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Effects of age, timbre, pitch contour, and background noise on melodic contour identification and sentence recognition by children

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Effects of Age, Timbre, Pitch Contour, and Background Noise on Melodic Contour Identification and Sentence Recognition by Children

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by Lindsey Marie Seyfried and Sarah Ann Troy

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PUBLIC PRESENTATION

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Introduction

Lindsey Seyfried and Sarah Troy collaborated together with the help of Dr. Yingjiu Nie in the Lab of Auditory Perception in Children and Adults on the four research studies completed there. They are as follows:

- The build-up of auditory stream segregation in adult cochlear implant users: Effect of differences in frequency and amplitude-modulation rate
- Build-up effect of auditory stream segregation using amplitude-modulated narrowband noise
- Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children
- Melodic Contour ID and Sentence Recognition by Cochlear Implant Users

Through these projects, we were involved in all areas of the research process. While we cannot claim the research project as our own, by assisting the graduate students and Dr. Nie, we exposed ourselves to how research is conducted in this field and gained valuable knowledge in the process.

Outline

1. Reading Articles: Dr. Nie provided us with research articles related to the topics (see bibliography). We read these articles and completed article summary sheets (see attached) to help us isolate and understand each component. Then we discussed different aspects of the research and made sure that we both understand all of the technicalities. We did this for eight articles.
2. Running Participants: We observed the testing of participants run by the graduate students. Once trained how to use the software and equipment, then we scheduled and tested the participants ourselves. We observed and assisted with nine participants and then tested three participants on our own. We kept a log of time spent in the lab that describes what we experienced with testing each participant, keeping in mind confidentiality and privacy. Lindsey spent about 29 hours running participants. Sarah spent 30 hours running participants.
3. Data Extraction and Analysis: With the help of Dr. Nie, we extracted and analyzed the data from the three participants that we tested ourselves. Once our task was clear, we were able to continue ourselves. We kept a log of time spent working on data extraction and analysis, what was accomplished, and any challenges faced during the time. We both spent approximately 9 hours working on this area.
4. Presentation Production: We organized the information collected from our three participants into a professional poster presentation. We will then be able to share this information for other professionals at the Spring 2017 Honors Symposium. We again kept a log of time spent working on the production of the poster presentation, what was accomplished, and any challenges faced during the time. We spent approximately 10 hours working on manuscript and presentation production.

5. Reflection: Our final step was to summarize the whole process in an individual personal reflection. Using our various logs and summaries from throughout the process, we created our own detailed summaries of each part of the research process and then reflected on what we learned, how we met our objectives, what stood out, the biggest challenges, how it changed our perspective, our feelings towards the research topics and the research process, and how we will use this information in our future professions.

Objectives

The objectives of our senior honors project were as follows:

- To gain knowledge of the research process especially in relation to the field of communication sciences and disorders
- To improve our ability to collaborate with other professionals within the field and adapt to challenges as they arise
- To learn about our own strengths and weakness in regards to the several of aspects of a research process
- To help the graduate students collect and analyze data to come to a conclusion about their research topics

Lindsey Seyfried's Reflection

As members of the James Madison University Honors College, Sarah and I were a part of the seminar entitled The Psychology of Sustainability and Connection to the Natural World which include a trip to the country of Malta. There we studied the relationship between humans and nature and experienced it firsthand. We learned of many studies within the fields of education and psychology that show an increase in attention, productivity, and good behavior as well as a decrease in stress and anxiety in children when a given task is moved outside. We were very much interested in how this might translate to speech-language therapy goals if sessions were moved into a natural environment. We reached out to several speech-language pathologists in the Harrisonburg area, but with their caseloads being so full and the many government regulations they were unable to take on our project and allow us access to their therapy sessions. While this project did not come to fruition, I still think Sarah and I learned a great deal from this first project attempt. I think it taught us a lot about experimental design. We wanted to know the answer to the question, "How does changing the location of speech/language therapy sessions to an outside space change the outcomes of the therapy?" so we needed to come up with a research protocol that would give us those results. While we never got all the way to the fine details of the design, we did spend a lot of time thinking about how to isolate the variables we wanted to study and how we would involve a speech-language pathologist who already has his/her specific clients. Throughout the process of deciding how to go about this project, we asked many different people for help. Not only did we ask many SLPs in the area, but also Dr. Lincoln Gray, the CSD Honors Liaison, Dr. Debbie Sturm, the professor of the Honors seminar, and Mrs. Debbie Yancey, a retired SLP who now teaches in the Exceptional Education department. We would not have made as much progress as we did if it were not for them. I think this

demonstrates the need for researchers to work on teams or at least be involved with others. It is important to be able to share your ideas with other professionals to get their ideas and feedback in order to take the project to its fullest potential. This project also taught us that researchers need to be resilient. It was discouraging for us that the speech-language pathologists in the area were unable to help us, but if we wanted to make this project happen we had to keep going. If we weren't on a deadline to submit our Capstone proposal we probably would have continued until we came up with a new idea for how to go about this project. Unfortunately, because of the deadline, we ended up abandoning this project and instead got to work with Dr. Yingjiu Nie in the Lab of Auditory Perception in Children and Adults at JMU. I am very glad that Sarah and I got this opportunity. I think this project provided us with many experiences that the other would not have. Sarah and I still have our entire clinical careers to do more research related to the topic of nature and speech/language therapy.

To understand the work being done in Dr. Nie's labs, we had to read the previous research that has been done in relation to the topics of stream segregation as well as sentence and melodic contour identification. I have had experience reading research articles in the past and I have a pretty good understanding of how to break them down into their parts to comprehend what the researchers are doing. I found the summary sheets we used particularly helpful because they laid out exactly what to look for in each article and provided an organized way to take notes on them. I will probably use these again as a graduate student especially when I am analyzing a large number of articles as I did for this project. In general, I easily grasped the purpose of the studies we read for this project, as well as what and who they were studying. In most cases, I was also able to understand what they were using as their independent and dependent variables. I had trouble with the experimental design and the measurements they used for the identified variables.

This was because of the technical terms used. Some of them I knew from my coursework in Communication Sciences and Disorders and some I had never heard before. I had trouble understanding even the terms that I knew within the context of the articles. I had difficulty figuring out what the numbers and descriptors meant for the stimulus sound, especially for the articles related to stream segregation. On my own, I read them repeatedly and tried to look up definitions for the terms I did not know. I made progress towards comprehension, but in the end, it took explanations by Dr. Nie and the graduate students as well as actually hearing the stimulus to fully comprehend how the researchers were manipulating the variables. I appreciated being able to go through these articles with Sarah. I liked being able to talk through the ideas with someone who was also at the beginning of their understanding of the studies of stream segregation as well as sentence and melodic contour identification. Through this aspect of the project, I realized that just because you have seen and read one research article within your field does not mean all research articles will be easy for you to figure out. There are so many different aspects of Communication Sciences and Disorders and so many different directions that people can take their research. I believe the most important thing I will take away from this part of the project is that you can never have too much practice reading and understanding research studies. As a future speech-language pathologist, it is important to stay up-to-date on the latest research to be able to provide the best care to my clients even when this means stepping outside of what I am familiar with to learn new aspects of the field. It is important to call on experts in the area of study when you are confused or trying to pass judgement on the research methods and conclusions.

Running participants was my favorite aspect of this project. Sarah and I started out observing the graduate students running their subjects and eventually took three child

participants on our own. Once the testing protocol is set up (which for Sarah and I, already was), it is not difficult to run the participants. You just take them through the trials in the randomly generated order. The difficult part is finding the participants and getting them scheduled. Alexandria (Allie) Matz, an Au. D. student, who was working on a project with stream segregation in cochlear implant users and normal hearing adults, had a lot of difficulties finding participants. Harrisonburg is not the best location for a population of people with cochlear implants. Allie did manage to find who she needed. I remember her saying that at one point in time she was so desperate that she went up to a woman in a restaurant who she saw was wear a cochlear implant processor and asked very politely if she would be in her study. Allie also needed adults over the age of 50 with normal hearing. She had plenty of responses when she emailed the JMU faculty and staff looking for people. Several times Sarah and I came to observe and when Allie tested the subjects' hearing before beginning the protocol their hearing was a little less than what is consider normal so she had to turn them away. Age-related hearing loss is normal and because many of the adults in and around Harrisonburg have spent time hunting or working around loud farm equipment, they are even more likely to demonstrate hearing loss. I think Allie's difficulties demonstrate one huge challenge for research with human subjects. To keep as many variables as possible controlled, you need to be specific in which subjects you can use for your testing. The difficulty is finding real human beings who meet the criteria you need within the geographical range of the study. Sarah and I were lucky enough to be able to use participants that had already been found by the graduate students. We only had to schedule our participants which still posed to a bit of a challenge especially with children who had to come when they were not in school, they had no extracurricular activities, their parents could drive them, and ideally when both Sarah and I were free.

The biggest challenge for Sarah and me when running the three children on our own was keeping them engaged and focused. Most of the trials are listening to sentences and clicking the words heard. The only thing that changes is the amount of background noise. We did our best to explain the goal of the testing, but it is hard to get the kids excited. I can completely understand why a child might find this boring. It is boring for Sarah and me as college students to sit with them while they complete the task and we completely understand the motivation behind why we are going through the task. We tried to break up the time for the children by letting them watch videos or play computer games, but it is still a long time to ask them to sit still. One mother helped us a lot with keeping her son on task. She even suggested of letting him run down the hallway between trials to get out some of his energy. This definitely made a difference. The protocol had to be what it was to get the results we wanted. As a speech-language pathologist, I think I will keep this experience in mind when creating lesson plans. All children and even adults need to have lots of different activities to keep them interested in what they are doing. It is also important to explain what the purpose of the activity is to get them motivated. That poses another challenge of doing research or working with human subjects. It can sometimes be difficult to explain to the subject what it is that you are studying and what you expect them to do for the trials especially if they are young children and/or not familiar with this particular field of study. Allie's project is one that is particularly difficult to explain because it is hard to describe the stimulus sound in common language. I admired her patience in having to say the directions repeatedly while allowing the subject to have as many practice trials as they needed until their results were consistent indicating that they understood the task.

