



2019

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Recommended Citation

Sa, Vienna (2019) "3D Printing: The Effect of Adapted Mallets on the Participation of Children with Severe and Multiple Disabilities," *Pacific Journal of Health*: Vol. 2: Iss. 1, Article 4.

DOI: <https://doi.org/10.56031/2576-215X.1005>

Available at: <https://scholarlycommons.pacific.edu/pjh/vol2/iss1/4>

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3D Printing: The Effect of Adapted Mallets on the Participation of Children with Severe and Multiple Disabilities

Abstract

The purpose of this study was to determine the changes in two measures of participation for a small sample of children with severe and multiple disabilities when using adapted mallets for instruments. The two measures of participation were: decibel level (dB) and frequency of sound produced. Three children between the ages of 5 and 11 years old participated in a single music therapy session testing four different popular adapted mallets, and a control mallet. A 3D-printed mallet grip was among the adapted mallets and was customized to the individual's hand contour. The sessions tested all five mallets in random order on the each of the three children. Although no noticeable pattern of preference was found for any type of mallet grip, the data indicated that across all the subjects, they produced the lowest dB level and the least frequency of sounds on the control mallet. The results show that there are different preferences for each individual child based on the material and design, not just the hand contour. There are several implications for future research on customizing the 3D-printed adaptive grips to not only their hand contour but the material and design preferences of each child to further increase their participation in music making.

Keywords

children, disabilities, multiple disabilities, severe disabilities, cerebral palsy, music therapy, 3D printing, music, augmentative, adapted mallets, participation

3D Printing: The Effect of Adapted Mallets on the Participation of Children with Severe and
Multiple Disabilities

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The purpose of this study was to determine the changes in two measures of participation for a small sample of children with severe and multiple disabilities when using adapted mallets for instruments. The two measures of participation were: decibel level (dB) and frequency of sound produced. Three children between the ages of 5 and 11 years old participated in a single music therapy session testing four different popular adapted mallets, and a control mallet. A 3D-printed mallet grip was among the adapted mallets and was customized to the individual's hand contour. The sessions tested all five mallets in random order on the each of the three children. Although no noticeable pattern of preference was found for any type of mallet grip, the data indicated that across all the subjects, they produced the lowest dB level and the least frequency of sounds on the control mallet. The results show that there are different preferences for each individual child based on the material and design, not just the hand contour. There are several implications for future research on customizing the 3D-printed adaptive grips to not only their hand contour but the material and design preferences of each child to further increase their participation in music making.

Acknowledgements

I wish to express my sincere gratitude to Dr. Hsiao, Dr. Waldon, and Dr. Brittin for their mentorship, guidance and encouragement in the development of this study. I sincerely thank Hunter Reusche and Mia Saucedo from the Music Management program for being my assistants by accompanying and learning aside with me. I also thank The Cube for the equipment and material for 3D Printing and Jeremy Hanlon for his constant dedication to this project and supreme guidance with 3D printing, imaging and scanning.

Literature Review

6.7 million or thirteen percent of all public school students in 2015-2016 receive special education services. Of those, children with multiple disabilities make up 2% of the total school age population in the 2014-2015 school year (United States Department of Education, 2017). According to the Individuals with Disabilities Education Act, the definition of multiple disabilities refers to “concomitant [simultaneous] impairments (such as intellectual disability-blindness, intellectual disability-orthopedic impairment, et.). The combination of which causes such severe educational needs that they cannot be accommodated in a special education program solely for one of the impairments” (IDEA, 2004). Due to these impairments, these students have to receive special services within a classroom that would be different from their typically developing peers.

It would be beneficial for these students to have an increased opportunity to participate in activities that will not only motivate them to practice functional behaviors, assist them in strengthening their weaknesses, but also give them an opportunity to freely express themselves in avenues where they can feel successful. Music therapy has been a beneficial type of therapy

for people with disabilities as it provides the student motivating opportunities to work towards an area of need in an environment that the student can feel successful in. The American Music Therapy Association requires music therapists to be competent in using adapted equipment, including specifically adapted musical instruments to better cater to students with disabilities.

