2016

Fine motor screening during conditioned play audiometry

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Fine Motor Screening During Conditioned Play Audiometry

by

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A Capstone Project
submitted in partial fulfillment of the
requirements for the degree of:

Doctorate of Audiology

Washington University School of Medicine
Program in Audiology and Communication Sciences

May 19, 2017

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Abstract:
The objective of this study was to explore the feasibility of creating and administering a protocol to screen fine motor skills during conditioned play audiometry (CPA). It was administered successfully to 17 children from two to four years of age. The screening was accepted by the 6 managing audiologists. The screening was rapid (under four minutes) and easy to administer. The total cost for all toys necessary was approximately $60.

Acknowledgements

I want to thank my primary advisor Roanne Karzon, Ph.D., who helped me come up with this out of the box topic and had the drive and passion to pursue it. Your guidance and mentorship over this past year has been unmatched. I would also like to thank both Melanie Wood, MS, OTR/L, ATP and Amy Stoyanov, MOT, OTR/L who provided insightful and crucial information to create the screening protocol. I would also like to thank my second reader Lisa Davidson, Ph.D., who took me and my project on last minute, and provided me with the help I needed. I appreciate the time you took to edit and read my paper even when you were jet-setting across the country. I would also like to give a special thanks to Banan Ead who helped me with the IRB. I honestly do not know how or if I would have been able to get through that process without you. It would have definitely not been as seamless. Finally, I extend my sincerest gratitude to the clinical audiologists: Lauren Ragnetti, Sue Hayashi, Robin Hudson, Julia Webb, Susan Cheung and Anna Tisdale and office staff: Imani Scutchins, Cheryl Faust, Tracey Marlow, and Jo Fernandez of the Department of Audiology at St. Louis Children's Hospital for their help recruiting test participants and who allowed me to take over every test session that involved 2-4 year olds. Without their patience, especially my clinical supervisor during the Fall semester, Lauren Ragnetti, M.S., the capstone project would have never been completed. I also want to thank Anna Tisdale and Alyssa Pursley for believing in this project enough to carry it on after I'm gone. Thank you to Beth, Beth, and Rene for all of your support throughout this capstone process as well as throughout my time at PACs.

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Introduction

Most pediatric audiologists are well versed in speech and language milestones and frequently refer for speech/language evaluations (Harvey et al. 2007), but tend to lack knowledge in other developmental areas such as fine motor development, the focus of our study.

According to the American Psychiatric Association (2013), five to six percent of school aged children are affected by a developmental coordination disorder. Dependent on definition and population sample, approximately 20–40% of children born with hearing loss have significant additional disabilities (Cupples et al. 2013). These may include, but are not limited to: cerebral palsy, autism spectrum disorder, and developmental delay (Cupples et al., 2013). Kennedy et al. (2006) reported that an additional disability was present in 19.2% of their sample of 120 British children with hearing loss. Similarly, 18.6%, was reported by Berrettini et al. (2008) for an Italian sample of similar size. A review by Picard (2004) suggested higher prevalence rates of approximately 30–40%, consistent with data collected through the Annual Survey of Deaf and Hard of Hearing Children and Youth in the United States, which indicated that 40% of the children surveyed had an educationally relevant additional need.

With respect to hearing and motor development, several studies report that children with hearing impairment show deficits (Fellinger, Holzinger, Aigner, Beitel, & Fellinger, 2015). Livingstone and McPhillips (2011) reported that 20 of 25 children (80%) with a bilateral hearing impairment greater than 60dB HL scored in the bottom 15% (borderline) and about 50% scored in the bottom 5% (definite problems) of the standardized sample of the Movement Assessment Battery (MAB) for children. The MAB includes measures of manual dexterity, ball skills, and static and dynamic balance. Fellinger et al. (2015) found that children with hearing impairment performed significantly below standardized test norms on the Zurich Neuromotor Assessment in

all four main subscales ($p<0.001$). The four subscales include: pure motor (repetitive, alternating, and sequential movements), pegboard, static balance, and dynamic balance (side-to-side and forward jumping). Thus it appears that fine motor skill development is an area that warrants investigation in children with hearing impairment.