I enjoyed observing and interacting with all the different subjects who came into the lab. We worked with children, adults, individuals with normal hearing, and cochlear implant users. I

liked seeing how the different personalities and ages responded to the testing. I think when it comes to research with human subjects is it easy to reduce the subjects to their code names and forget that they are individuals and not just data points. While some of this is necessary to keep the research unbiased and to keep the identities of the subjects confidential, it is important as a researcher to remember that these people have their own lives and personalities which they share with us to benefit our educational careers, the research project, and the entire field of Communication Sciences and Disorders.

I knew the least about data extraction and analysis and needed the most guidance in this area. Sarah and I had only ever taken the basic statistics class required by the CSD major and both of us had taken it within our first couple of semesters at JMU so it had been awhile since we had to used our knowledge. Dr. Nie helped a great deal with this aspect of the project. For extraction, she set up the table for us to fill out with the data we received from each subject and for analysis she sat with us and gave us systematic directions for how to run the data in the SPSS program. She was very patient with us and took her time explaining to be sure that we knew what each output meant and what conclusions we could draw from it. I never realized how many ways there are to analyze any one set of data. I definitely do not have enough experience at this point in my educational career to be able to choose how to analyze a data set on my own. However, a few days after we did the initial analysis, we realized that we needed to analyze one additional aspect of the data, I was not confident in my ability to do it without Dr. Nie's guidance, but as we went through it together I realized how much I had learned. To my surprise, I knew what to click to get the output we needed. Dr. Nie also helped us decide on how to create graphs to display our data and showed us how to set them up. She walked us through creating the first one and then left us to complete the rest on our own. This is an area that I probably would

have been able to do on my own as I have some experience making graphs in Excel, but it would have taken me longer without her help. With the review, I am more confident in my graph making skills and will use what I have learned in the future when I need to make graphs to display any type of data whether that be for a research project or to display the progress of a speech/language client.

Sarah and I decided to show the data and analysis gained from the three child participants that we ran ourselves on a poster for the Spring 2017 Honors Symposium to demonstrate what we have done for our project. Michael Morikawa, another Au. D. student, whose project ours stemmed off of, had presented a poster at the American Audiology Association conference. We worked off his poster which helped us create our poster to a high standard. I was nervous about this process because it seemed to be the final test of our knowledge. When Sarah and I sat down together to write the introduction, it helped us realize how much we had learned and could now explain. I think creating the poster was an important step in my mind for being able to think through the project as a whole. The introduction section lays out what the field already knows. The methods show what we did. The results show what we discovered and the discussion explains what we have learned. I'm not sure I would have been able to process the experience the same way if we had not created the poster for presenting.

I also appreciated having to write this reflection because it allowed me to think about not only the data and the results, but also the process as a whole and my own experience with the process. I like that I will have a written record of my experience that I can look back on. This reflection was more for me while the poster is more for others interested in the project. It was not until I started writing this reflection that I realized how much Sarah and I had really done. It did not feel like as much work as it was spaced out over the course of three semesters, but when I

started writing about what we did and what it meant to me, I realized the quantity and quality of work we had done.

Overall, I think the project met our objectives. The first objective was "to gain knowledge of the research process especially in relation to the field of Communication Sciences and Disorders." I can say, with confidence, that I have learned a lot about the research process. The best way to learn about anything is to experience it and that is what we did. I knew the research process from working through it in classes. This was my first hands-on experience outside of science classes. In these classes, the professor or teacher already knows what is expected to happen and there are not any new discoveries. In this project, we were collecting data to find new trends. This was also my first experience with research specific to the field of Communication Sciences and Disorders. I had read articles related to the CSD field for classes in the past, but this was very different. After spending time observing the graduate students, Sarah and I were able to run participants on our own. We were able to go through all the steps of analyzing previous articles, finding and running participants, extracting and analyzing data, as well as create a poster to share what we learned.

Our second objective was "to improve our ability to collaborate with other professionals within the field and adapt to challenges as they arise." Our whole project was a collaboration because we worked with the graduate students on projects they had already established. We were either observing their research or using their protocol on our own subjects. Sarah and I also collaborated with each other on many aspects of the project including our proposal and final poster. We made good research partners because we balanced each other out. I think her strengths are my weaknesses and vice versa. We tried to be sure we were always communicating well with each other, the graduate students, and Dr. Nie. Additionally, within Dr. Nie's lab there

are many different graduate students who need to share the space and we share the sound booth with another lab with its own set of researchers. Because of this, it is very important that we keep a calendar and everyone puts when they need the computers or the booth in that calendar. Organization is key to keeping the lab functioning.

Sarah and I observed and experienced challenges during this process, but we were able to figure out ways past them. This whole project with Dr. Nie was a way around the trouble we found with our first project. We also learned the difficulties of finding and scheduling participants and that the only way around it is to keep reaching out to more people. I think the challenge we faced that will be most applicable in both of our careers is the fact that children get bored easily. You need to have a set of tricks and activities if you want to keep them engaged and focused on any one task.

Our third objective was "to learn about our own strengths and weaknesses regarding the several aspects of the research process" From this project, I think one of my strengths is collaborating with others. I loved the fact that I had a partner on this and I believe that Sarah and I did a good job of sharing the work. I also think we were good about asking for help when we needed it and not trying to do things on our own even when we were confused. Another strength I demonstrated in this project was my ability to be methodical and logical. I think am good at not getting too overwhelmed when I had a lot of different aspects of the project to do and keep track of. I took everything one step at a time and kept moving forward with what needed to be taken care of at that moment. I think a weakness I saw in myself during this project is the ability to create small talk. Finding conversation topics to discuss with adult strangers has always been difficult for me. I have always preferred interacting with children. I noticed that Sarah was much better at this and did a better job of making the participants feel welcome. This is something I

will need to continue to work on because in life and as a clinical speech-language pathologist I will have to make conversation with adults I know very little about.

Our fourth and final objective was "to help the graduate students collect and analyze data to come to a conclusion about their research topics". I hope the graduate students found us helpful. Sarah and I appreciated being able to work with them. I liked having other students, who were more experienced but not much older to explain things and help us along. While we only ran the protocol on three participants on our own, I still feel like we added to the productivity of the lab overall. When Sarah and I compared our data to the data of Michael's larger project we saw some of the same correlations such as the fact that normal hearing children's ability to identify spoken sentences degrades when pitch contour becomes unnatural. However, because of our small sample size we were not able to see significance for some of the other trends.

Because the research side and the clinical side of Communication Sciences and Disorders go together, this research experience will make me a better consumer of research as a clinical speech-language pathologist. It has taught me how to deconstruct and critique articles before applying them to practice and has provided me with experiences that have helped me to better understand the research process. Research in CSD is driven by what is being seen in clients on the clinical side. The clinical procedures used are driven by what is being discovered in the research. Even the topic of the project itself relates to Speech-Language Pathology as it has to do with speech perception. A person's ability to produce speech is related to their ability to perceive speech. Many children who get cochlear implants need speech-language therapy to catch up with the abilities of their same aged peers. It may one day be relevant for me to understand how children with cochlear implants perceive speech related to timbre, pitch contour, and background noise and how that compares to their normal hearing peers.

Research was never something I saw myself doing. It was not something I was particularly interested in. I always knew I want to be on the clinical side of Communication Sciences and Disorders as a speech-language pathologist or audiologist. I ended up finding this project solely because of the Honors Capstone requirement and I am glad that I did. I enjoyed the project much more than I thought I would. My favorite part of the project was running the participants. I think that demonstrates why I have decided to be a clinical speech-language pathologist. I want to interact with people. I did enjoy extracting and analyzing the data to understand the results, but I would much rather have spent this time working directly with the people or at least creating lesson plans for therapy that would directly affect one individual. Because this project is more on the audiology side of CSD, it was one factor that led me to consider going into that profession instead of speech-language pathology. After observing and experiencing the clinical side of audiology through a class, I did in fact decide against it because it felt less creative and more medical. I still enjoyed this experience immensely and am extremely grateful that it was a part of my undergraduate education here at James Madison University. Graduate school, wherever I choose to attend, will provide many new opportunities to be involved in research. I have not yet determined whether I will include a Master's thesis in my plan of study, but I believe this project has helped prepare me for any future research endeavors as I have been witnessed to the challenges that come with research especially that with human participants.

Sarah Troy's Reflection

For our Honors Capstone Project, Lindsey Seyfried and I decided to collaborate on a research topic for which we were both passionate. During the summer of 2015, Lindsey and I both studied abroad in Malta, where we completed our Honors Seminar course on The Psychology of Sustainability and Connection to the Natural World. Through this course, we learned about how time spent in the natural environment has many benefits for one's health, intelligence, and happiness. While studying this topic abroad, Lindsey and I started wondering if speech-language pathology services conducted outside would produce better results than traditional therapy done inside in a clinic or a classroom. Since Lindsey and I are both a part of James Madison University's Honors College and are both Communication Sciences and Disorders majors entering the field of speech-language pathology, we decided that it would be a great idea to collaborate on an Honors Capstone Project to test if speech therapy conducted outdoors would affect the therapy results.

