This may have caused greater difficulty in the process of responding because instead of not only repeating what the subject heard, they had to remember the pattern, look on a page and point to a symbol with the word above it, which they believed was correct. This may have diverted the subject's attention and changed their responses unknowingly. Due to the trend in results that yielded significance at the level of .05 for the DPT test for the right and left ears, the DPT may not be a valid test to include in the modified APD test battery.

The acceptability questionnaire was supportive in determining if the subjects were able to understand the symbols, turn the pages and understand the testing. It appeared that subjects

0005, 1103, 1105 and 1106 found that some pictures were difficult to identify. Unfortunately, Boardmaker had limited options for the (symbol) pictures that could be utilized. Subjects 1105 and 1106 felt that not all the pictures appropriately matched the words. Again this was a limitation of using Boardmaker in order to create the symbol (picture) pages. Subjects 0004 and 0005 believed they did not have enough time to answer the questions. Unfortunately, the timing in between each stimuli could not be adjusted. It may be possible to pause in between each stimuli for future testing. Some subjects found certain sections confusing, which could attribute to poorer scores for the sections they did not fully understand. The only test that provided sample test stimuli was the Dichotic Digits test. It would be important to create additional sample test stimuli for the other three tests for future testing. Specifically, subject 1103 explained that it was difficult to hear the words during the gentleman's story for the SAAT test. Subject 0007 mentioned that it was slightly difficult to remember to turn the pages. The results from the acceptability questionnaire interview provided valuable insight regarding the ability of children who use AAC to understand the symbols and words in order for them to take the modified response format of the APD tests.

Research is greatly lacking in the area of assessment for children with potential Auditory Processing Disorders who use Augmentative and Alternative Communication. The goal of this pilot study was to determine if it was possible to create a modified response format for an Auditory Processing Test battery in order for children who use AAC to be tested for APD. The outcome of this study demonstrated that it would be feasible to create a response method for children who use AAC to be tested for APD, which would aid in determining treatment plans and goals for children who use AAC. Once the parents and therapists of these children are aware an APD exists, the parents will be motivated to access remedies for their child such as: learning

about their children's APD, helping the child learn about their APD in order to become a self-advocate, helping the child learn to develop into an active participant, gaining cooperation and support from the child's teacher in order to implement the classroom management recommendation created by the child's management team, using Frequency Modulated (FM) assistive listening devices, practicing auditory training exercises, environmental modifications, and management strategies (Florida State Department of Education, 2001).

Limitations

Many limitations appeared throughout this study. Due to the lack of research on APDs in the pediatric population who use AAC, the current study was considered a pilot study. Subject recruitment was difficult due to the fact that there was no funding to compensate the subjects for their time and travel. The study design could have been organized differently by providing the subject with both the standard response format and the modified response format in random order. Analysis of the data was limited due to the small number of subjects that participated in this study. Therefore, the trends for normalizing the data had to be analyzed subjectively. Children who use AAC were difficult to recruit because many of these children do not have normal cognitive function and developmental abilities. This leads to difficulty when testing children for APD because it is not possible to determine if the test results are due to an APD or if they are a result of the child's impaired cognitive abilities or developmental delays.

CASE STUDY

J.M., a 10 year old boy, was born at 37 ½ weeks gestation weighing 7 pounds 3 ounces with spina bifida, Arnold Chiari malformation and a seizure disorder. He had three spinal cord surgeries, three brain surgeries, a ventriculoperitoneal (VT) shunt from the right side of his brain to his peritoneal cavity and surgery for screw placement in his knees. He is primarily nonverbal, but can say "yes, "no," "mom, "dad," his brothers names "matt" and "Bobo" for Brandon, the name of his former aid at school "Ho" and "home." He also uses basic ASL to communicate. He attends Wolf Branch Elementary School in IL. He is placed in regular education and attends a resource class. Cognitive testing was conducted in February of 2011 using the Cognitive Assessment System by Riverside Publishing and results indicated that J.M. had low average intelligence. He wears glasses, uses a wheel chair, uses a walker and has leg braces. He receives the following services at school: speech therapy, occupational therapy, physical therapy and augmentative and alternative communication therapy. He also receives American Sign Language (ASL) instruction to assist in communication.

Prior to testing, J.M.'s mother signed an informed consent form, which explained the study. Otoscopy, tympanometry and an audiometric screening were conducted. His ear canals were clear and his tympanic membranes were visible. Tympanometry was conducted using a GSI-33 Module Ear Analyzer revealed normal middle eardrum movement bilaterally. The audiometric screening was performed using a Grason-Stadler, Inc. (GSI) 61 audiometer and revealed hearing within normal limits at 25 dBHL from 250 Hz-8000 Hz. His mother reported that J.M.'s hearing had been tested at his doctor's office on an annual basis and he has not exhibited any hearing loss previously.

J.M. was tested in a single walled soundproof booth. He wore ER3A insert earphones to hear the stimuli. The four APD tests that were presented were the Dichotic Digits test, the Duration Pattern test, the Masking Level Difference Test and the Selective Auditory Attention Test. His mother accompanied him in the booth and was able to turn the pages for each of the APD tests. J.M. responded to the stimuli by pointing to the correct symbol on a symbol page, which was created using Boardmaker software. J.M. uses the Vantage from Prentke Romich Company everyday at school and occasionally at home.

J.M. was capable of pointing to the correct picture on the symbol page. Before each test was performed, J.M. was given 3-5 practice trials to ensure that he understood the task. He was re-instructed before the test was presented and said "yes" when asked if he understood what to do.

J.M. scored a 1 out of 20 on the Dichotic Digits test, which is below average. He scored a 12 and 11 on the Duration Pattern Test for the right and left ears respectively, which is below average. He scored 0 dB MLD on the MLD, which is below the mean of 6 dB MLD. J.M. scored a 78% on the SAAT, which is considered within the normal range.

J.M. did not display any difficulty when pointing to the pictures on the symbol pages. This suggests that children who use AAC will be able to respond using the modified response format of the APD tests. Unfortunately, it was difficult to interpret the results of the modified response format for the APD tests because J.M. seemed to understand the testing and how to respond yet his results suggested he may not have fully understood what was asked of him. The results may also have indicated that he may have an APD. Another reason for his poor performance on the modified response format for the APD tests may be related to other causes. Because J.M. is a child who is multiply involved, it is difficult to isolate the source of his below

average performance on the tests for APD. The goal of the modified response format of the APD tests was to create a battery in which children who use AAC could be assessed. The results will provide professionals with evidence to facilitate the treatment of children who may have an APD, coexist with other impairments.