Pediatric audiologists have an opportunity to observe fine motor skills during conditioned play audiometry (CPA) and are often one of the first specialists to interact in a play-type session with a child undergoing differential diagnosis. If their observations of fine motor skills can be quantified using a more formal screening tool, recommendation for referral to occupational therapy for those children identified as being at risk would be accelerated.

Based on decades of research, early identification and intervention for fine motor development is important because children's brains are most flexible or "plastic" during the birth to three period of life (Edwards & Sarwark, 2005). Various reports confirm that intervention is more effective and less costly when provided earlier in life rather than later (Center on the Developing Child at Harvard University, 2010). Appropriate and timely recognition of a child's developmental delay is necessary for referral to early intervention services. Early intervention serves to help affected children overcome or improve motor dysfunction and provides the necessary tools and resources to their families, allowing them to become more confident in caring for a child with special needs (Edwards & Sarwark, 2005).

The American Speech-Language-Hearing Association (ASHA) guidelines clearly support the practice of "whole child" audiology stating that referrals to other professions, agencies, and/or consumer organizations fall under an audiologist's scope of practice (American Speech-Language-Hearing Association, 2004. Thus, screening for fine motor development and recommendation for referral to occupational therapy is within the scope of practice for a

pediatric audiologist. Stated more emphatically by Wolfe and Scholl (2008), “Only a myopic audiologist would consider his/her work done after completing a diagnostic evaluation.” These authors serve to remind us of the difference between screening and diagnosis and that we must keep in mind where the audiologist’s role ends and where another professional’s begins.

Comments from informal conversations with pediatric audiologists support the desire to serve their patients by observing the “whole child”, in addition to the evaluation of hearing. When asked, “What does whole child audiology mean to you?” three audiologists from local pediatric medical departments replied as follows:

> “Whole child audiology to me means assessing and treating the child’s needs; not just matching targets and Xs and Os.” (Nancy McManus, AuD., personal communication, April 10, 2015).
>
> “To me, whole child audiology means looking at each child individually and deciding what is appropriate for each child.” (Kristin Gossett, personal communication, April 20, 2015)
>
> “A child is first and foremost a child and then he may have special needs” (Pam Koprowski, AuD. personal communication, July 2015).

During CPA, many of the play activities used by audiologists involve fine motor skills for which there are developmental criteria in the literature (personal communication, Melanie Wood, Occupational Therapist at St. Louis Children’s Hospital, September 2015). For example, placing toddler sized coins into a toddler piggy bank and stacking one to two blocks has a developmental expected age of 2.0 years of age (Folio & Fewell, 2000, Kid Sense, 2016). It seems advantageous to harness observations into a formal screening tool.

This study explored the feasibility of screening fine motor skills during CPA for potential referral to occupational therapy. More specifically, our study aims were as follows:

1) Develop a screening protocol based on activities inherent in conditioned play audiometry. This approach reduces time and cost.
2) Assess feasibility by using the screening protocol with at least 15 children during hearing assessment with CPA.
3) Measure acceptance of the screening tool by the managing audiologists.
4) Assess expense of the screening protocol.
5) Asses ease of administration of the screening tool.

Methods

The study was approved by Washington University's School of Medicine Human Studies Committee. A screening tool that is both acceptable and feasible for use in the audiology clinic should meet the following five characteristics of a good screening tool: 1) easy to administer, 2) inexpensive, 3) minimal to no discomfort, 4) reliable, 5) valid (Boston University School of Public Health). In addition, screening is appropriate when the disease or disorder is a significant health problem with potential for treatment and early treatment for the disorder has significant value. (Herman, 2006)

There were five phases to the study:

1) Collaborate with experts from Occupational Therapy to determine which toys/activities commonly used in CPA (e.g., stacking rings, placing pegs in a board) have known expected ages referenced in the literature.