Upon coming back to James Madison University in the fall of 2015, Lindsey and I, with the help of Dr. Gray, started trying to put together this Capstone project. Unfortunately, after months of contacting various speech-language pathologists within Harrisonburg City and Rockingham County, we came to terms that there were too many complications with our project idea. For instance, privacy and confidentiality were an issue. Also, while many speech-language pathologists said they would be interested in hearing the results of such a study, no clinicians wanted to change their normal environment to try therapy outside. Having clients and parents agree to move the therapy outside would have been an even bigger issue. Therefore, Lindsey and I resorted to contacting faculty members within the Communication Sciences and Disorders department at JMU to see if we could help with any of their current research projects. Luckily,

Dr. Yingjiu Nie agreed to have us conduct research in the Lab of Auditory Perception in Children and Adults. In this lab, we assisted with various research studies that were being conducted by Dr. Nie and several graduate students in the Doctor of Audiology program.

For our research project, Lindsey and I had many objectives. We hoped to gain knowledge of the research process especially in relation to the field of communication sciences and disorders. As I did not know much about how research was conducted in the field before to this project, I definitely feel as if I have gained useful knowledge. Prior to actually conducting research and collecting data in the lab, Dr. Nie assigned Lindsey and I multiple articles to read to enhance our knowledge on the research topics we would be exploring. Lindsey and I each read and summarized these articles. There was a lot of information in these articles that I had not previously known which enhanced my knowledge of the field of audiology before I began the research. For instance, I learned a lot about how different pitch contours and background noise effected speech perception from the article by Miller, et al. (2010). This was a big part of our research study so it was great to have this background knowledge before beginning the research. Additionally, through the article by Gavin et. al (2015), I learned that their study found a relationship between a musical background and an increased performance on melodic contour identification testing. Since the study by Michael Morikawa, a graduate student in the Doctor of Audiology program at JMU whom Lindsey and I helped with research, on *Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children* also examined how musical experience could affect melodic contour identification, I found that this article relates well to Michael's study, for which we would be helping collect data. Many of the articles also included important information on cochlear implant users, which I found very informative because I did not know much about the effects of cochlear implants prior to this

research project. After further discussing the research topics and methods with each other and Dr. Nie, Lindsey and I then learned more about the specific aspects of the research process by observing the graduate students in the lab. After we were trained to use the lab software and equipment by Dr. Nie and the graduate students, Lindsey and I were then able to schedule and test the research participants ourselves.

Another objective of ours was to improve our ability to collaborate with other professionals within the field. I definitely believe that I strengthened my ability to collaborate effectively. Lindsey and I made excellent research partners, as we always made sure that at least one of us would be available to test the research participants coming into the lab that Dr. Nie had scheduled for us to test. We both worked in the research lab for about an equal amount of time. Collaborating with one another made scheduling research participants easier because we had a more flexible schedule available. Most of the time, however, Lindsey and I would both be in the lab together. This way, we were able to help one another and always made sure that the research program was run effectively and without error. Lindsey and I worked not only with one another and Dr. Nie, but also with the graduate students in the Doctor of Audiology program. Therefore, we were working on multiple research studies at once, which seemed a bit daunting when we first started the research process. However, Lindsey and I kept the instructions given to us for each project organized and were able to effectively help out with all of the research studies assigned to us. If we ever ran into any challenges, we always made sure to communicate effectively with Dr. Nie or the graduate students in order to solve any problems efficiently.

Lindsey and I also hoped to learn to adapt to challenges as they arose within the laboratory. We definitely had some challenges along the way. One challenge that we dealt with was helping one of the graduate students, Allie Matz, find research participants for her study that

she was conducting for her AuD dissertation. In order to meet the criteria for Allie's study, participants had to have normal hearing (no more than a 20 dB loss). Allie was looking for willing participants over the age of 50 years old with normal hearing. On four different occasions, we helped Allie test the hearing of participants over the age of 50 years old but found that their hearing loss was greater than a 20 dB. Therefore, these participants were unable to participate in the study. While it was definitely a challenge trying to find a participant over the age of 50 years without any degree of hearing loss, we did not give up hope and eventually had a participant who matched all of the criteria needed to participate.

This experience taught me some of the difficulties of conducting well-rounded research. For instance, I learned of the difficulty of finding participants of all age groups who fit into the criteria for the study. Additionally, I learned how crucial it is for all participants in the study to fit exactly into the set criteria. For example, one of the participants had only a slight hearing loss of 25 dB in one ear. Allie considered testing this participant for the research study since it seemed as if we would never find a participant over the age of 50 years without more than a 20 dB loss. However, if Allie had used this participant in her study, then she would have had to change the criteria. Instead, Allie decided to turn away the participant. Luckily, the next participant over the age of 50 years had normal hearing and we finally had a subject for the study.

While helping Michael Morikawa with his research study on *Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children*, we had a similar problem. Michael had two young participants come in for his study who had both had normal hearing when they had been tested recently in school. However, when we did the routine hearing check on the audiogram, we found that both participants had sensorineural hearing loss.

Therefore, since participants had to have normal hearing, they did not qualify for the study. In addition to having to tell the young participants that they could not participate in the study, which both participants seemed to be looking forward to, we also had to inform them and their parents of their hearing losses. However, this experience taught me how you must be prepared for this scenario when conducting research or working in the field of audiology. I also learned that hearing tests at schools sometimes are not as accurate as they are supposed to be. Therefore, some children's hearing losses may go undiagnosed, such as in the case of these two participants. This can have many implications for their learning and communication abilities. Therefore, even though it was difficult to have to inform them about the hearing loss, I am glad that they were tested for our study so that they became aware.

While conducting research in the field of audiology, I was surprised to discover that many individuals truly did not know about their own hearing losses. While most hearing losses we discovered while testing participants in the lab were only mild to moderate hearing losses, six out of the twelve participants that we tested had hearing losses of which they were previously unaware. Four of the participants who had had hearing loss were adults who had not had their hearing tested in years. However, the two young participants with sensorineural hearing loss who had come into the lab to participate in Michael's study had been getting their hearing tested at school yet their sensorineural hearing losses had gone undiagnosed. These findings made me realize how important it is to spread awareness about how common hearing loss is, especially as one ages. It also made me realize how important it is that hearing is tested by skilled audiologists who do an extensive screening, not just school nurses who may not screen students' hearing at all levels. Hearing losses can have many implications on one's ability to communicate or to learn in school or the workplace. Therefore, I have a new realization of how important it is for one to

have their hearing tested by skilled audiologists and to be proactive about one's hearing abilities and needs.

In addition to having problems finding participants who met our criteria, we also ran into issues with participants cancelling or not showing up to the laboratory when they scheduled. While this is an issue that can be very frustrating, it is something that I have learned happens frequently within research studies. I will now be prepared for dealing with cancellations and "no-shows" in my future research or career, as I have learned in my Methods and Observation course that it is not uncommon for clients to cancel or not show up to their appointments in speech-language pathology clinics.

Another challenge that we became aware of while helping Michael with his study was the short attention span of children. While testing the two young participants under the age of 15 years on the same day, we realized that neither child's attention span was going to last for the full three hours of the program. Therefore, we decided to split up the program so that each child completed the first half of the program that day and then completed the second half of the program about a month later. We also frequently asked if they needed a short break, giving them time to relax or use the bathroom if needed. This way, each child stayed fully engaged and the results were not affected by a lack of attention. When testing subject who was below the age of 10 years old, I realized how much more difficult it was to hold the attention span of a subject at this young of an age. While at first the participant seemed intrigued by our research study, he became fatigued after only about two conditions on the experiment. Therefore, we had to start giving him breaks after about every two conditions. We also gave him rewards, such as playing computer games or running through the hallway to get his energy up. In addition, we had to use the mouse to click the answers on the computer screen for him because of his young age, which

was something we had not previously had to do with any of our other subjects. I now know that if I work with children in my future career as a speech-language pathologist, I may have to make modifications to therapy strategies when working with younger clients. I will also have to allow frequent breaks and incorporate exciting activities into my therapy lesson plans in order to hold my clients' attention spans for effective therapy or research.

Another objective of ours was to learn about our own strengths and weaknesses regarding the several aspects of a research process. A weakness of mine was definitely remembering all of the steps in order to correctly set up the lab equipment and software programs before testing the participants. I have never been very technologically advanced which posed a challenge as there was a lot of technology and equipment involved in each research study. However, Lindsey was very meticulous when it came to setting up the software and equipment so it was extra helpful to have her to collaborate and assist. Also, since she was enrolled in the Methods and Observation in Audiology course in the fall semester of 2016, Lindsey also had more practice using an audiogram and working in an audiology clinic than I had. Therefore, she was extremely helpful to have as a research partner. Another strength of mine throughout the research process would definitely be my communication and interpersonal skills. When conducting research in these programs, we had to interact with the research participants in a friendly and professional manner. We also had to explain the tasks in a common language that participants would understand. Additionally, we had to encourage the participants, especially the younger children, to be attentive while completing their tasks. As I have always had good interpersonal skills, I believe that I was able to communicate and interact with the participants effectively. My patience was also a beneficial characteristic, as many of the programs took several hours for the participants to complete. Additionally, my organizational skills were needed in order to keep all of the

instructions and information for each of the different research studies in an organized, detailed manner.

Our final objective was to assist the graduate students in collecting and analyzing their data in order to summarize the findings of their research topics. Lindsey and I observed and assisted with testing nine participants between April and December of 2016. We then tested three research participants on our own using the Angel Sound software between November 2016 and February 2017. In December 2016, we started extracting and analyzing the data from the three participants that we tested ourselves. During my Statistics course two years ago, I learned how to use the software program SPSS. However, I had never had to apply my knowledge of the program outside of that course until we started this data extraction process. Dr. Nie demonstrated how to use SPSS to extract and organize the data so that it could be used for our study's analysis. I may have to use SPSS in my future graduate studies or career if I am conducting research so I was glad to have the opportunity to utilize the program once again. While extracting the data, Lindsey and I realized that one child's data was an outlier, scoring higher on certain trials than most of the other children had on the same trials. Since this data throws off the common trend, it might have implications for the results of Michael's study as well as our own. This further illustrated the importance of having a large population included in the research study to make sure that findings are correct.