CONCLUSIONS

The results of the parent questionnaire concluded that all children have some peculiarity and individual differences within the range of normal. The four APD tests were found to be an unreliable measure from the first test session compared to the second test session. The DD test, the MLD test and the SAAT were found to be reliable tests to administer utilizing the modified response format of the APD tests. The modified response format was an acceptable APD test battery to examine patients for APD based on the responses from the acceptability questionnaire interview and the case study. The modified response format of the APD test battery created for this pilot study appeared to be an acceptable, valid and fairly reliable assessment tool for children who use AAC.

Currently, more research needs to be obtained in order to test subjects who use AAC for APD. Future studies are necessary to test a large population to create norms for the modified response format of this APD test battery. Also, it would be vital for future studies to expand the test battery to include additional tests. Further research should include testing a larger number of subjects who use AAC in order to conclude if the testing can be completed and strictly analyzed for determining whether or not an APD exists.

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TABLES

Table 1. Subject Information		
Subject ID	Subject Age	Subject Gender
0001	11	Female
0002	11	Female
0003	11	Female
0004	11	Male
0005	9	Female
0006	8	Female
0007	10	Male
0008	9	Female
1101	11	Female
1102	9	Female
1103	9	Male
1104	9	Female
1105	11	Female
1106	9	Female
1106	10	Female
AAC	10	Male

Table 1 shows the subject ID, age and gender.

Table 2. Otoscopic, Tympanometric and Audiometric Data							
Subject ID	Subject Age	Oto Right	Oto Left	Tymp Right	Tymp Left	Aud Right	Aud Left
0001	11	Clear	Clear	WNL	WNL	WNL	WNL
0002	11	Clear	Clear	WNL	WNL	WNL	WNL
0003	11	Clear	Cerumen	WNL	WNL	WNL	WNL
0004	11	Clear	Clear	WNL	WNL	WNL	WNL
0005	9	Clear	Clear	WNL	WNL	WNL	WNL
0006	8	Clear	Clear	WNL	WNL	WNL	WNL
0007	10	Clear	Clear	WNL	WNL	WNL	WNL
0008	9	Clear	Clear	WNL	WNL	WNL	WNL
1101	11	Clear	Clear	WNL	WNL	WNL	WNL
1102	9	Clear	Clear	WNL	WNL	WNL	WNL
1103	9	Clear	Clear	WNL	WNL	WNL	WNL
1104	9	Clear	Clear	Hypercompliant	WNL	WNL	WNL
1105	11	Clear	Clear	WNL	WNL	WNL	WNL
1106	9	Clear	Clear	WNL	WNL	WNL	WNL
1106	10	Clear	Clear	WNL	WNL	WNL	WNL
AAC	10	Clear	Clear	WNL	WNL	25	25

Table 2 displays the subject ID, age and results for Otoscopy, Tympanometry and Audiometry.

Table 3. Parent Questionnaire Data																
Subject ID	Subject Age	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 14	Q 15	Q 16
0001	11	None	None	N/A	No	Holy Infant/5th	A+	No	No	No	No	No	7th grade	English	No	No
0002	11	None	25 mg of Benadryl	Yes	No	St. Louis Charter School/ 5th	A	No	No	No	No	No	>5th grade	English	No	No
0003	11	None	None	N/A	No	St. Stephen Protomartyr	A	No	No	No	No	No	Yes	English	No	Yes, PE Tubes
0004	11	None	Motrin, Epipen	No	No	MRHE/5th	A's and B's	No	No	No	No	No	>5th grade	English	No	No
0005	9	None	Multivitamins	Yes	No	Assumption School/3rd	A	No	No	No	No	No	Yes	English	Filipino	No
0006	8	None	None	N/A	No	St. Joan of Arc/ 2nd	B	No	No	No	No	No	4th grade	English	No	No
0007	10	None	None	N/A	No	St. Joan of Arc/ 6th	B	No	No	No	No	No	Yes	English	No	No
0008	9	None	None	N/A	No	Suppington Elementary/3rd	A	No	No	No	No	No	Yes	English	No	No
1101	11	None	None	N/A	No	Holy Infant/5th	A	No	No	No	No	No	Yes	English	No	No
1102	9	None	None	N/A	No	St. Louis Language Immersion/ 3rd	Above Average	No	No	No	No	No	Yes	English	French	No
1103	9	ADD/ADHD	1 mg of Intuniv	Yes	No	Willow Brook Elementary/4th	Good	No	No	1st and 2nd grade	No	No	Yes	English	No	No
1104	9	None	None	N/A	OT, PT, DT before 3 yo, ST	Pierremont Elementary/3rd	Above Average	No	All gifted program	No	Speech artic for "r" sound	Speech	>3rd grade	English	No	Meds/PE Tubes
1105	11	None	None	N/A	No	River Bend Elementary/6th	B's and C's	No	No	No	No	No	Yes	English	No	No
1106	9	None	None	N/A	No	Ross Elementary/3rd	B's and C's	No	No	No	No	No	Yes	English	No	No
1107	10	None	None	N/A	No	Armstrong Elementary 4th	B's and C's	No	No	No	No	No	Yes	English	No	No

Table 3 includes the subject ID, age and responses to questions 1-16 not including #13 on the parent questionnaire (located in Appendix A). The abbreviations for Subject 1104 on question 4 are: Occupational Therapy (OT), Physical Therapy (PT), Developmental Therapy (DP) and Speech Therapy (ST).