2) Establish developmental cut-offs for selected toys/activities based on published normative data for developmental milestones of motor development (Folio & Fewell, 2000).
3) Include toys/activities appropriate for several age groups (2.0 years, 2.5 years, 3.0 years, 3.5 years, 4.0 years).
4) Collaborate with occupational therapy colleagues to create a preliminary screening protocol with pass/refer criteria for each toy/activity.
5) Assess the screening tool with patients to see if it is feasible for use in a busy clinic setting. The following criteria were used to determine the ease of use during conditioned play audiometry:
    a. Rapid--test time less than five minutes.
    b. Interference--test procedures do not interfere with the hearing test.
    c. Acceptable--test protocol acceptable to the managing audiologists.
    d. Easy—test is easy to administer and interpret.

Participants

Children referred to the Audiology Department of St. Louis Children's Hospital were recruited according to the guidelines of the Human Research Protection Office of Washington University. Informed consent was obtained from the parent/guardian prior to testing. Potential reasons for attrition were failure to condition for CPA, failure to engage the patient in the toys/activities, tester error and withdrawal by the guardian. Of the twenty-three children enrolled, six could not be conditioned for CPA; therefore, seventeen children, ranging from 2.0 to 4.11 years of age (mean age 3.4 years) were included in the data analysis. As depicted in Table 1, seven participants were female and ten were male. With respect to the established age categories,

participants were as follows: 2.0 years (n=2), 2.5 years (n=2), 3.0 years (n=6), 3.5 (n=2), and 4.0 years (n=5).

Development of Screening Protocol

Based on standardized developmental assessments of fine motor development, including the Peabody Developmental Motor Scales (Folio & Fewell, 2000), and the expertise of two experienced pediatric occupational therapists, age/developmental levels were developed for each of the selected tasks: putting coins in a toddler piggy bank and placing pegs in a board with large holes. To provide several options for each age group, four additional toys/activities were added: small piggy bank for use with real pennies, placing pegs in a board with small holes, stacking blocks and line tracing. Based on Folio & Fewell, (2000) and the expertise of the collaborating occupational therapists, developmental expectations for these additional selected toys/activities were established as well. The developmental age compared to the expected age for referral ranged from four months to 11 months. For example, the expected age for tracing a horizontal line within 25 degrees of straight was 3.6 years and the referral age was four years; placing pegs in a peg board with large holes had an expected age of 13 months and referral age of two years (see Appendix B for full list of developmental cut-offs and corresponding referral ages). This information, for toys/activities, was organized into a screening protocol with pass/refer criteria for each toy/activity (see Appendix A).

Procedure

Testing was conducted in one of three sound suites using a Grason Stadler Instrument-61 audiometer, which is calibrated yearly. Toys/activities were as follows: one inch wooden blocks, a large and small peg board with accompanying pegs, a toddler piggy bank and coins, a small

piggy bank with real pennies and tracing a premade two-inch line with a pen. A complete description and photographs of the toys/activities may be found in Appendix C.

The five audiologists managing the CPA test sessions had an average of 15 years of experience (ranging from four months to 32 years). The assistant, a 3rd year audiology graduate student, was constant across all 17 sessions. With respect to administration of the protocol, the audiologists were given a copy of the screening tool but needed no in-service training because it was the assistant who administered the protocol. Because the assistant was in collaboration with the occupational therapists in developing the tool, and it was incorporated into common audiology practice of CPA, no additional training was required. Prior to administering the screening protocol, the assistant had CPA experience with more than 50 children.

The child either sat on the parent's lap or by themselves in a chair in the middle of the room. Loudspeakers situated at a 45-degree angle to the left and right of the child, headphones, or insert earphones were used to transmit test stimuli. In general, the order of the toys presented by the assistant progressed from the youngest developmental level to the oldest. An exception was stacking 8-10 blocks, which has an expected age of 3.0 years, following the placement of small pegs in the peg board, which has an expected age of 3.5 years. Based on level of engagement (see appendix D), toys were transitioned in and out. The assistant verbally reinforced each correct response with comments such as "good job", "way to go", and "good listening".

The audiologist presented the stimuli (speech, warble tones, or narrowband noise) and the child was conditioned to respond to stimuli by participating in a task, such as placing a coin in a piggy bank, at supra-threshold levels. After the child was conditioned, the audiologist first obtained a speech reception threshold followed by thresholds at 250 Hz, 500 Hz, 1000 Hz, 2000

Hz, 4000 Hz and 8000 Hz. The number and sequence of frequency specific stimuli varied based on the testing audiologist's judgment.