When Lindsey and I analyzed the data that we had collected from testing these three subjects, we found some significance that matched up with the significance of Michael's larger study on *Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children*. For instance, both our study and the larger study found that normal hearing children's ability to identify sentences was significantly degraded when the pitch contour

was unnatural (not in the spoken condition). However, not all of our data matched the same trends as the larger study's data. For instance, the full study found that normal hearing children's melodic contour identification was affected by the complexity of speech timbre. We did not see this trend, but this is probably due to our small sample size. Also, the one subject who was an outlier on all of the melodic contour identification tasks probably affected the trends of our data in this area. The full study also found that the performance of melodic contour identification and sentence identification was lower overall in the younger group of children. We did not find a significant age correlation on either task for our set of subjects. However, when looking at how single-to-noise ratio and age group interacted together, we found that there was a significant correlation showing that the younger (below age 10) subject's sentence recognition was more affected by greater levels of background noise. We also found that there was a significant effect of signal-to-noise ratio on the sentence recognition performance across pitch contours. We found that all three of our subjects had the worst results on the sentence recognition tasks when the background noise was three louder than the signal. The results then improved when background noise and signal were at the same intensity. All three subjects had the best results on the sentence recognition tasks when the signal was three times louder than the background noise.

It was very interesting for me to analyze the data and see the trends in our study as well as to compare these trends to the larger study. I was very intrigued by how pitch contour, signal-to-noise ratio, and timbre affected perception in research that I had conducted myself, and not just read about. I felt as if this was a great learning experience for me both in terms of understanding how pitch contour, signal-to-noise ratio, and timbre affect perception as well as understanding how to collect and analyze research data. I did not have much experience with the research process prior to this project as I had never before conducted research in a laboratory.

Therefore, my knowledge and perspectives of the research process has grown over the past three semesters. I now have a deeper understanding of the importance of the paperwork, preparation, privacy protection, and background research that comes with each study. I have always aspired to have a clinical career in the communication sciences and disorders field, but after conducting this research, I am now open to searching for a career in which I can conduct more research.

Additionally, while I have studied audiology in my major of Communication Sciences and Disorders, I have always been more drawn to the speech-language pathology aspect of the major. Due to this project, I have enhanced my knowledge of the field of audiology and now have a deeper interest in this area of CSD. I was very interested in learning about the dissertations of the graduate students in the Doctor of Audiology program while working in the lab with them. While I still plan on attending a graduate program in speech-language pathology, I now have a stronger appreciation for the work of audiologists. Learning about both the study being conducting on the build-up of auditory stream segregation in adult cochlear implant users as well as the study being conducted on the melodic contour ID and sentence recognition by cochlear implant users has led me to develop an interest in potentially working with individuals with cochlear implants in my future career as a speech-language pathologist. I also was very interested in learning more about how pitch and timbre affect word recognition. I gained a better understanding of the difference between pitch and timbre and what allows us to discriminate between differences in both pitch and timbre. Since cochlear implant technology codes both pitch and timbre the same way which interferes with cochlear implant users' discrimination of these aspects of sound, I found Dr. Nie and the graduate students' research in this area to be very needed and interesting. I really enjoyed the passion that I saw in the graduate students when

discussing their research topics and hope that I find an area of research in graduate school that I am just as passionate about.

I believe that my experience assisting Dr. Nie and the graduate students in their research conduction as well as my experience extracting and analyzing the data while working on this Honors Capstone Project have provided me with skills and experience that will be of great help to me in my future studies and career. I have a much deeper understanding of the research process than I did only one year ago. I also have learned many skills and have gained a better appreciation of my strengths as well as a deeper understanding of my weaknesses. I have learned how to better collaborate with others as well as how to adapt to challenges that arise. I know that I will use the knowledge and skills that I have learned throughout this process to help me succeed in my future studies, research, and career.

Effects of Age, Timbre, Pitch Contour, and Background Noise on Melodic Contour ID and Sentence Recognition by Children

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Introduction

- Timbre, pitch and background noise have an affect on perception of speech and melodies
  - Timbre is the distribution of energy across time and frequency that contributes to listeners' ability to determine the difference between individual speech sounds as well as musical sounds
  - Pitch is "the attribute of auditory sensation in terms of which sounds may be ordered on a musical scale" (Moore, 2003)
  - Different levels of background noise affect the ability to a listener to correctly perceive the intended signal
    - Signal-to-Noise ratio is a comparative measure of the intensity of signal to background noise
- Cochlear implant coding degrades these signals so in order to improve cochlear implant technology, there needs to be a better understanding of how pitch, timbre, and background noise affect normal hearing listeners' perception
- Crew et al. (2015) created the Sung Speech Corpus and used it to compare the perceptual abilities of adult musicians vs. non-musicians
- This study used the Sung Speech Corpus to find out if timbre, pitch contour, background noise, and age had an effect on children's perception
- This experiment was conducted as a portion of a project to explore the following research questions:
  - How do different pitch contours affect performance on sentence perception?
  - How does timbre complexity affect performance on melodic contour identification tasks?
  - How does the presence and degree of noise affect performance on sentence perception?
  - Does age have an effect on performance for either task?

Methods

- Participants: 3 NH Children
  - normal hearing
  - age groups: 7-9 yrs. (<10 yr) vs 10-17 yrs (=>10 yr)
- Stimuli:
  - Sung Speech Corpus (Crew et al., 2015)
  - Two separate types of tasks:
    - Melodic Contour Identification (MCI): 9 alternatives (Figure 1)
    - Sentence Identification: (Figure 2)
  - Background noise: Speech shaped noise presented at three different SNRs
- Apparatus:
  - Stimuli presented at 60 dB A via HDA200 to the right ear only
- Conditions:
  - MCI
    - Piano – random contour with fixed instrument
    - Fixed Word – random contour with constant word (Bob)
    - Fixed Sentence – random contour with the same sentence
    - Random Sentence – random contour with any possibly sentence
  - Sentence Identification
    - Spoken – normal speech utterances
    - Random – any possible pitch contour
    - Flat – constant pitch across words

Methods—cont'd

Melodic Contour Identification

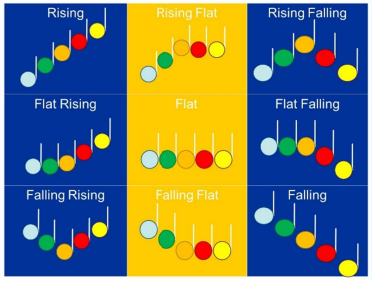


Figure 1. 9 alternative melodic contours when sentences were varied across four timbre complexity levels : piano, fixed word, fixed sentence, random sentence. (Adopted from Crew et al., 2015)

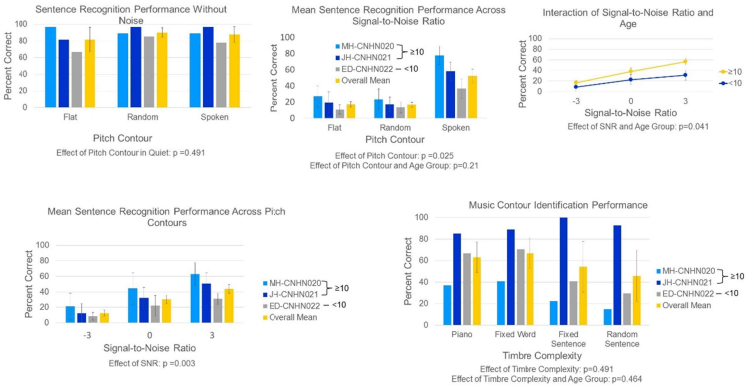
Sentence Identification

Ann	Buys	No	Black	Belt
Bob	Finds	Two	Blue	Coat
Dave	Gives	Three	Brown	Gloves
Fred	Has	Four	Green	Hats
Greg	Loans	Five	Gray	Jeans
John	Moves	Six	Gold	Pants
Kate	Needs	Eight	Pink	Rings
Mark	Sells	Nine	Red	Socks
Pat	Takes	Ten	Tan	Shoes
Tim	Wants	Twelve	White	Ties

Figure 2. Alternative word options for the Sentence Identification tasks when pitch contour is varied. (Adopted from Crew et al, 2015)

- 10x5 closed set monosyllable word bank which a five word sentence will be formed always in the syntax of" "name, verb, quantity, color, article of clothing"
- Pitch contour was varied across three melodic contour alternatives: natural, flat, or random
- Concatenated sentence identification was recorded in percent correct of one whole sentence

Results



Discussion

- With our three subjects, we found normal hearing children's ability to identify spoken sentences was significantly degraded when the pitch contour was unnatural.
  - This trend was also seen in Morikawa, Nie, & Fu (2016).
- As signal-to-noise ratio increased, performance also increased.
- We did not see that normal hearing children's melodic contour identification was affected by the complexity of speech timbre which is probably due to having such a small sample size. One of our subjects was an outlier and scored much higher on all of the MCI tasks.
  - Morikawa, Nie, & Fu (2016) saw that as speech timbre became more complex melodic contour identification performance decreased.
- For the effect of age, neither task had a significant correlation for our set of subjects. Individual data showed a trend that the participants age 10 and above scored higher than those under 10 in the presents of noise.
  - Morikawa, Nie, & Fu (2016) found that performance of melodic contour identification and senterce identification was overall lower in the younger group of children.
- There was a significant interaction shown between signal-to-noise ratio and age. The participants age 10 and above had a greater increase in performance as the signal-to-noise ratio increased.