In the case of students with multiple disabilities, they often have areas of need in the motor area and would benefit from receiving adaptive equipment to help them meet the motor goals within music therapy. Currently the only reference on adaptive instruments for music therapy is by Elliott (1982). She had published a book on ways and situations in which to adapt instruments. One of the most immediately gratifying avenues for children to enjoy participating within the music setting is to produce sounds on instruments. There are currently three adaptive mallets sold within stores that are readily available to music therapists, and none of which are truly customizable. The range of motor function of children with multiple disabilities is so vast, there is a need for a mallet that is customizable. With the release of 3D printing opportunities, one can design an adaptive mallet that can be made to fit perfectly with the student's individualities with relatively affordable costs. In related fields of physical therapy, speech and language therapy, and occupational therapy indicates the benefits of adapted equipment, but there is a lack of published research virtually no recent published research on the benefits of adapted equipment in the field of music therapy working with students with multiple disabilities.

Research Purpose

The purpose of this study was to determine the changes in two measures of participation for a small sample of children with severe and multiple disabilities when using

adapted mallets for instruments. The two measures of participation were: decibel level (dB) and frequency of sound produced. This research will seek to identify the characteristics of certain models of adaptive mallets that will lead the students to produce the most frequent and audible sounds.

Methods

Research Design

The participants were involved in a single music therapy session testing four different popular adapted mallets, and a control mallet. A 3D-printed mallet grip was among the adapted mallets and was customized to the individual's hand contour. The sessions tested all five mallets in random order on the each of the three children.

Participants

Participants were a convenience sample selected from one classroom in a specialized elementary school for children with disabilities. The classroom serves children with severe and multiple disabilities from a school district in the state of California. The children selected had limited control over all motor movement, no means of independent mobility, and need to be transported by caregivers.

Parental permission from the participants were obtained to participate in the study and to be audio recorded for the purposes of data collection (Appendix A). There were four parental permission forms returned within the specified time period and one out of those four participants was sick during the testing procedures. There were three students with multiple disabilities that effectively participated within the study.

Apparatus and Materials

The materials used for testing were four different adaptive mallets and one mallet without any augmentation for control. The control mallet was the Nino Percussion Mallet with the Felt Tip in Medium Hard density. The first of the augmented mallets was the Nino Percussion Mallet with the Felt Tip in Medium Hard density attached with the American Drum

CF4 Adaptive Mallet Cuff. The next augmented mallet was the Nino Percussion Mallet with the Felt Tip in Medium Hard density attached with the Closed Cell Foam Tubing. The third augmented mallet was the American Drum TM1 Adaptive T-Bar Mallet, Standard Bar (T-bar mallet with soft blue rubber ball). The last augmented mallet was the Nino Percussion Mallet with the Felt Tip in Medium Hard density attached with a customized 3D-printed mallet grip.

The customized 3D-printed mallet grip was made by the researcher who took the molds of the three participants' hands in Model Magic material. Then, after the material dried, the molds were 3D scanned into MeshMixer modeling software and 3D printed in durable, pliable PLA Filament.

Procedure

The researcher brought each individual participant with their respective aide from a class lunch for 5-7 min. They were brought to a soundproof room with an audio recording application (Sound Meter iOS, 2014) 6" away from the frame drum to record all sounds. The audio recording application recorded frequency of sound produced as well as decibel level (dB). Each participant was separately given four different adaptive mallets and one control mallet without any augmentation to produce a sound on a 10" frame drum within a song structure of 30 seconds. The sounds and dB level will be recorded when the song begins and immediately stopped when the 30 seconds had passed. The research design gave each participant a random order to use the mallets determined from a random number generator. Because of time constraints, the researcher tested all five different mallets with each participant during a single session. When a mallet was dropped, the aide or the researcher immediately placed the mallet

back in the hand of the designated participant without ceasing the song. After the testing, the participants were promptly returned to the class.

Results

All quantitative data was collected using the data sheets found in Appendix B. Data was recorded after multiple analyzations of the audio recordings of the sessions. Data was collected and compiled in the tables below:

Table 1

Frequency of Sound Produced

Name	Control	Cuff	3D	Transverse	Foam
MAR	3	10	6	5	13
MIK	19	13	33	13	24
AM	6	25	3	40	13

Table 2

Highest Average Level of dB Recorded

Name	Control	Cuff	3D	Transverse	Foam
MAR	109	110	110	108	111
MIK	112	113	115	112	111
AM	113	112	109	109	109