A questionnaire using a Five-Point Likert Scale for questions one to five and seven was given to each participating audiologist to assess their acceptance of the screening protocol. The Likert Scale is a multiple point scale which allows the individual to express the extent to which they agree or disagree with a particular statement (McLeod, 2008). Questions one to three assessed opinions regarding the impact of the protocol on the hearing test. Questions four and five explored which toys worked and opinion regarding the sequence of activities. Question seven assessed whether the audiologists thought the fine motor screen was a good addition to CPA. Question six was an estimate of the additional time needed to administer the screening with a multiple choice response of A) 0 minutes, B) 1-2 minutes, C) 3-4 minutes, and D) greater than 5 minutes. Two of the six audiologists did not complete the questionnaire because they did not feel as if they had enough experience with the screening protocol. See appendix E for the complete questionnaire. The Likert Scale responses provided numerical values with one being the worst or a negative response and five being the best or a positive response. Depending on the question, "strongly disagree" may have obtained a value of one or five. For example, for question one, "The fine motor screening was an intrusive procedure to the patient", "strongly disagree" was a score of five. In contrast, for question seven, "A fine motor screen is a good addition to our current clinic procedure", "strongly disagree" was a score of one.

Results

Of the 23 children enrolled, six could not be conditioned and the protocol was not administered. All six of these participants were conditioned and tested using visual reinforcement audiometry. Participant one had missing data for the small piggy bank activity

due to tester error. Screening results for participants who could be conditioned are shown in Table 1. This table includes the participant number and age, the nine tasks administered in the protocol (with a + or - depicting whether or not the child completed the task), and the average level of engagement for the session. Level of engagement ranged from 0, which denoted that the child had no interest in the tasks and would not participate, to a 3, which signified that the child was actively engaged and eager for the next turn (see Appendix D for engagement level descriptions). It should be noted that NA means the task was not applicable and not given because participant age was below the task developmental age. All 17 children successfully performed the screening tasks assigned to their age range.

Figure 1 depicts responses of the audiologists to the questionnaire. The number of responses varied because not all audiologists answered each question. Of responses obtained, the overall average score across questions one through five and seven was 4.6 with five being the highest (most positive) score possible. The range was three to five (Figure 1). With respect to the amount of additional time needed (question six), three audiologists estimated 1-2 minutes and one responded 0 minutes.

The cost of additional toys to administer the screening tool in the study setting was approximately $40. Audiologists reported that the additional time needed to administer the screening toll was no more than two minutes. The total time related to test administration and scoring was calculated to be four minutes. Assuming an audiology assistant salary of $15/hour, the cost of the additional four minutes would be $1.00.

Discussion

A screening tool for fine motor development was developed and successfully administered during conditioned play audiometry for 17 participants. Three of the six

participants who could not be conditioned for CPA were under 30 months of age and may have not been developmentally ready for play audiometry. Participants 20 and 21 exhibited behavioral issues that precluded successful performance of the required tasks. Participant 16 had a diagnosis of cerebral palsy and lacked coordination necessary for CPA. Since the current study was successful and the screen was less than four minutes, it makes it possible and important to consider completing the fine motor screen as an after activity when visual reinforcement audiometry or other assessment protocols are used. If a child in the two to four year age range cannot be conditioned for CPA, it is plausible that they may be at risk for fine motor delays.

Toys commonly used for CPA that worked well included the toddler piggy bank and placing pegs into a peg board with large holes. The new toys/activities of stacking blocks, a peg board with small holes, a small piggy bank with real pennies and tracing a preexisting line, were well received by both the participants and managing audiologists. The line tracing worked well but was a novel task to the hearing test and audiologist. Skepticism from the audiologists appeared to diminish once the assistant demonstrated that the tracing task worked without disruption to the hearing test.

The order of activities was arranged to keep the screening tool from interfering with the hearing test. Blocks appeared to work best as the last activity during the formal protocol. They seemed to take the most time and concentration on the child's part. When the child could not perform fast enough to keep pace with the hearing test, block stacking was transitioned to an "after activity" following the hearing test. When the block activity was moved to the end, more time was available to optimize performance on the motor-skills aspect of the task without regard to listening for the "beeps." Line tracing, which seemed to take too much time and concentration in combination with listening for the hearing test, also worked best as an "after activity".