Table 4. Parent Questionnaire, Question 13 Data		
Subject ID	Subject Age	Q 13
0001	11	None
0002	11	None
0003	11	Frequently needs requests, directions, or information repeated.
0004	11	Talk louder than normal, like the TV louder than normal, Appears to be a selective listener, Tendency to ignore you when he/she is engrossed in something, difficulty putting thoughts onto paper during writing, performs better one on one, poor comprehension of math "word problems" or abstract concepts, poor ability to identify keywords emphasized in conversation by stress cues, low confidence and/or self esteem.
0005	9	None
0006	8	Appears to be a selective listener, Appears to be easily distracted, Frequently needs requests, direction, or information repeated, takes a long times to complete homework
0007	10	Appears to be a selective listener, Frequently needs requests, direction, or information repeated, have greater tendency to ignore you when he/she is engrossed in something
0008	9	Say "Huh" or "what" frequently, have a greater tendency to ignore you when he/she is engrossed in something
1101	11	None
1102	9	None
1103	9	Talk louder than normal, like the TV louder than normal, appears to be a selective listener, appears to be easily distracted, frequently needs requests, directions or information repeated, have a greater tendency to ignore you when he/she is engrossed in something, has difficulty putting thoughts onto paper during writing, performs better one on one, experiences difficulty paying attention in the classroom, takes a long time to complete classroom work and/or homework
1104	9	Talks louder than normal (sometimes), Have a greater tendency to igrnore you when he/she is engrossed in something
1105	11	None
1106	9	Performs better one on one, poor comprehension of math "word problems" or abstract concepts, experiences difficulty understanding the point or focus of group activities, takes a long time to complete classroom work and/or homework
1106	10	None

Table 3 shows the subject ID, age and parent responses to question number 13 (located in Appendix A) on the parent questionnaire.

Table 6. Pearson Correlation and Confidence Interval Data		
APD Test	Pearson Correlation	Confidence Interval
DDCorrect1*DD Correct2	0.52223	(0.0621,0.98230)
DPTRCorrect1*DPTRCorrect2	0.87992	(0.74098,1.00000)
DPTLCorrect1*DPTLCorrect2	0.8208	(0.69753, 0.94407)
MLDScore1*MLDScore2	0.66159	(0.35728, 0.96590)
SAATCorrect1*SAATCorrect2	0.73461	(0.45048, 1.00000)

Table 6 displays the results for DD Correct1, DPTR Correct1, DPTL Correct1, MLDScore1 and SAAT1Correct, which includes all standard and modified response format correct data from the first test session. The response for the DD Correct2, DPTR Correct2, DPTL Correct2, MLDScore2 and SAAT2Correct, includes all modified response format correct data from the second test session. The results indicate the Pearson correlation coefficient and the confidence interval for each APD test.

	Table 7. Mean and P-value Data				
	APD Test				
	DD Mean	DPT Right Mean	DPT Left Mean	MLD Mean	SAAT Mean
Modified	19.7857	16.3571	14.7143	9.1429	38.3571
Standard	19.8125	23.375	20.9375	9	39.5625
P-Value	0.8943	0.003	0.0021	0.9102	0.5191

Table 7 includes the means for each APD test for the Modified and Standard response groups results. The means were calculated by averaging the 2 measures for each subject then taking the average across the subjects within each group.

Table 8. Mean and Standard Deviation		
APD Test	Mean	Standard Deviation
DDT	19.92	±0.29
DPT R	21.55	±4.70
DPT L	19.7	±5.63
MLD	8.83	±2
SAAT	40.08	±2.64

Table 8 reveals the mean and standard deviation for each APD test. The means and standard deviations were calculated using the 12 subjects that took the modified response format of the APD test battery at the 2nd test session.

Table 9. Acceptability Questionnaire Data							
Subject ID	Subject Age	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6
0001	11	Yes	Yes	Yes	No	No	No
0002	11	Yes	Yes	Yes	LSL	No	No
0003	11	Yes	Yes	Yes	No	No	No
0004	11	Yes	Yes	Sometimes	No	No	No
0005	9	No	Yes	Sometimes	No	No	No
0006	8	Yes	Yes	Yes	LSL	No	No
0007	10	Yes	Yes	Yes	No	Soft of	No
0008	9	Yes	Yes	Yes	MLD	No	No
1101	11	Yes	Yes	Yes	No	No	No
1102	9	Yes	Yes	Yes	SAAT	No	No
1103	9	Most of the time	Yes	Yes	No	No	SAAT-hard to hear word during story
1104	9	Yes	Yes	Yes	No	No	No
1105	11	Most of the time	Sometimes	Yes	LSL	No	No
1106	9	Most of the time	Sometimes	No	SAAT	No	No
1106	10	Yes	Yes	No	SAAT	No	No

Table 9 indicates the subject ID, age and responses to the 6 questions on the acceptability questionnaire (located in Appendix F).

APPENDIX A

Appendix A includes the 16 questions from the parent questionnaire.

Questionnaire for Auditory Processing Disorder

Subject ID: Date:

_____ _____

1. Does your child have any of the following diagnosis?
    a. ADHD or ADD
    b. Learning Disability
    c. Anxiety Disorder
    d. Bipolar Disorder
    e. Aspergers syndrome
    f. Dyslexia
    g. Hearing Impairment
    h. Autism Spectrum Disorder (ASD)
    i. Cognitive Impairment
2. Is your child on any medication? (name and dosage)
    a.
    b.
    c.
    d.
3. Did your child take their medication today?_____
4. Has your child been previously assessed by speech therapist, occupational therapist, physiotherapist, audiologist, neuro-psychologist, or other professional? If so which one(s)?
    _____
    _____
5. What school does your child attend and what grade is he/she in?_____
6. What are your child's grades so this year?
    _____
7. Has your child previously received phonological awareness training?_____
8. Has your child's school performance changed in the past 1-2 years? If so, please describe
    _____
    _____

9. Has your child ever received reading intervention services (in the past or currently)?_____
10. Does your child have an IEP in place? What areas is/was the IEP written for?
    _____
    _____
11. Does your child receive therapy services at school? If so, which ones?
    _____
    _____
12. Does your child read at grade level? If not, what their current level? -
    _____
13. Does your child exhibit any of the following:
    a. Talk louder than normal.
    b. Like the TV louder than normal.
    c. Misunderstands what is said.
    d. Say “Huh” or “What” frequently.
    e. Appears to be a selective listener.
    f. Appears to be easily distracted.
    g. Frequently needs requests, directions, or information repeated.
    h. Have a greater tendency to ignore you when he/she is engrossed in something.
    i. Difficulty telling which direction you are calling from.
    j. Unusual sensitivity to or complains about noise.
    k. Delay before responding to questions or instructions.
    l. Appears to be confused or forgets by multiple, lengthy or quickly presented verbal instructions.
    m. Difficulty following directions when background noise is present.
    n. Difficulty following multiple step directions in quiet or noise.
    o. Mishears words by a single phoneme or syllable/confuse similar sounding words (e.g. hears “dime” for “time”, “50” for “15”, “tear a tree” for “territory”)
    p. Poor auditory memory (poor recall of information presented auditorily, with no visual cues)
    q. Poor accuracy “filling in the blank” when auditory information is incomplete.
    r. Has difficulty putting thoughts onto paper during writing.
    s. Performs better one on one.
    t. Poor reading skills (sounding out words, or comprehension of text).
    u. Poor comprehension of math “word problems” or abstract concepts.
    v. Poor ability to identify keywords emphasized in conversation by stress cues.
    w. Experiences difficulty paying attention in the classroom.
    x. Difficulty expressing/ explaining information or paraphrasing.
    y. Experiences difficulty understanding the point or focus of group activities.
    z. Takes a long time to complete classroom work and/or homework.

aa. Is teased or left out of activities or peers.
bb. Unusually tired after school.
cc. Experiences behavioral problems.
dd. Low confidence and/or self-esteem.