Table 3

Frequency of Sound Produced Across Time

Name	1st	2nd	3rd	4th	5th
MAR	3	10	7	5	13
MIK	19	33	13	13	24
AM	6	3	13	40	25

Table 4

Highest Average Level of dB Recorded Across Time

Name	1st	2nd	3rd	4th	5th
MAR	109	110	110	108	111
MIK	112	115	113	112	111
AM	113	109	109	109	112

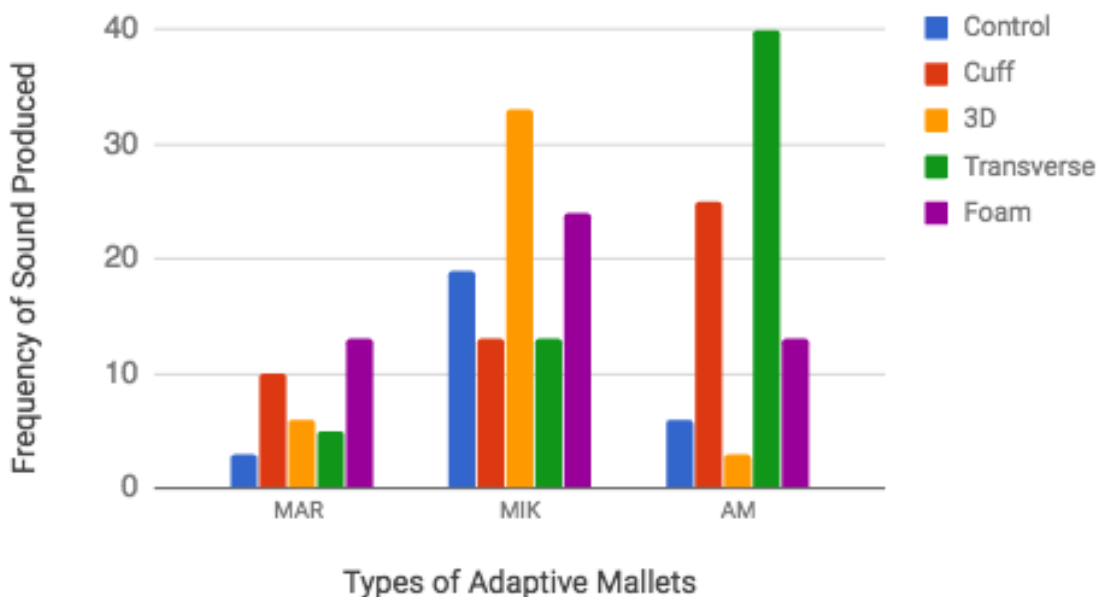
The One-Way ANOVA was conducted for two measures: Frequency of Sound Produced and Highest Average Level of dB Recorded. This was chosen to make comparisons across five samples.

Table 1 $SS= 166.93$ $df= 4$ $MS= 41.73$ $F= .27$ $P= .89$

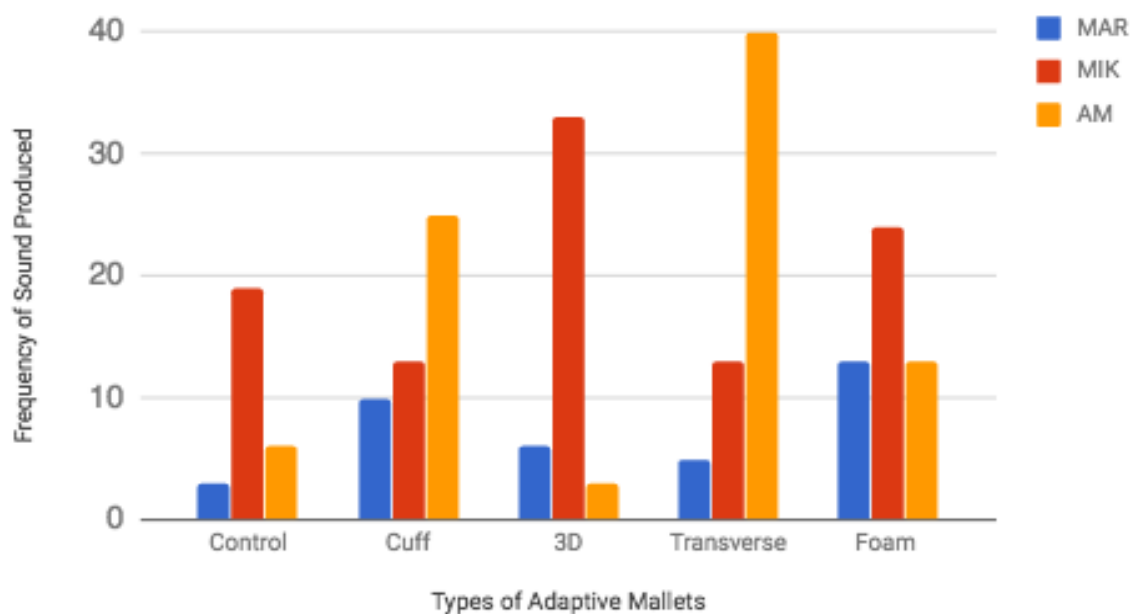
Table 2 $SS= 8.4$ $df= 4$ $MS= 2.1$ $F=0.46$ $P= 0.7$
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None of the results were shown to be statistically significant for either of the One-Way ANOVA measures.