References

- Crew, J. D., Galvin, J. J., & Fu, Q. (2015). Melodic contour identification and sentence recognition using sung speech. The Journal of the Acoustical Society of America J. Acoust. Soc. Am., 138(3).
- Moore, B. (2003). An introduction to the psychology of hearing. London: Academic Press.
- Morikawa, M., Nie, Y., & Fu, Q. J. (2016). *Effects of age and musical experience on melodic contour ID and sentence recognition by children*. Paper presented at the AudiologyNOW!, Phoenix, AZ.

Acknowledgement

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Lindsey Seyfried's Research Log

March 22, 2016

Area of Work: Lab Preparation

Start Time: 1:45 PM
End Time: 3:00 PM

Description of Work: Sarah and I met with Dr. Nie for the first time to talk about what we are going to do for this project and what our first couple of steps need to be. She showed us around the lab and taught us about the equipment and programs we will be using. We met Michael Morikawa, one of the graduate students, briefly and he explained a little bit about his project entitled *Effects of Age and Musical Experience on Melodic Contour Identification*. We will set up a meeting with him soon to learn the specifics of his project. It is a relief to finally have a project and I am excited to get started.

March 29, 2016

Area of Work: Running Participants

Start Time: 8:30 AM
End Time: 10:30 AM

Description of Work: Sarah and I observed Alexandria (Allie) Matz while she ran her protocol on a participant who uses a cochlear implant. Her study is entitled *The Build-up of Auditory Stream Segregation in Adult Cochlear Implant Users: Effect of Differences in Frequency and Amplitude Modulation Rate.* This was our first experience with Allie's project so she talked us through what she was doing for future reference.

March 29, 2016

Area of Work: Lab Preparation

Start Time: 10:15 PM
End Time: 11:15 PM

Description of Work: On my own, I went through the Collaborative Institutional Training Initiative (CITI) Training for researchers involved primarily in Social/Behavioral Research with human subjects. It covers ethics, confidentiality, informed consent, federal regulations, etc. The training quizzed me on each section and I sent those results to Dr. Nie. She will now be requesting that Sarah and I be added to the IRB.

March 31, 2016

Area of Work: Lab Preparation

Start Time: 2:30 PM
End Time: 3:30 PM

Description of Work: Sarah and I met with Michael to learn more about his research and how to run the Sung Speech Program on Angel Sound. He walked us through the steps of what would happen when we test a child including which forms to have them and their parents fill and what trials to have them complete. He showed us how to use both computers (the one in the sound booth and the one outside). It will be a good test for Sarah and me to run the protocol on each other to make sure that we understand all the steps.

April 5, 2016

Area of Work: Running Participants (Practice)

Start Time: 12:00 PM
End Time: 3:45 PM

Description of Work: Sarah and I went in the lab to practice using the Sung Speech Program and ran trials on each other. We did relatively well on our own based on what Michael had taught us last week. We emailed Michael to get answers to the few questions that we did have. I think we are well prepared to run this program on real participants.

April 15, 2016

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 12:00 PM

Description of Work: We observed Allie running a participant who uses cochlear implants. I find it interesting that Allie pulls up the mapping off their processor to tailor the stimulus to their own hearing in order to get the best possible results from a cochlear implant user.

September 16, 2016

Area of Work: Reading Articles

Start Time: 11:00 AM
End Time: 2:00 PM

Description of Work: I read and analyzed the articles by Böckmann-Barthel et al. (2014), Crew, Galvin, & Fu (2015), and Deike et al. (2012). Böckmann-Barthel et al. and Deike et al. both looked at the relationship between frequency separation of the two stimulus streams and the proportion of a 30s sequence in which listeners were segregating those streams. Böckmann-Barthel et al. looked to see if streams were first perceived as a single stream while Deike et al.

look to see if CI users' ability to segregate streams is similar to normal hearing listeners. These both relate to Allie's project. Crew, Galvin, & Fu used the Sung Speech Corpus, like Michael's project, with normal hearing adults to see if musicians had better performance. Reading these articles posed somewhat of a challenge for me. I appreciated having the worksheets to help me break them down and pull out what was most important.

September 17, 2017

Area of Work: Reading Articles

Start Time: 1:00 PM
End Time: 4:00 PM

Description of Work: I read the articles by Galvin, Fu, & Oba (2008), Miller, Schlauch, & Watson (2010), and Moore & Gockel (2012). Galvin, Fu, & Oba looked at the relationship between the timbre of an instrument, the interval between notes, and the cochlear implant users' ability to identify the melodic contour. This relates most directly to Michael's project. Miller, Schlauch, & Watson looked at how fundamental frequency manipulation can affect speech intelligibility in background noise. Moore & Gockel gathered information from many different studies about stream segregation to look at which perception qualities can cause a listener to segregate two streams. This article relates most directly to Allie's project. I found these articles to be a bit easier than the ones I did yesterday. This is probably because I already had some experience from those articles. I am excited to meet with Sarah to continue to get more out of all the articles.

September 21, 2016

Area of Work: Lab Preparation

Start Time: 9:00 AM
End Time: 11:30 AM

Description of Work: We met with Dr. Nie to help calibrate the new lab in the Health and Behavioral Studies building. This process took much longer than expected because we had to keep trying different things to figure out what was going on. Everyone got a late start running participants this semester because we had to wait for all the equipment and computers to be moved and set up in the new building. Calibrating the equipment reminded us about how to use the everything in the lab.

September 30, 2016

Area of Work: Running Participant

Start Time: 8:00 AM
End Time: 9:30 AM

Description of Work: We went to the lab to observe Allie running a normal hearing participant. Unfortunately, when Allie went to screen the participant's hearing to make sure it fell within the limits of normal hearing, they demonstrated a little bit of a hearing loss. Allie was very good about sharing this information with the participant. She explained that is it completely normal to lose some hearing as you get older. She also recommended the JMU Audiology Clinic if the they wanted to get an in-depth hearing evaluation. I have a lot of experience with using an audiometer to measure hearing, but watching Allie was good practice.

October 5, 2016

Area of Work: Running Participants

Start Time: 1:30 PM
End Time: 2:30 PM

Description of Work: We went to the lab to again observe Allie's project. We were hopeful that this participant's hearing would fall within the range of normal, but unfortunately it did not and they had to be sent away.

October 12, 2016

Area of Work: Lab Preparation

Start Time: 3:45 PM
End Time: 5:00 PM

Description of Work: We meet with Michael and Dr. Nie to review and practice the procedure for running child participants for the Sung Speech experiment. Michael shared his poster for the American Audiology Association conference and showed us some of the trends he has seen in his data. We are preparing to run two child participants in the next few weeks so he walked us through Angel Sound again.

October 17, 2016

Area of Work: Reading Articles

Start Time: 5:00 PM
End Time: 6:00 PM

Description of Work: I read the article by Nie & Nelson (2015). They looked at the role of spectral overlap and amplitude modulation on stream segregation. This article had many of the same concepts from previous articles so that made it a lot easier to break down and comprehend.

October 18, 2017

Area of Work: Reading Articles

Start Time: 5:30 PM
End Time 6:30 PM

Description of Work: I read the article by Nie, Zhang, and Nelson (2014). This study looked at neural responses during a stream segregation task. It was very different from the others in that they were not only looking at the outward response of the participant, but also what was happening in their brain.

October 19, 2016

Area of Work: Running Participants

Start Time: 11:00 AM
End Time: 12:30 PM

Description of Work: For Allie's project, we had two participants come in as normal hearing participants over the age of 50. Neither met the criteria for normal hearing when we tested them. Unfortunately, we had to send them both home. It was disappointing to have to send home another two participants because they did not have normal hearing, but the fact that there have been four participants all with hearing loss attests to just how common it is.

October 25, 2016

Area of Work: Running Participant

Start Time: 1:00 PM
End Time: 4:30 PM

Description of Work: We had a normal hearing participant come in for Allie's project. He met the criteria for normal hearing. Allie had Sarah and I make the variable changes so we could get some practice using MATLAB for testing.

October 31, 2016

Area of Work: Running Participants (Practice)

Start Time: 4:00 PM
End Time: 5:00 PM

Description of Work: Sarah and I came in to practice running participants ourselves to prepare for this Saturday when we will be running two child participants using Michael's protocol. We did a good job of troubleshooting on our own. Dr. Nie came to the lab and answered our final questions. I think just the two of us should be okay to do everything on our own this weekend.

November 5, 2016

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: Sarah and I ran two siblings on the Sung Speech Program. I was kind of nervous about doing this especially since it was a Saturday and anyone who would be able to help us was not on campus. Sarah and I were able to figure everything out on our own and it ran smoothly. We got through half of the protocol and will schedule a time for them to come back because they were both getting bored after sitting there for a long time.

November 17, 2016

Area of Work: Article Analysis

Start Time: 12:15 PM
End Time: 1:45 PM

Description of Work: Sarah and I met to go over the first three articles that we had read. It was nice to be able to go over the details with her and talk things through. I felt like I got more out of the articles after this meeting.

November 29, 2016

Area of Work: Article Analysis

Start Time: 12:15 PM
End Time: 1:45 PM

Description of Work: Sarah and I met to discuss the remaining four articles. The discussion was just as helpful as the previous time.

December 3, 2016

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: The same two participants came back to finish the protocol in Angel Sound. They were more attentive compared to the end of the last session. I think everyone was glad that the protocol had been broken down into two separate sessions to allow a fresh start.

December 13, 2016

Area of Work: Data Extraction

Start Time: 8:00 AM
End Time: 11:00 AM

Description of Work: Sarah and I went into the lab to extract the data from the outputs given by the Sung Speech Program. We put the data into a table on SPSS for analysis. This took us longer than expected probably because we lacked experience with SPSS. It had been quite a few semesters since either of us had used it in statistics class. Sarah and I will hopefully be able to run a few more participants and then analyze the data for trends and significance.