Audiologists responded very favorably to the screening protocol (Figure 1). All scores were between three to five on a 5-point Likert Scale (mean= 4.64). Of particular importance, the audiologists reported that the protocol was not intrusive (4.8) and worked well (4.6). Screening must be a quick assessment. The audiologists estimated that the amount of time added to the hearing test was no more than two minutes, with an additional two minutes for scoring by the assistant. Collectively, these responses suggest that the screening was easy to administer.

The additional cost of administering the fine motor screening was minimal (approximately $1.00) and an added benefit is that the majority of the toys used in this protocol are readily available in a pediatric audiology setting. For this particular study, a toddler piggy bank, smaller piggy bank, and small peg board were purchased. If one had to purchase all of the toys in this study protocol, the cost would be approximately sixty dollars.

Limitations in a feasibility study are small sample sizes for participants, managing audiologists, and assistants. It is important to note that due to reasons stated above, not all of the eligible children were able to condition and participate in the study. This could have potentially skewed the sample. For example, the participant with cerebral palsy would likely have fine motor difficulties, but was not screened due to the experimental protocol.

Next steps for research include the determination of pass/refer criteria and to assess reliability and validity. Children who have been evaluated for fine motor skills and have no deficits, as well as children with known fine motor deficits are needed to assess both sensitivity and specificity of the screening tool. The audiologists and assistants should be blind to the status of the child's fine motor skills. Since the current study was for development of the protocol and feasibility of administration, these issues were beyond the scope of the project.

Conclusion

A screening protocol for fine motor skills in children of two to four years of age was developed and successfully administered to a small group of children during conditioned play audiometry. It was shown to have good acceptance among audiologists and was feasible in the busy practice setting. Further research with a larger population of audiologists, assistants and participants is needed to assess reliability and validity.

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Participant	Gender	Age	Tasks									Average Engagement
			1	2	3	4	5	6	7	8	9	
1	M	3.8 y.o	+	+	+	+	+	Missing Toy	+	NA	NA	2
2	M	3.1 y.o	+	+	+	+	+	+	+	+	NA	3
3	F	3.10 y.o	+	+	+	+	+	+	+	+		3
4	F	2.2 y.o	+	+	+	+	NA	NA	NA	NA	NA	2
5	F	3.3 y.o	+	+	+	+	+	+	+	NA	NA	2.6
6	M	2.3 y.o	+	+	+	+	+	NA	NA	NA	NA	2
8	M	4.4 y.o	+	+	+	+	+	+	+	+	+	2
10	F	2.5 y.o	+	+	+	+	+	+	NA	NA	NA	3
11	F	4.1 y.o	+	+	+	+	+	+	+	+	+	2
12	M	3.4 y.o	+	+	+	+	+	+	-	+	NA	3
13	M	3.8 y.o	+	+	+	+	+	+	+	+	NA	2
14	M	2.7 y.o	+	+	+	+	+	+	NA	NA	NA	2
17	F	3.11 y.o	+	+	+	+	+	+	+	+	NA	2
18	F	4.8 y.o	+	+	+	+	+	+	+	+	+	2
19	M	4.11 y.o	+	+	+	+	+	+	+	+	+	3
22	M	3.4 y.o	+	+	+	+	+	+	+	NA	NA	3
23	M	4.5 y.o	+	+	+	+	+	+	+	+	+	2

Table 1. Results of participants who completed the Screening Protocol. Tasks included: 1. Stack 2-3 blocks, 2. Large peg board, 3. Toddler piggy bank, 4. Pick up real penny, 5. Stack 4-6 blocks, 6. Place real penny in small bank, 7. Stack 8-10 blocks, 8. Small peg board, 9. Trace horizontal line. + signifies completed task satisfactorily; - signifies participant did not complete the task; NA signifies task was not applicable and not given because of participant age and task developmental age.