14. What's the primary language used in the home?-
    _____
15. Is your child bilingual or multilingual? If so, what are the languages spoken?
    _____
16. Does your child have a history of frequent otitis media or middle ear infection? If so, How were they
    treated?_____

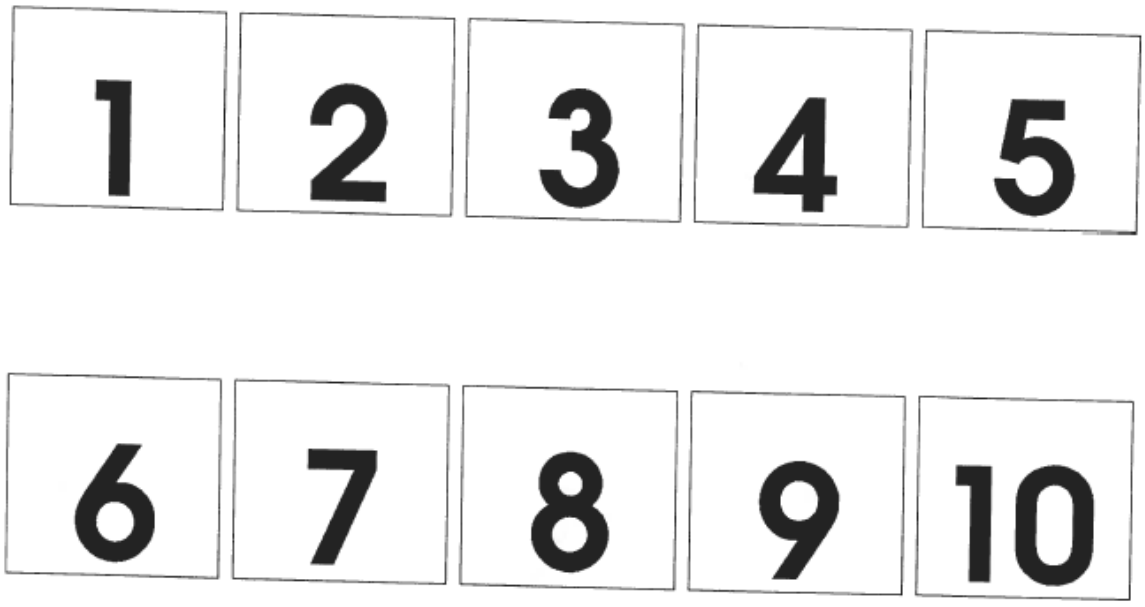
Compiled By: familyeducation.com

Raviv Practice London AP Questionnaire

wvsha.org

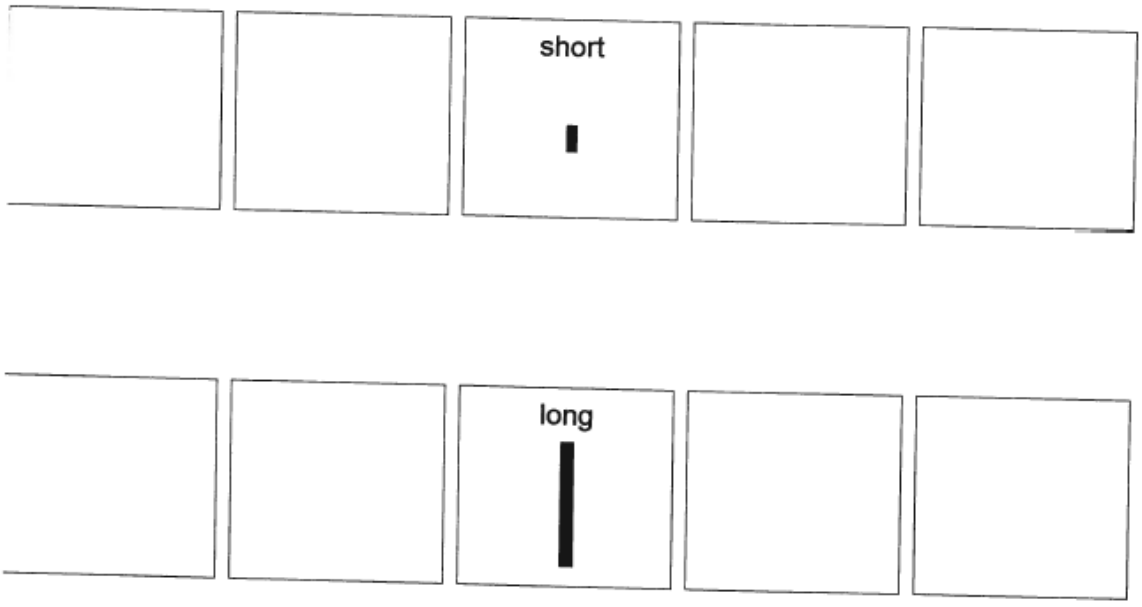
APPENDIX B

Appendix B shows the symbols for the Dichotic Digits Test.