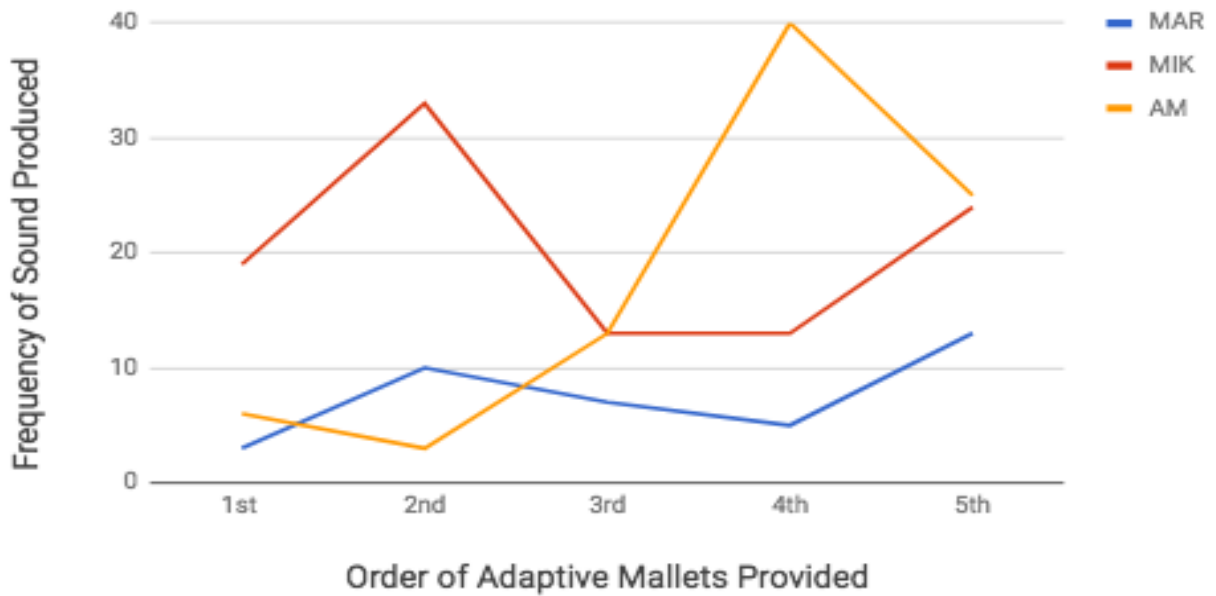
Frequency of Sound Produced by Different Clients