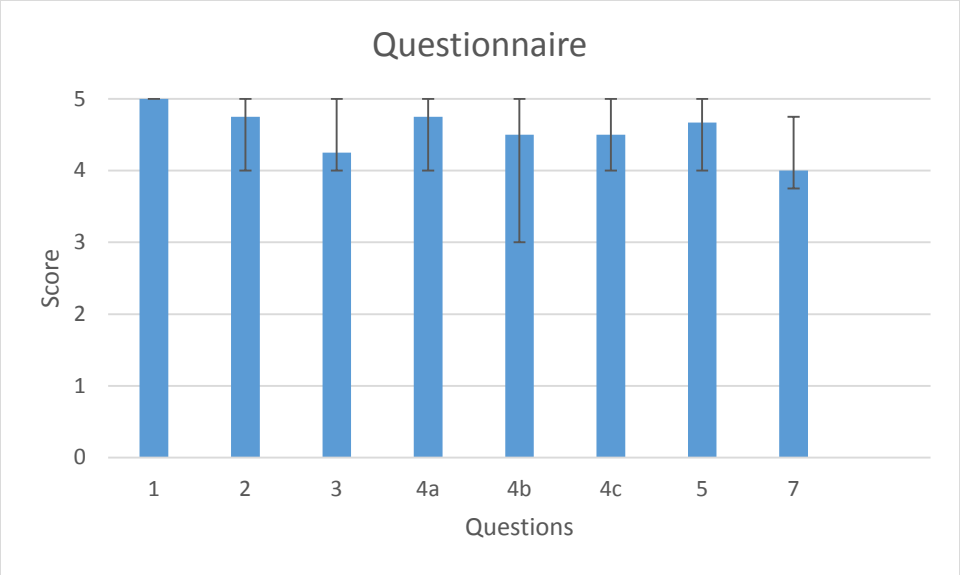


Figure 1. Average score and range by question for the audiologist questionnaire.
0 represents least favorable opinion, 5 represents most favorable opinion. Questions included: 1.The fine motor screening was intrusive to the patient; 2.The fine motor screening was not intrusive to the hearing test; 3. How often did the fine motor screening negatively impact the hearing test; 4.With respect to the toys, the following worked well: a. Small pig & real pennies b. Stacking of blocks c. Line tracing; 5. How well did the toy sequence (toddler bank 1st, blocks or tracing last) work?; 6. How much additional time was required to add the protocol?; 7. A fine motor screen is a good addition to our current procedure.

Appendix A

Screening Protocol

Participant #____ Date of Test:_____ Date Of Birth:_____
Age: _____

Developmental Cutoff:	**Task Completion: (+/-)**	**Level of Engagement: 0-3**	**Comments:**
2.0 yrs			
1. Stacking 2-3 blocks	_____	_____	
2. Large Peg Board, place 3 pegs	_____	_____	
3. Toddler Piggy Bank, put coin in	_____	_____	
4. Pick up real penny, pincer grasp	_____	_____	
2.5 yrs			
5. Stack 4-6 blocks	_____	_____	
6. Place real penny, small piggy bank	_____	_____	
3.0 yrs			
7. Stack 8-10 blocks	_____	_____	
3.5 yrs			
8. Small Peg Board, place pegs	_____	_____	
4.0 yrs			
9. Trace horizontal line, within 25 degrees of straight	_____	_____	

Appendix B

Developmental and Proposed Referral Ages

Activity	Developmental Age	Proposed Age for Referral
Stacking 2-3 blocks	15-16 months	2.0 years
Place 3 pegs in a peg board with large holes	13months	2.0 years
Put a large toy penny in a toddler piggy bank	15-18 months	2.0 years
Pick up a real penny with a pincer grasp	15-18 months	2.0 years
Stack 4-6 blocks	19-20 months	2.5 years
Place real penny in small piggy bank	19-24 months	2.5 years
Stack 8-10 blocks	25-36 months	3 years
Place 3 pegs in a peg board with small holes	2.5-3.0 years	3.5 years
Trace a horizontal line within 25 degrees of straight	3.5-3.6 years	4 years

Appendix C

Task Description:

Stacking Large Blocks- child must pick up a 1-inch block, preferably plain wood to decrease distraction, from either a steady surface or the palm of your hand and successfully stack it on another 1-inch cube block that is already in place on a steady surface. Number of blocks stacked depends on age.