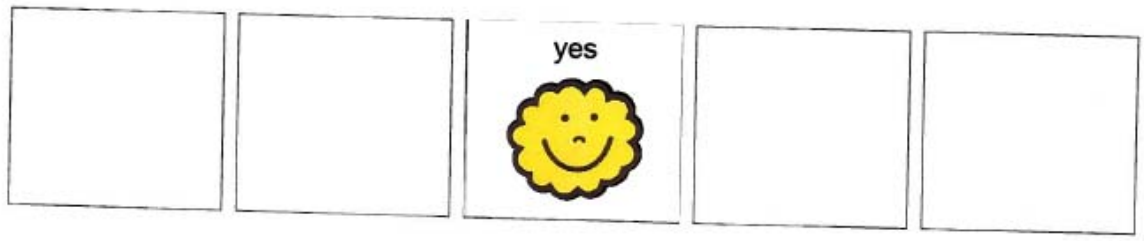
APPENDIX C

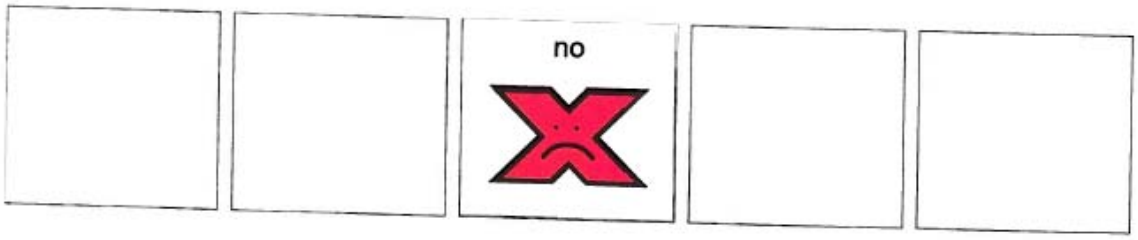
Appendix C illustrates the symbols for the Duration Pattern Test.



APPENDIX D

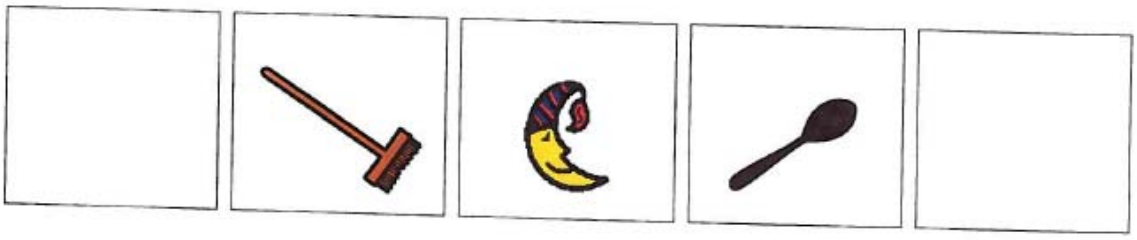
Appendix D displays the symbols for the Masking Level Difference Test.