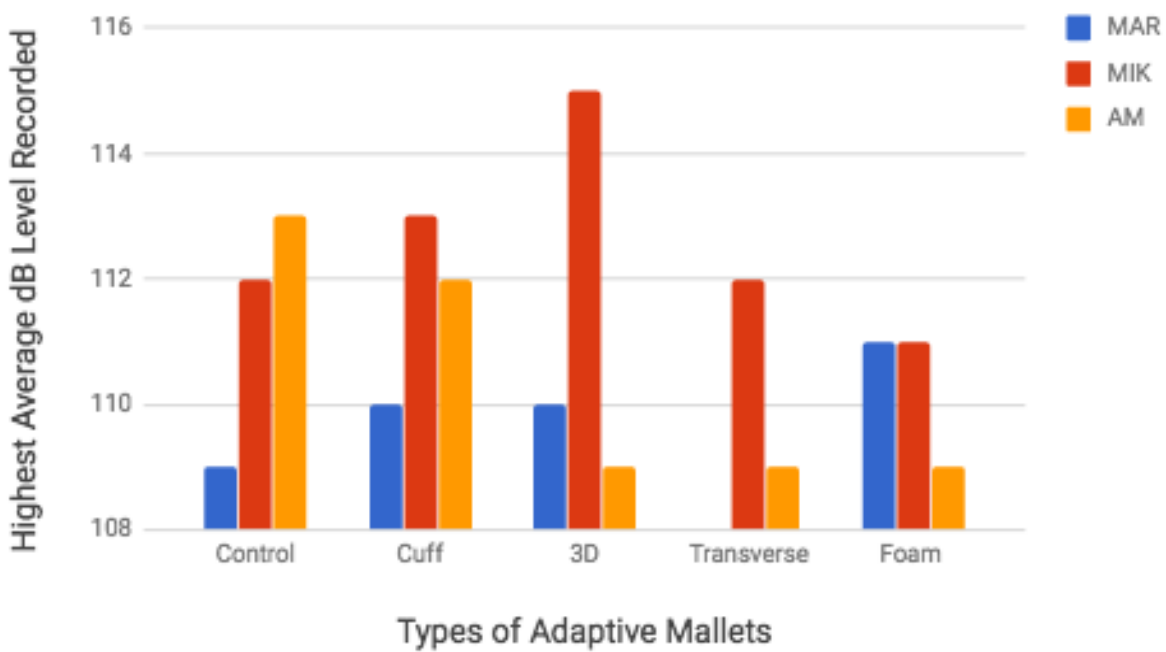
Frequency of Sound Produced on Different Types of Adaptive Mallets