Large Peg Board, place 3 pegs- child must place at least 3 of the large pegs into any of the holes on the peg board with large holes. (see picture below)

Toddler Piggy Bank, put penny in- child must be able to hold the toddler sized coin and successfully place it into the slot on top of the toddler size piggy bank. (see picture below)

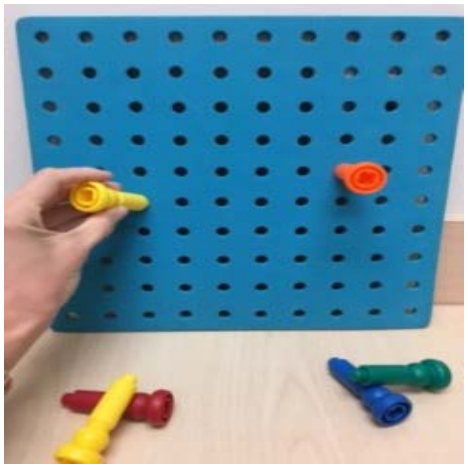
Pick up real penny, pincer grasp- child must be able to pick up a real penny from a steady surface using a "pincer grasp" which involves the coordination of the thumb and index finger. (see picture below)

Place real penny, small piggy bank- child must be able to pick up a real penny using a pincer grasp and successfully place it into the slit of a small "real" size piggy bank. (see picture below)

Small Peg Board, place pegs- child must be able to place at least 3 of the small pegs into any of the holes on the peg board with small holes. (see picture below)

Trace horizontal line, within 25 degrees of straight- child must be able to trace an existing line that is placed in front of him, veering no more than 25 degrees from the original line. A writing utensil with the diameter similar to a ball point pen is to be used (see picture below)

Stacked Blocks

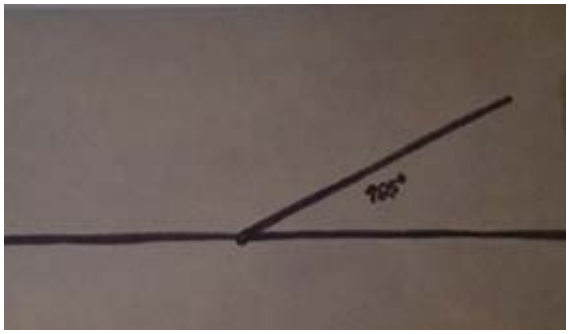


Large Peg Board

Toddler Piggy Bank and Coins

Small Piggy Bank

Small Peg Board



Horizontal Line, within 25 Degrees of Straight

Appendix D

Level of Engagement Descriptions:

0- has no interest in the task at hand and will not participate.

1- Child participates in the task for at least 1-3 turns child is not consistently interested and is easily distracted. Frequent re-direction to the task is needed.

2- Child is engaged in the task and is willing to participate for an extended period of time. He/she remains focused. Child may appear bored with the game, but this does not affect participation or success.

3- Child is actively engaged and eager for the next turn. Child is focused and genuinely appears to enjoy the game. Smiles on and off.

Appendix E

Screening Protocol Questionnaire

1. The fine motor screening was an intrusive procedure to the patient

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

2. The fine motor screening was not intrusive to obtaining the hearing test

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

3. How often did the fine motor screening negatively impact obtaining the hearing test?

Very Frequently	Frequently	Occasionally	Rarely	Never
O	O	O	O	O

4. With respect to the toys, the following worked well:

A. Small pig & real pennies

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

B. Stacking of blocks

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

C. Line tracing

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

5. The fine motor screening sequence always started with the toddler piggy bank, and ended with either stacking of blocks or tracing the lines depending on age. This toy sequence worked well with the existing procedure

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

6. How much additional test time was required to administer the fine motor screening (excludes consent process and any counseling)

A. 0 minutes
B. 1-2 minutes

C. 3-4 minutes
D. Greater than 5 minutes

7. A fine motor screen is a good addition to our current clinic procedure.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

Please add any additional comments you may have:

Thank you!