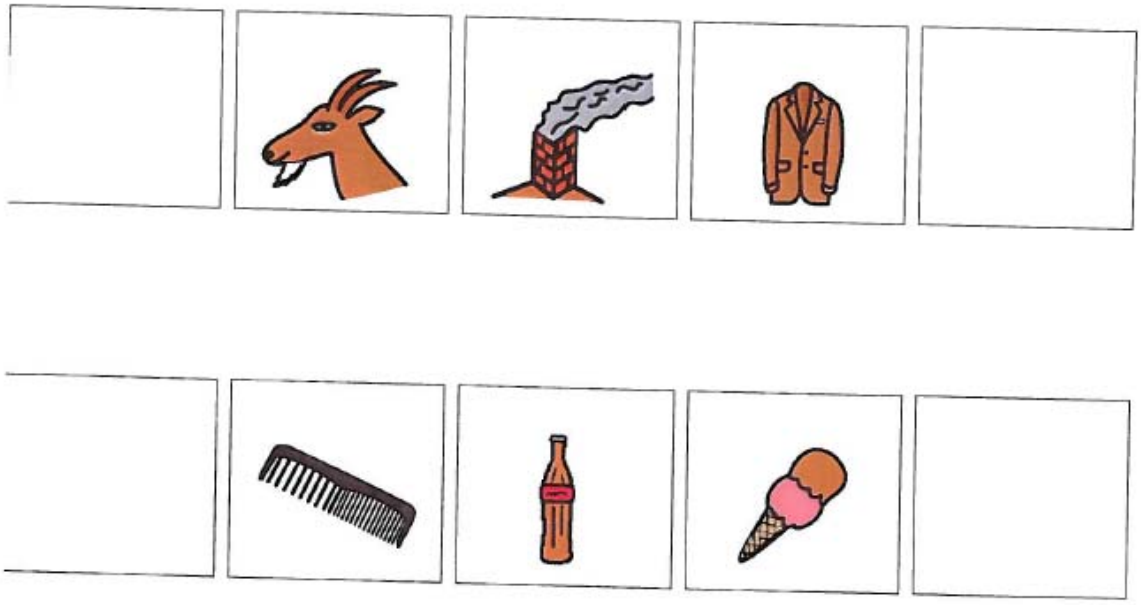


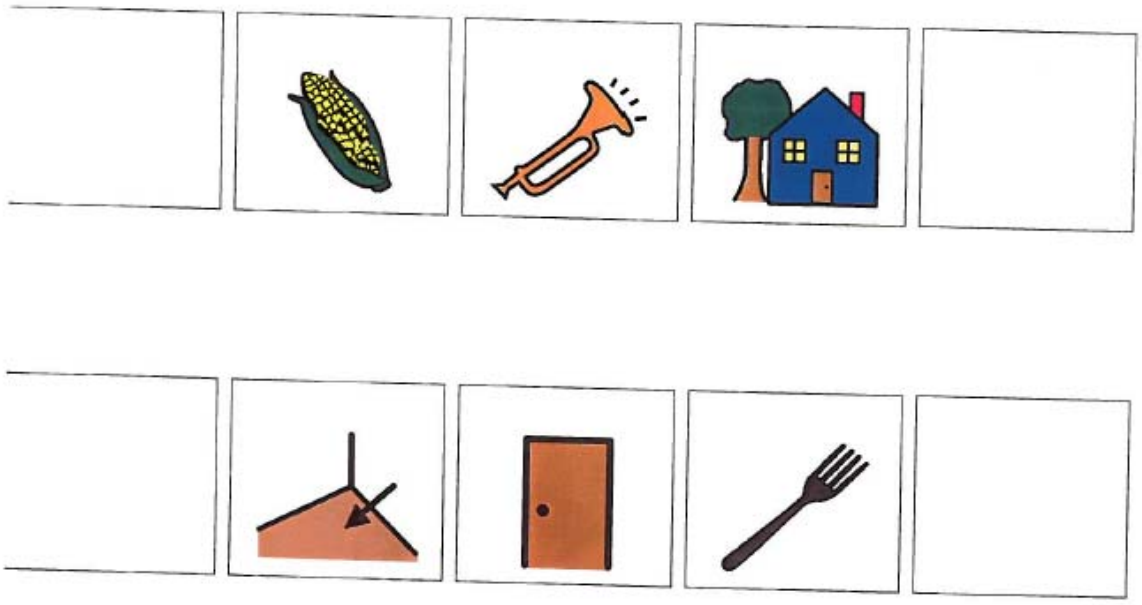


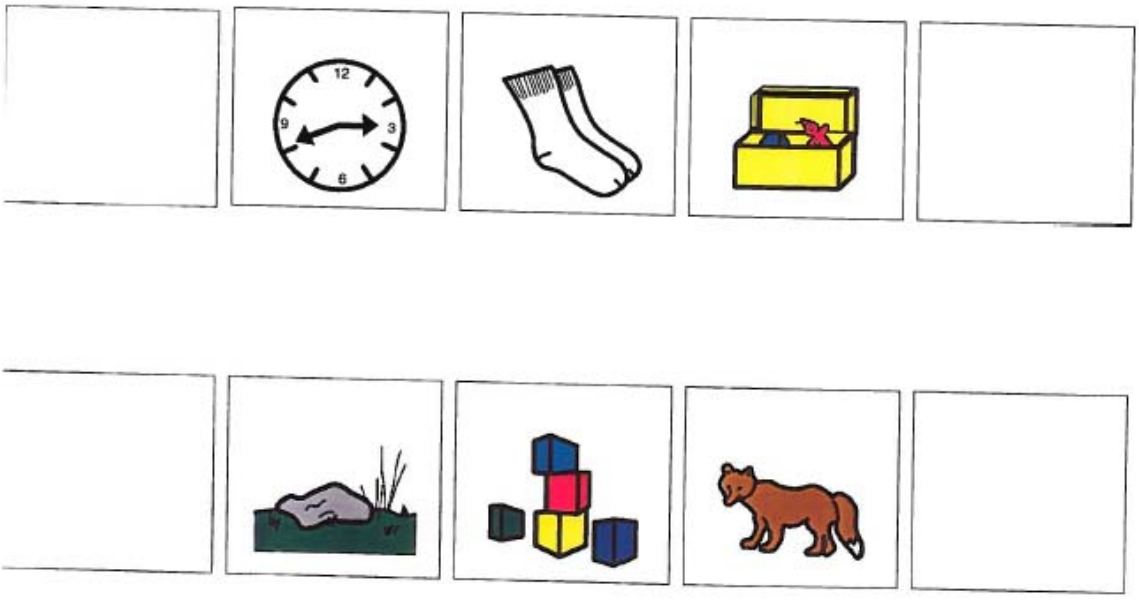
APPENDIX E

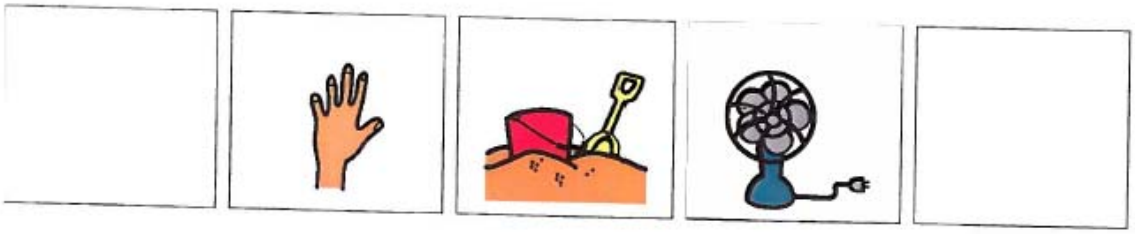
Appendix E includes the symbols for the Selective Auditory Attention Test.