December 14, 2016

Area of Work: Lab Preparation

Start Time: 11:00 AM
End Time: 12:30 PM

Description of Work: Sarah and I went to lunch with Dr. Nie and some of the graduate students from the lab. It was nice to spend some time with them and celebrate the end of the semester. We found out more about what trends are being seen in some of the other projects going on in the lab.

February 25, 2017

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: We ran a participant using Michael's protocol on our own. Because the protocol is very repetitive and can be boring, he got very fidgety, even more so than the older participants that we had tested. It helped that we allowed him to take breaks. We only had to do the sentence recognition testing because he had already done the music contour identification aspect for another study within the lab. Overall, he worked hard and we managed to finish in a relatively timely manner.

March 23, 2017

Area of Work: Data Extraction and Analysis

Start Time: 9:00 AM
End Time 1:00 PM

Description of Work: Sarah and I went to the lab to organize the rest of the data. We ended up reorganizing the data we had previously extracted to make the analysis easier and added the data from the third participant. Dr. Nie then walked us through how to go about analyzing the data and we discussed what the results mean. She then helped us decided how to set up the graphs and

gave us a review on how to make them in Excel. Sarah and I then started making the graphs on our own. It is exciting that everything is finally coming together.

March 24, 2017

Area of Work: Presentation Production

Start Time: 12:00 PM
End Time: 3:00 PM

Description of Work: Sarah and I met in the lab to finish the graphs and start formatting things on the poster. After we got what we needed off the computer in the lab and we ended up leaving to work somewhere else because the graduate students needed the computers. We went to another area and began writing our introduction.

March 26, 2017

Area of Work: Presentation Production

Start Time 5:00 PM
End Time: 7:00 PM

Description of Work: Sarah and I met to finish writing our introduction. It is very helpful to have Michael's poster as an example because it shows us what needed to be included. We also organized and compared these research logs.

March 26, 2017

Area of Work: Presentation Production and Data Analysis

Start Time: 2:30 PM
End Time: 4:00 PM

Description of Work: We met in the lab with Dr. Nie to show her the progress we had made on the poster. She seemed impressed with our introduction and gave us some feedback on the graphs and on what p-values should be included. Sarah and I then spent some time collecting the p-values and adding them to the poster. In doing this, we realize that we had never analyzed to see if there was a significant correlation between age group and music contour identification performance. Dr. Nie helped us to go back and analyze this portion. I was surprised by how much I remembered all of the different settings necessary on SPSS to get the analysis we wanted. We also began comparing our results to the results of Michael's study.

March 28, 2017

Area of Work: Presentation Production

Start Time: 11:15 AM
End Time: 1:00 PM

Description of Work: Sarah and I met to work more on our poster and our final write up for the Honors College. We wrote the discussion on the poster as well as the introduction and acknowledgements for our final submission.

March 30, 2017

Area of Work: Presentation Production

Start Time: 10:00 AM
End Time: 1:00 PM

Description of Work: Sarah and I met with Dr. Nie to go over our poster. We created another graph showing the interaction of signal-to-noise ratio to add to the poster as well as wrote our references and acknowledgements for the poster. We also spent some time formatting this document.

Sarah Troy's Research Log

March 22, 2016

Area of Work: Lab Preparation

Start Time: 1:45 PM
End Time: 3:00 PM

Description of Work: Dr. Nie, Lindsey, and I met to discuss what we would be working on for our Capstone project. Dr. Nie showed us the laboratory that we would be starting to work in during the semester while helping two graduate students, Michael Morikawa and Allie Matz, on their current research projects. Dr. Nie showed us how to use the equipment in the laboratory, how to calibrate the equipment, and how to use certain applications on the computer systems that we would need to use while conducting research. Dr. Nie then introduced us to Michael Morikawa, one of the graduate students who we would be assisting with his research on *Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children.* Michael explained the aspects of his research project and set up a time for us to meet to learn more.

March 23, 2016

Area of Work: Lab Preparation

Start Time: 5:00 PM
End Time: 6:00 PM

Description of Work: In order to be able to test subjects in the research laboratory, I had to complete the Collaborative Institutional Training Initiative (CITI) Program. The program informed me about research methods and guidelines such as students' roles in research, ethical principles, the federal regulations, risks, informed consent, privacy and confidentiality, research with prisoners and children, and other areas of the research process.

March 29, 2016

Area of Work: Running Participants (Observation)

Start Time: 8:30 AM
End Time: 10:30 AM

Description of Work: Lindsey and I observed Allie running her program on a participant for her study on *The build-up of auditory stream segregation in adult cochlear implant users: Effect of differences in frequency and amplitude-modulation rate.* She taught us how to run her program for future reference so that we could help her run participants on the program as well. This was the first time I had tested the hearing of someone who had a cochlear implant so I was very interested.

March 31, 2016

Area of Work: Lab Preparation

Start Time: 2:30 PM
End Time: 3:30 PM

Description of Work: Lindsey and I met with Michael in the lab to learn more about his research in *Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children*. He showed us how to the audiograms to test the hearing of subjects, how to use the computer program Angel Sound that we would be using while conducting research for his program, and gave us step-by-step instructions on how to set up and run his research program on participants. While it was a lot of information to take in, this meeting was very informative and made me excited to be a part of this research process.

April 5, 2016

Area of Work: Running Participants (Practice)

Start Time: 12:00 PM
End Time: 3:45 PM

Description of Work: Lindsey and I practiced running the Angel Sound program, used for Michael's research, on one another in order to have experience with the software before using the program to test actual research participants. This was definitely a learning experience for both of us, as neither of us had ever used a program like this before, but Michael's instructions had well prepared us. We recorded our challenges and questions to ask Michael, which he answered in a timely fashion so that we were able to understand the program and research process completely.

April 7, 2016

Area of Work: Running Participants (Observation)

Start Time: 6:00 PM
End Time: 7:00 PM

Description of Work: I met Michael in the lab to observe him running his program on two young participants. I was excited to observe this and learn more about Michael's research. However, when we tested the hearing of both participants using an audiogram, we found that both the participants had sensorineural hearing loss. Therefore, they did not qualify for the study and could not be participants. While it was disappointing for us to not have these subjects qualify as research participants, it was definitely more disappointing to the participants, who had to be told that they had the early stages of sensorineural hearing loss. The news came as a shock to them because they had both had their hearing tested during school checkups. This experience taught

me how to act professionally when explaining disappointing news to a subject or client, which is definitely something that I may have to do one day in my future career as a speech language pathologist. The experience also taught me the importance of having hearing tested at various levels by a true audiologist using an audiogram. Michael explained to the participants that some hearing screenings in schools are not as extensive as the audiogram testing done today so this is why the girls' hearing losses had gone undiagnosed in the past.

April 15, 2016

Area of Work: Running Participants (Observation)

Start Time: 9:00 AM
End Time: 12:00 PM

Description of Work: Lindsey and I observed Allie running her program on a participant with a double cochlear implant for her study on *The build-up of auditory stream segregation in adult cochlear implant users: Effect of differences in frequency and amplitude-modulation rate*. It was interesting to learn about the subjects' experience with a double cochlear implant.

April 20th-30th, 2016

Area of Work: Reading and Summarizing Articles

Start Time-End Time: 7 hours altogether

Description of Work: I read the 7 articles that Dr. Nie assigned us to read. I then summarized the purpose, methods, experimental design, results, and implications of the studies in an organized summary sheet. I found these articles very informative and relative to the research studies that we would be helping with in the lab.

September 21, 2016

Area of Work: Preparation in Lab

Start Time: 9:00 AM
End Time: 11:30 AM

Description of Work: Due to the new facilities being built in the new Health Behavioral Science building on campus, all of the equipment from HHS had to be moved. Therefore, the equipment had to be recalibrated in the new lab. Dr. Nie, Lindsey, and I met to recalibrate the equipment and to refresh our memory of how to use the equipment necessary to test research participants.

September 30, 2016

Area of Work: Running Participant

Start Time: 8:00 AM
End Time: 9:30 AM

Description of Work: We had a participant over the age of 50 years scheduled to run Allie's program on for her research *on The build-up of auditory stream segregation in adult cochlear implant users: Effect of differences in frequency and amplitude-modulation rate.* Unfortunately, when we tested the hearing of the participant using the audiogram, the subject did not have normal hearing. Therefore, we were unable to include the participant in our research study. This experience illustrated the importance of testing the hearing of individuals before including the participants in a study. It also gave me experience using an audiogram to measure hearing and instructing the subject on how to fill out certain paperwork needed prior to participant in the study. Even though the participant's hearing was close to perfect, we were unable to include the subject in our research study because the participant had a 5 dB loss and did not want this loss to effect the data.

October 5, 2016

Area of Work: Running Participant

Start Time: 1:30 PM
End Time: 2:30 PM

Description of Work: We had a participant scheduled to run Allie's program on for her research the build-up of auditory stream segregation in adult cochlear implant users: Effect of differences in frequency and amplitude-modulation rate. Unfortunately, when we tested the hearing of the participant, the subject did not have normal hearing so we were unable to include the participant in our research study. This again illustrated the importance of testing the hearing of individuals before including them in our study. It also gave me more experience using an audiogram to measure hearing.

September 23, 2016

Area of Work: Running Participant (Observation)

Start Time: 9:00 AM
End Time: 10:00 AM

Description of Work: I observed Allie running her research the build-up of auditory stream segregation in adult cochlear implant users: *Effect of differences in frequency and amplitude-modulation rate on a normal hearing listener who was in the field of audiology*. It was interested to see someone who knew so much about audiology and the topic of study participate because usually the participants who I have seen in the lab in the past have not known much about the field of audiology.