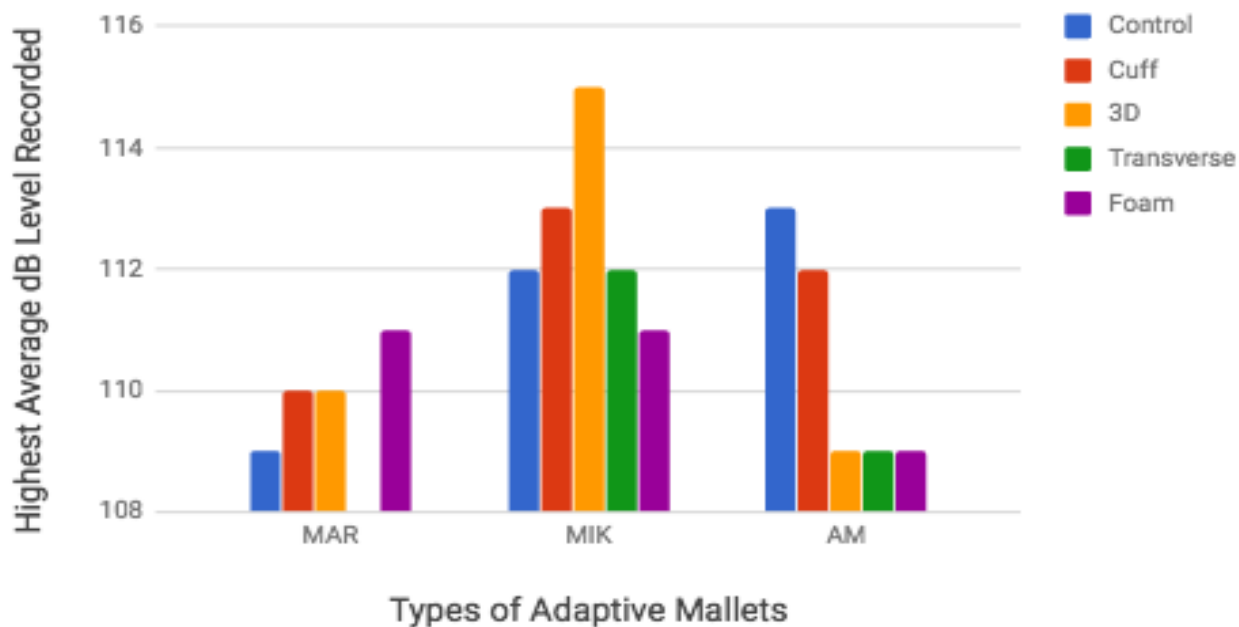
Frequency of Sound Produced Across Time



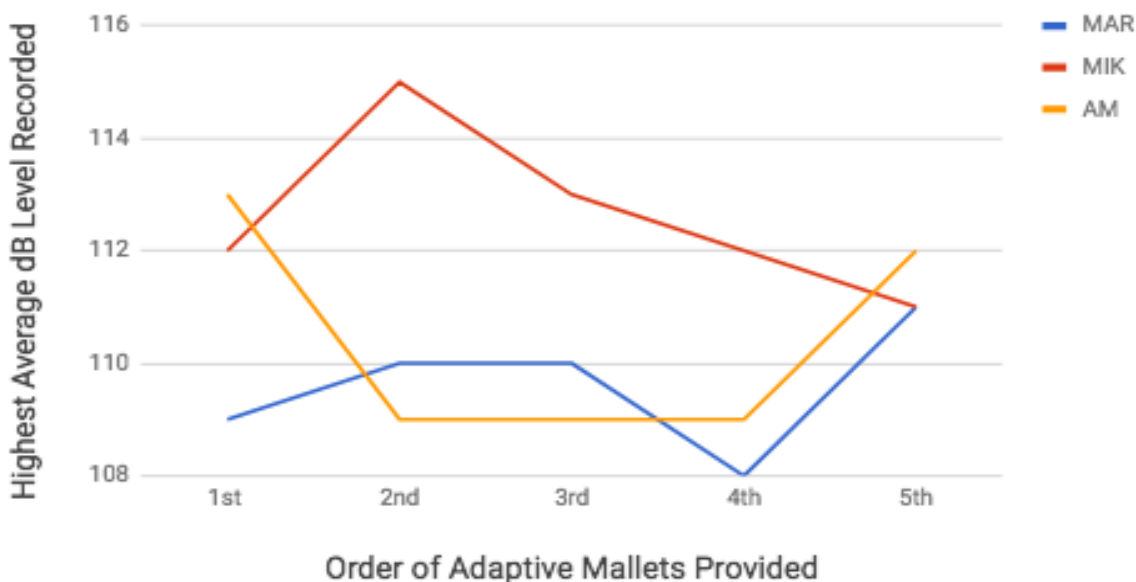
Highest Average dB Level Recorded on Different Types of Adaptive Mallets



Highest Average dB Level Recorded by Different Clients



Highest Average dB Level Recorded over Time



Discussion

The purpose of this study was to examine the differences and characteristics of certain models of adaptive mallets that will lead the students to produce the most frequent and audible sounds. In the graph, *Frequency of Sound Produced on Different Types of Adaptive Mallets*, each participant played the most frequent times on different adaptive mallets. MAR played the most on Foam, MIK played the most on the 3D printed, and AM played the most on the Transverse. However, Control (without any augmentation) was had the least about of sound produced across all three clients. In graph, *Frequency of Sound Produced by Different Clients*, there is an apparent vast difference in skills across all of the participants. For participant AM, she did produce sound on the drum because she was producing sounds with snapping her head on beat. To see if there was a practice effect of learning the exercise over time, refer to graph, *Frequency of Sound Produced Across Time*. There does not seem to be a general positive or negative trend among participants regarding the frequency of sound produced with the order of adaptive mallets provided. The results were based on the individualities of each adaptive mallet as opposed to practice effect.

In the graph, *Highest Average dB Level Recorded on Different Types of Adaptive Mallets*, the participants generally played the loudest on the Cuff or 3D mallet. MIK played the loudest on the 3D printed adaptive mallet. However, Control (without any augmentation) did not see too much of a difference in dB level compared to the other mallets. In graph, *Highest Average dB Level Recorded by Different Clients*, one could see that MIK is able to play the loudest out of the three and AM had the most variety (her mood often was labile). To see if there was a practice effect of playing louder or quieter over time, refer to graph, *Highest Average dB Level*

Recorded over Time. There does not seem to be a general positive or negative trend among participants regarding dB level with the order of adaptive mallets provided. The results were based on the individualities of each adaptive mallet as opposed to practice effect.