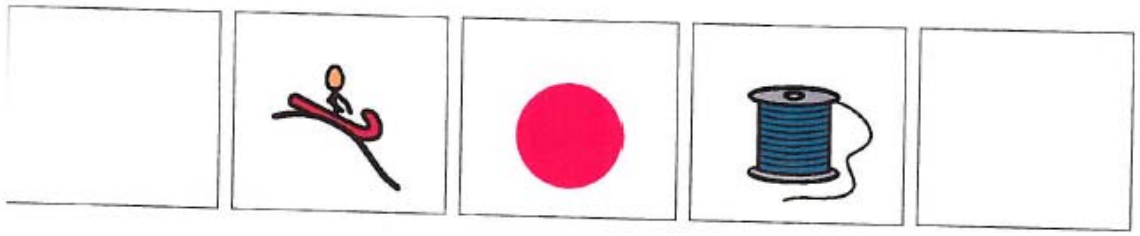


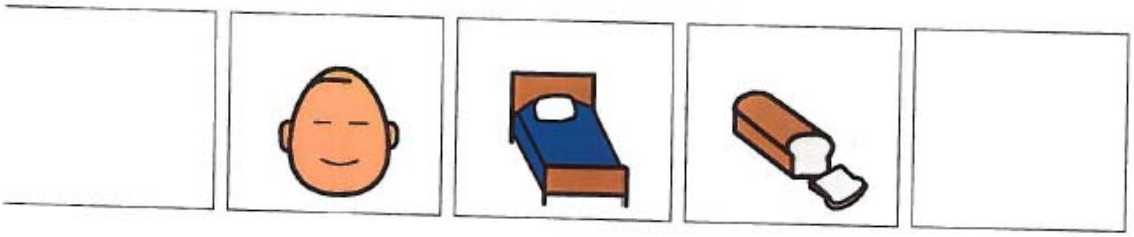


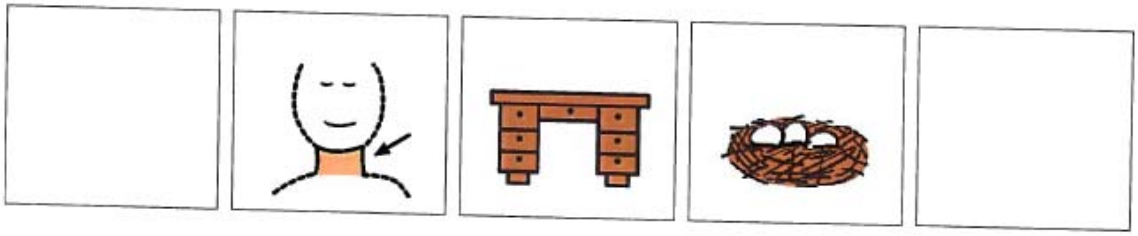


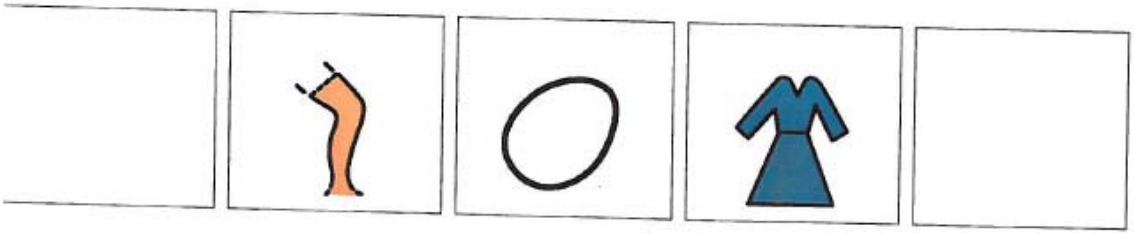

12
9
3
6

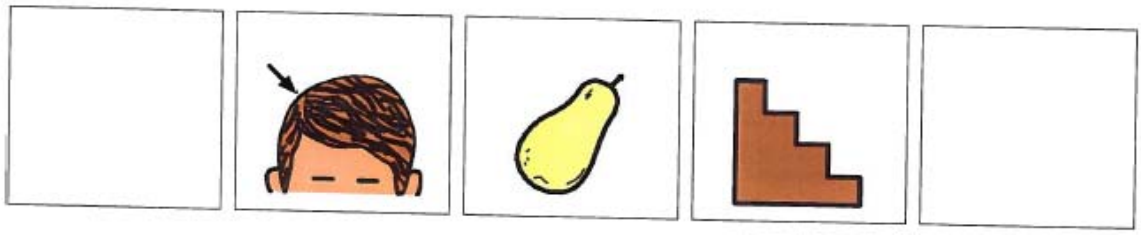


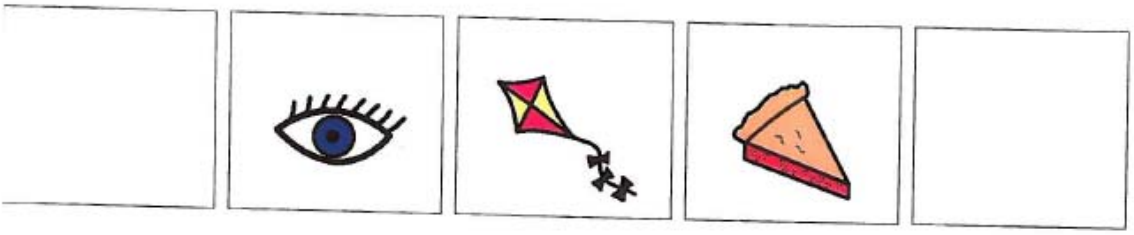


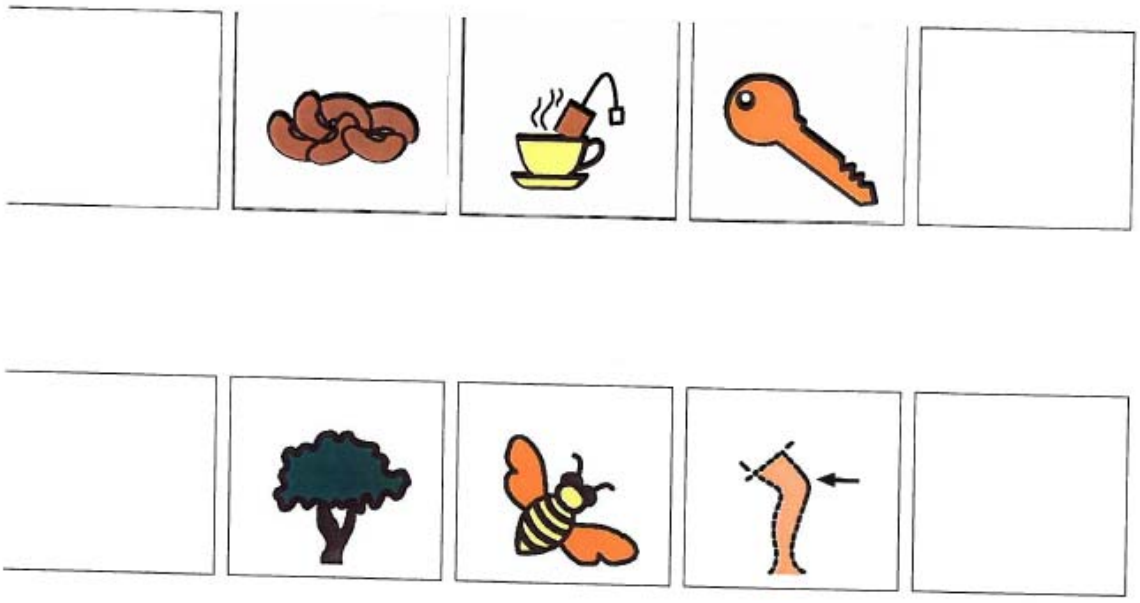


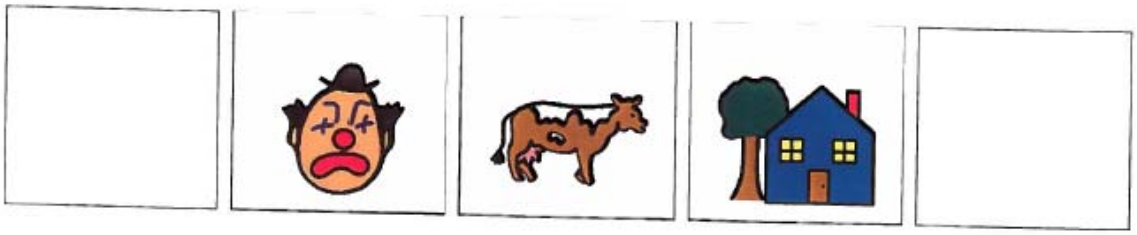


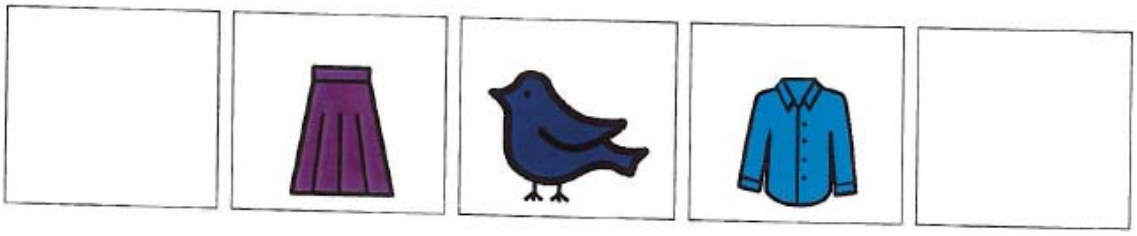


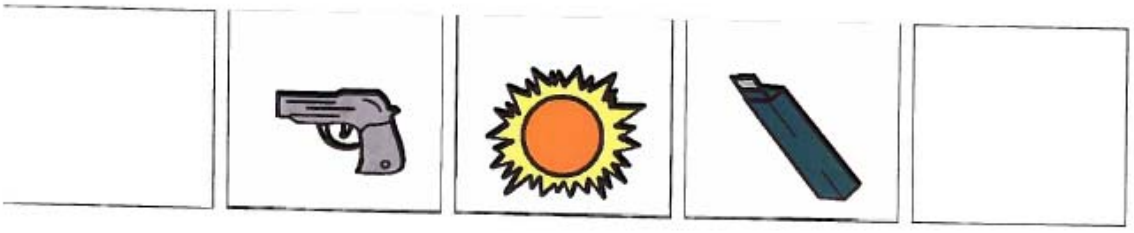


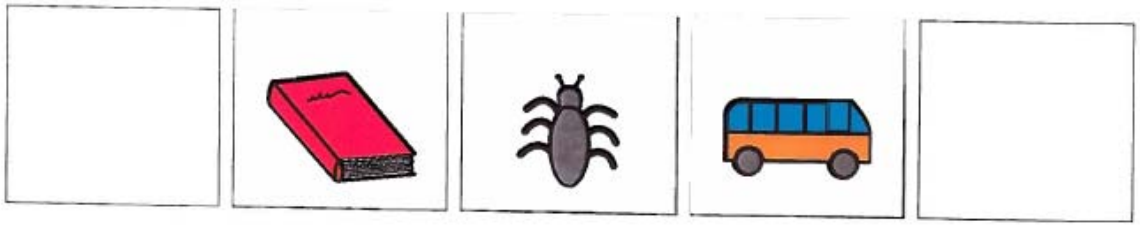


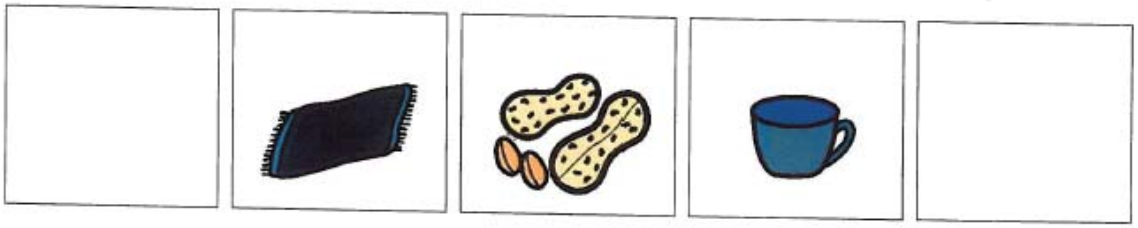


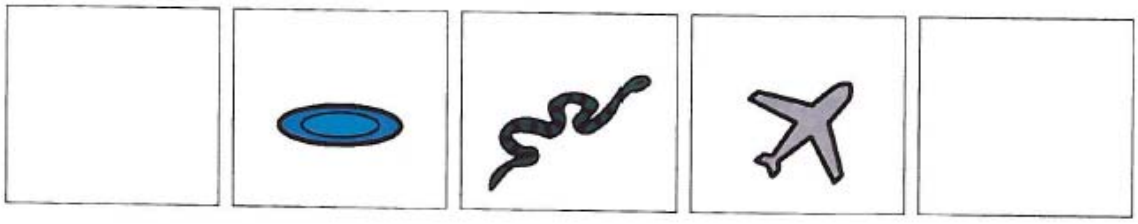


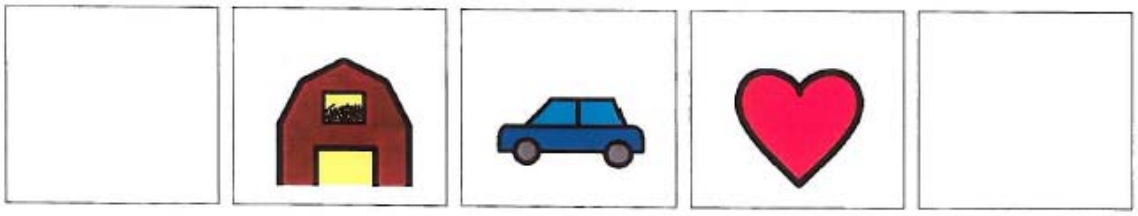


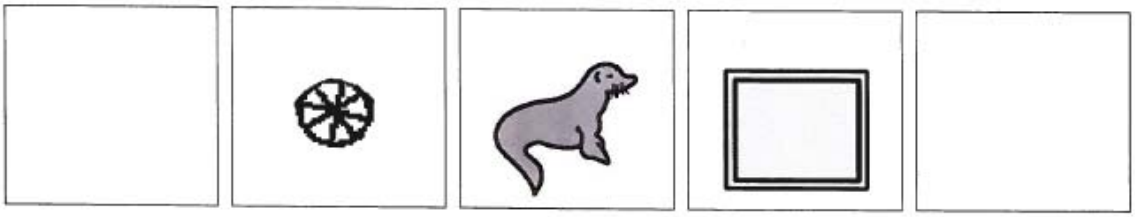












APPENDIX F

Appendix F includes questions 1-6 from the acceptability questionnaire.

Questionnaire to Determine the Acceptability of the Modified Response Format of the APD Test Instruments

Subject ID: Date:

_____ _____

1. Did you recognize all the pictures? _____
2. Did the pictures appropriately match the word? _____
3. Did you think you had enough time to respond to the questions? _____
4. Were any sections confusing? If so, which ones?

   _____

5. Did you find it difficult to turn the pages?

   _____

6. Do you have any other comments?

   _____

Developed by: Allison Soll

Principle Investigator