October 12, 2016

Area of Work: Preparation in Lab

Start time: 3:45 PM
End time: 5:00 PM

Description of Work: Lindsey and I met with Michael to talk about his findings in his research on the Effects of Age and Musical Experience on Melodic Contour ID and Sentence Recognition by Children. He explained the final results of his dissertation and showed us his poster that he was presenting at a symposium. He then refreshed our memory of how to use the Angel Sound software, which Lindsey and I will be using to test participants and then compare our findings to Michael's findings.

October 19, 2016

Area of Work: Running Participants

Start Time: 11:00 AM
End Time: 12:30 PM

Description of Work: We had two participants over the age of 50 years, scheduled to run Allie's program on for her research. Unfortunately, when we tested the hearing of both individuals, neither had normal hearing so we were unable to include the participants in our research study. Again, this provided me with experience using an audiogram and also illustrated the significance of test the hearing of individuals before deciding to include them in research programs. It also exemplified how common small losses of hearing are in individuals over the age of 50 years. It showed me that sometimes collecting data and finding qualified research participants came with a challenge, but that it was extremely important to stick to the set criteria of the research study.

October 25, 2016

Area of Work: Running Participants

Start Time: 1:00 PM
End Time: 4:30 PM

Description of Work: Allie, Lindsey, and I tested a participant over the age of 50 years and found that he had normal hearing. Again, I gained experience with the audiogram and this time, I was finally able to gain experience running the MatLab program. The participant was very engaged in the study and asked many questions about the equipment that we used in the research laboratory. It was great to have a participant be so intrigued and active in the research study. While we were only able to run half of the program on the participant due to time constraints, it was very valuable experience.

October 31, 2016

Area of Work: Preparation in Lab

Start Time: 4:00 PM
End Time: 5:00 PM

Description of Work: Lindsey and I practiced testing each other on the Angel Sound software that Michael used for his research. We did this to refresh our memory before we tested real participants using this software.

November 5, 2016

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: Lindsey and I ran Michael's program on two young participants. We tested their hearing on the audiogram and found that they both had normal hearing. This was great experience for me because it was my first time using an audiogram without the supervision of a professor or graduate student. We also set up and ran the program without the help or supervision of a graduate student or professor. We had each child take turns and had them each finish half of the program. We decided to run the other half for each child on a separate day because they were getting tired and we wanted them to have the best results.

November 17, 2016

Area of Work: Article Discussion

Start Time: 12:15 PM
End Time: 1:45 PM

Description of Work: Lindsey and I met to discuss three of the articles that Dr. Nie assigned us to read. We discussed what we learned as well as how we could apply this information to our own research.

November 29, 2016

Area of Work: Article Analysis

Start Time: 12:15 PM
End Time: 1:45 PM

Description of Work: Lindsey and I met to discuss the other four articles that Dr. Nie assigned us to read. We discussed what we learned as well as how we could apply this information to our own research.

December 3, 2016

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: The same participants who had participated in Michael's program came into the lab to finish the rest of the conditions. Both participants seemed to be much more attentive than they had at the end of the previous session so it emphasized that participants, especially young children, truly do need breaks in order to get the best results.

December 13, 2016

Area of Work: Data Extraction and Analysis

Start Time: 8:00 AM
End Time: 11:00 AM

Description of Work: Lindsey and I extracted the data that we had collected while testing several participants using the Angel Sound software and organized the data on SPSS. During my Statistics course two years ago, I learned how to use the software program SPSS. However, I had never had to apply my knowledge of the program outside of that course until we started this data extraction process. Dr. Nie demonstrated how to use SPSS to extract and organize the data so that it could be used for data analysis for Michael's study. I may have to use SPSS in my future graduate studies or career if I am conducting research so I was glad to have the opportunity to utilize the program once again. While extracting the data, Lindsey and I realized that one child's data was an outlier, scoring higher on certain programs than most of the other child had on the same program. Since this data throws off the common trend, it might have implications for the results of Michael's study. This further illustrated the importance of having a large population included in the research study to make sure that findings are correct.

December 14, 2016

Area of Work: Lab Preparation

Start Time: 11:00 AM
End Time: 12:30 PM

Description of Work: Dr. Nie, Lindsey, two other graduate students and I met for lunch to celebrate the end of one semester. We talked about what we had learned so far in the research lab and what we were expecting to accomplish in the upcoming semester.

February 25, 2017

Area of Work: Running Participants

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: We had a young boy below the age of 10 years old come into the lab to run some of the Angel Sound conditions on him. We tested his perception using the Angel Sound application that we used while running Michael's program except this time we did not test the subject on the Melodic Contour conditions. We only tested his perception on the Concatenated Spoken, Random, and Flat Sentences with -3 dB, 0 dB, and 3 dB levels of background noise in each sentence identification. Since the subject was so young, we had to navigate the computer mouse for him, which we had not needed to do previously. We also had to give him more breaks than we had given participants in the past in order for him to stay attentive and on task. Therefore, this experience showed me how you have to adapt your habits and behaviors when working with different clients or participants, especially young children. We then were able to compile this data on a further date onto an Excel file with the data from the two children whose perception we tested on November 6th. This way, we could get experience comparing and analyzing data.

March 16, 2017

Area of Work: Data Analysis

Start Time: 1:30 PM
End Time: 4:00 PM

Description of Work: I met with Dr. Nie and two other graduate students to discuss what we have learned so far using Angel Sound and Sung Speech Lab. Dr. Nie helped guide me on what material I should include in my final manuscript. Dr. Nie explained how the tests and programs we had been using in the lab tested the participants' processing of pitch and timbre. She explained the different between pitch contour and timbre and how both aspects could affect the subjects' perception of the sounds and words they heard through the programs. She also explained how we as normal hearing listeners are able to differentiate between differences in timbre, but how CI listeners usually cannot. CI listeners have trouble differentiating between timbre because in CI technology, frequency and timbre are coded the same way. Therefore, CI listeners have a harder time discriminating between timbre differences and pitch differences. Dr. Nie and some of the graduate students are working on testing children to see when they reach their maximum ability to understand timbre and pitch differences. They are looking into the developmental effects and word recognition effects based on the timbre and pitch discrimination abilities. They are carrying out this research on both normal hearing children and children with cochlear implants in order to try to better understand how cochlear implant technology can be further developed to assist individuals with cochlear implants in discriminating between timbre and pitch differences. I found this information so interesting so I was happy to be a part of this meeting to learn more about the Sung Speech Lab and the projects that the graduate students are currently involved in here at James Madison University.

I worked with Dr. Nie to organize the data from the participants whom we tested on November 6th, December 3rd, and February 25th on the Angel Sound conditions. We compiled their data in SPSS, one file for the Concatenated Sentence conditions and another file for the

Melodic Contour ID conditions. Again, since I had not used SPSS since taking the Math 220 course over two years ago during the first semester of my sophomore year, using this application was a bit of a challenge. However, Dr. Nie was a huge help in guiding me through the program and refreshing my memory on the different functions of SPSS. Dr. Nie explained how to make a long as well as a wide format to organize the data. I learned different functions of SPSS that I had not previously know how to use and that I will definitely use in my future when compiling data.

March 23, 2017

Area of Work: Data Analysis, Manuscript and Presentation Production

Start Time: 9:00 AM
End Time: 1:00 PM

Description of Work: I worked with Lindsey to finish extracting the data from the participants whom we tested on November 6th, December 3rd, and February 25th using the Angel Sound software. We finished extracting and organizing the data on our own without the help of Dr. Nie. We organized the files based on the Sentence ID and Melodic Contour ID conditions. We were then able to analyze the data to see if there were any trends in the results. We then met with Dr. Nie, who showed us how to use the SPSS software to test the p values of the data and find if our data showed any significance. The p values for the SNR conditions, the SNR conditions interacting with age group, and the pitch conditions, all were less than .05 and therefore were significant. It was very interesting to be able to analyze this data and compare our findings to Michael's. For example, for age group, we did not find any significant trend. However, Michael had in his study. It seemed that our sample size was too small to show any real significance. Also, one of our subjects had scored very high on certain conditions which participants normally did not do as well on. These factors all effected the significance of our study's findings.

We then were able to organize our data onto Excel in order to put together charts that we are planning to use on our final poster for the Honors Symposium. It felt great to see our collected data organized in a meaningful way so that we could interpret the significance of our findings. I really enjoyed this experience because I felt as if I was learning something that will truly be helpful in my future studies and career, as I will have to use analyze and extract data in any research I conduct in a graduate program or career.

March 24, 2017

Area of Work: Presentation Production

Start Time: 12:00 PM
End Time: 3:00 PM

Description of Work: Lindsey and I met in the research lab to create graphs and charts of our data from the three young subjects we tested using Angel Sound. We then started to write our introduction and summarize what we found to format our poster for the symposium. It was great to see our project coming together into a final presentation.

March 26, 2017

Area of Work: Presentation Production

Start Time: 5:00 PM
End Time: 7:00 PM

Description of Work: I met with Lindsey to finish writing our introduction and to discuss our findings from our Angel Sound software.

March 27, 2017

Area of Work: Presentation Production

Start Time: 2:30 PM
End Time: 4:00 PM

Description of Work: Lindsey and I met with Dr. Nie to show her the progress we had made on creating our poster. We reviewed and edited our introduction as well as some of our graphs so that the graphs included Standard Error. Dr. Nie explained the importance of using Standard Error when using mean data. We then also analyzed our p values to further understand the significant trends of our study. We found that our study's data differed slightly in terms of significant results compared to Michael's study. This is most likely due to our smaller sample size and the fact that one of our participants' data was an outlier compared to the others.

March 28, 2017

Area of Work: Presentation Production

Start Time: 11:15 AM
End Time: 1:00 PM

Description of Work: Lindsey and I met to finish working on our poster, particularly the Discussion section. We then started putting our documents, summary sheets, and reflection together into one document that we will submit to the Honors College. We also began writing our acknowledgements in this document.