Limitations and Future Recommendations

There are several future recommendations and limitations regarding the pilot study. It was observed that the students would perform slightly better over time. Due to the time constraint of this pilot study, it was difficult to control for this practice effect. One could remedy this by either incorporating the song structure within the daily routine so that the clients may be familiar with it to account for the learning aspect or have the participants warm up by playing the song structure through a few times. The researcher in the future should also count the amount of times a participant drops a mallet as that would indicate dislike for that particular mallet. An interesting recommendation for the future would be to test out different textures and materials, for some participants they seemed to enjoy the texture of the foam adaptive mallet as it is novel and demonstrated this by holding on to the mallet longer. Another suggestion if there was ample time to have the participants do the experiment several times and average those numbers to account for the random errors such as the participant having a bad day or was sick. A larger sample size would truly benefit the general body of knowledge and make the results more generalizable for the public/ music therapists to reliably trust and use.

There is no current literature in the body of knowledge on 3D printed adaptive equipment for music therapists. The process for creating these adaptive mallets were intensive, but the researcher had no experience with 3D printing equipment prior to this. The possibilities and implications for this new type of process are endless. Once the initial mold of a client's

hand is 3D scanned into the software, one could easily adjust it to any device such as a tambourine, bells, spoon, or whatever needs to be adapted to an individual's hand. Another point to think about, one could also easily change the material and the texture it would be made from to further customize it to a client's preference. The material used can be switched to be made durable, malleable, or completely flexible. In the future, when 3D printers become more readily available, one could print out a grip within 1-2 hours.

In the current body of literature there is a large gap in terms of adaptations for individuals that have disabilities. 13% of all students have a disability and that is an area that needs to be focused on. There needs to be additional research and implementation in specialized population in order to meet the needs of all music therapy clients regardless of their disability.

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Appendices

Appendix A. Parental Consent Form:

Parental Consent Form

Dear Parent or Guardian,

Your child is invited to participate in a research study being conducted at Walton Special School. The study investigates the most effective adaptive mallets on motor function.

My name is Vienna Sa, MT-BC and I am a Board-Certified Music Therapist and Music Therapy Graduate Student at the University of the Pacific. Your child was selected as a possible participant in this study because of their attendance in music therapy sessions in their classroom.

The purpose of this research is to study the mallet grips that will increase their participation in music therapy. If you decide to allow your child to participate, he or she will be asked to participate in 5-7 minutes of music making once a week for 3 weeks. The study will be conducted in November 2017. Audio recordings will be used to collect data on the performance of the adaptive mallets.

The risks to your child while participating in this study are minimal as might be experienced in the course of regular music therapy sessions in Walton Special Center's classrooms. These risks may include frustration or discomfort with new experiences using musical instruments. We will carefully monitor your child to assist them so as to limit or stop any activity that would cause them discomfort.

At the end of the study, your child will be able to take home the customized 3D printed mallet grip for their personal use.

All information from this study will remain confidential. Data collected will be coded to remove identifying information. Written data will be kept in a locked file cabinet on the campus of the University of the Pacific. Audio recordings will be destroyed at the end of this study. Written data will be shredded. Results will be presented without identifying any child in the class or professional presentation.

If you have any questions about the research at any time, please email me at v_sa@u.pacific.edu. Your child's participation in this study is entirely voluntary. Your decision whether or not they will participate will involve no penalty or loss of benefits to your child. If you decide to allow your child to participate, you are free to stop at any time without penalty to your child. Your child will continue to receive regular music therapy services at Walton Special Center upon the completion of this study, should you decide to remove your child from the music therapy sessions.

By signing this form, I have read and understood the information provided above and agree to have your child participate. You may withdraw your consent at any time and stop your child's participation at any time without penalty.

Child's Name: _____

Participant's Signature: _____ **Date:** _____

Appendix B. Data Recording Form:

Data Recording Form

Date _____ Participant # _____ 1st Mallet # _____ 2nd Mallet # _____

Frequency

Record a tally (/) for each audible sound on the instrument. Start when the music begins and stop when the music ends.

1st Mallet # _____ 2nd Mallet # _____

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Latency

Record the amount of time between the verbal prompt and the desired behavior. The subject will be provided 4 opportunities.

	1st prompt	2 nd prompt	3 rd prompt	4 th prompt
1 st Mallet # _____				
2 nd Mallet # _____				

dB

Record the decibel level for each audible sound after each provided opportunity. The subject will be provided 4 opportunities.

1st prompt

2nd prompt3rd prompt4th prompt

1 st Mallet # ____				
2 nd Mallet # ____				