March 30, 2017

Area of Work: Presentation Production

Start Time: 10:30 AM
End Time: 1:00 PM

Description of Work: Lindsey and I met with Dr. Nie to put the final touches on our poster. We then worked on putting our documents together and formatting them into this document. It was great to see our final presentation all coming together.

Lindsey Seyfried's Article Summaries

Böckmann-Barthel, M., Deike, S., Brechmann, A., Ziese, M, & Verhey, J. L. (2014). Time course of auditory streaming: do CI users differ from normal-hearing listeners? *Frontiers in Psychology,* 5:775. doi: 10.3389/fpsyg.2014.00775

1. State the purpose of the study

   The purpose of this study was to examine the time it takes cochlear implant users to segregate two streams of auditory signals with changes in frequency separation and compare this to what has been observed for normal-hearing listeners for the same task.

2. Describe the participants:

   There were eight cochlear-implant users who were participants. Four were male and four were female. They ranged from age 60 to age 83. Their CI experience ranged from 8 months to 16 years. Only one CI was used by each participant even if they had two and any residual hearing was blocked by an attenuating ear plug.

3. State the independent variable(s).

   The independent variable was the frequency separation between the two streams of the stimulus.

4. State the dependent variable(s).

   The dependent variable was the proportion of the 30s sequence in which the CI user indicated that they were hearing one stream or two streams. The third part of the proportion is that between when the stimulus started and when the participant made their perceptual decision.

5. Identify the experimental design.

   Sounds were presented to the CI users in a free-field condition in a sound attenuating room through a single, frontally located active monitor loudspeaker. The level was adjusted for each individual's comfort. Tones from a high frequency set and tones from a low frequency set were presented in alternating ABAB order at the rate of 6 tones per second with four different fundamental frequency separations ranging from 2 to 14 semitones. There were 40 test sequences presented in random order.

   Listeners were to push the left button on a mouse (labeled 1) for as long as they heard a single stream of alternating high and low tones. Listeners were to push the right button (labeled 2) for as long and they perceived two sets of alternating high and low tones. They were to push a button as soon as they heard one of the two perceptions and switch to the other button if the perception changed.

6. Summarize the results of the study.

   - Five participants increased their perception of segregated streams and decreased their perception of single streams as the frequency separation between the two streams increased. Three participants had similar proportions of single stream and segregated stream perception across all the presentations.
   - At a frequency separation of 6 semitones there was equal perception of segregated streams and a single stream.
   - Three participants provided the first response within 3 seconds. Two participants provided the first response after 10 seconds. No relationship was found between response time and frequency separation.
   - The probability of a two-stream first response rises close to 100% when the difference in frequency is large.
   - For high frequency separation, the perception of two-streams reaches a maximum within the first two seconds. For low frequency separation, the perception of two streams increases more slowly.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   This study shows a functional relationship between the frequency separation of the two stimulus streams the proportion of the 30s sequence in which the CI user indicated that they were hearing one stream or two streams. This data from CI users is like that of normal-hearing listeners.

   - The mean results are similar to the results found for normal-hearing listeners showing there is stream segregation in CI users.
   - The individual data for three of the listeners, was not consistent with typical results. If there was no stream segregation, one would expect all one-stream responses which did not occur. For these users, it could be that they experienced uncertainty in the task.
   - The frequency separation has no effect on response time. However, CI listeners need more time to input their first decision. This indicates a perceptual difference where it is harder for the CI users to find the appropriate cues to segregate streams.
   - The data for both normal-hearing listeners and CI users argues against the build-up hypothesis that there is an initial one-stream perception which changes into a two-stream perception.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   - This study is significant because it tested stream segregation for CI users presented with their familiar processor settings. It showed that their stream segregation is comparable with that of normal hearing listeners.
   - Because the CI users could segregate streams just as normal-hearing participants, it seems that the ability to segregate streams is not dependent on the ability to discriminate

frequencies as these are often degraded by processors. More research needs to be done to find out what cues are used.
- This study does not support the hypothesis of build-up. If it were true, a first response of two-streams would have to take longer that a first response of one stream because the participant would first have to disregard the immediate internal response of one stream. This is not the case and thus this long held assumption seems to be incorrect.
- I learned that stream formation is not affected by the use of a cochlear implant. I previously would have assumed that individuals who use cochlear implants would have trouble separating sounds from different sources.

Crew, J. D., Galvin, J. J., III, & Fu, Q. (2015). Melodic contour identification and sentence recognition using sung speech. *The Journal of the Acoustical Society of America*, 138 (3). http://dx.doi.org/10.1121/1.4929800

1. State the purpose of the study

   The purpose of this study was to look at speech and music perception using Sung Speech Corpus in adults with normal hearing as well as observe any advantage for musicians.

2. Describe the participants:

   Sixteen normal hearing participants were in the study. They were divided into musicians and non-musicians with 8 people each group.

3. State the independent variable(s).

   For the sentence recognition, the independent variable was the shape of the contour: flat, fixed, or random.

   For the melodic contour identification, the independent variable was the timbre of word stimulus: fixed word, fixed sentence, random sentence.

   For both tasks, musician and non-musician were also an independent variable.

4. State the dependent variable(s).

   The dependent variable is the ability of the participant to identify the five-word sentence presented or the melodic contour depending on the task.

5. Identify the experimental design.

   Sounds were presented to subjects in a sound-treated booth while facing a loudspeaker. Stimuli were presented at 65 dBA. For the sentence task, a test sentence and pitch contour were randomly selected. For the melodic contour task, the pitch contour was randomly selected within the timbre trials. As a control, melodic contour was also measured with a

piano sample. For sentence recognition, listeners were to respond by clicking on the words that best matched the sentence presented. Performance was based on complete sentence recognition. For melodic contour identification, listeners were to respond by clicking on melodic contour they heard.

6. Summarize the results of the study.

   - For sentence recognition, both groups scored near 100% for all conditions.
   - For musical contour identification, musician performance was high for all conditions, while non-musician performance was not high and more variable.
   - Non-musicians did better with musical contour identification for piano and fixed word than fixed sentence or random sentence.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   For sentence recognition, the study showed no functional relationship between contour shape and correct responses. Both groups did well for all conditions. For musical contour, the non-musicians did better with piano and fixed word than fixed or random sentence. Musicians showed an advantage and did better on all musical contour identification tasks.

   - There is no significant musician advantage for sentence recognition.
   - The musician advantage became stronger as the timbre got more complex

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   - This study is significant for the CSD field because the Sung Speech Corpus program represents a new tool for research. It can also be used to monitor both speech and music perception in an individual over time and thus improvements and decrements in speech and/or music perception can be easily studied.
   - I learned that musical contour has no effect on sentence recognition in adults. I previously would have thought otherwise because sometimes it is difficult to understand words in songs. I guess this is no different that it sometimes being difficult to understand someone when they speak. The presence of a melody is not necessarily causing the issue.

Deike, S., Hell, P., Böckmann-Barthel, M., & Brechmann, A. (2012). The build-up of auditory stream segregation: a different perspective. *Frontiers in Psychology.* 3:461. doi: 10.3389/fpsyg.2012.00461

1. State the purpose of the study

   The purpose of this study was to test the validity of the assumption known as the build-up effect that all streaming sequences are first perceived as a single stream before being segregated.

2. Describe the participants:

   The subjects of the research study were 9 males and 13 females ages 19-38 with normal hearing.

3. State the independent variable(s).

   The independent variable was the frequency separation between the two streams of the stimulus.

4. State the dependent variable(s).

   The dependent variable is the proportion of the 30s sequence in which the CI user indicated that they were hearing one stream or two streams.

5. Identify the experimental design.

   Sounds were presented to listeners in both ears through headphones in an acoustically shielded chamber. Tone complexes were presented in ABAB sequences for 30 seconds with a rate of 6 Hertz. There were 10 sequences presented per frequency separation condition ranging from 4 to 12 semitones.

   Listeners were to push the left button on a mouse (labeled 1) for as long as they heard a single stream of alternating high and low tones. Listeners were to push the right button (labeled 2) for as long and they perceived two sets of alternating high and low tones. They were to push a button as soon as they heard one of the two perceptions and switch to the other button if the perception changed.

6. Summarize the results of the study.

   - Two-stream perception increases and one-stream perception decreases with increasing frequency separation.
   - The probability that the first perception was one stream is higher for small frequency separations, but declines to near zero for large frequency separations.
   - No matter if the listener indicated that they heard one stream or two the distribution of the initial time taken to make a first perception looked similar.
   - Conventional analysis of this data showed the build-up of two-stream perception. However, the new normalized analysis shows that large frequency separation values demonstrate no build-up and for small frequency separation build-up is present but not to the same extent as shown by conventional analysis.
   - For six semitones, at first there is one-stream dominance which balances out to both one-stream and two-stream perception by the end of the sequence.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

The study shows a functional relationship between the frequency separation of the stimuli's two streams and the proportion of the 30s sequence in which the CI user indicated that they were hearing one stream or two streams.

- There is no basis to assume a one-stream perception default.
- The first perception is dependent on the frequency separation.
- For the smallest frequency separations, the build-up effect shown is small and one-stream remains dominant. Therefore, it may not be true build-up at all.
- Ambiguity, like that at 6 semitones, may be necessary for the build-up effect to occur.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

    - This study is significant because it does not support the commonplace hypothesis of build-up. It begins to disprove an assumption made by many in the CSD field.
    - This study is also significant because this normalized analysis of stream segregation data produces psychophysical measures that better correlate with neural data.
    - This study opens the door for more studies into the idea of build-up. It shows that assumptions made in analysis of previous studies may not be true. It changes the way researchers should look at stream segregation data.
    - From this study, I learned about the concept of build-up. I previously was unaware that researchers assumed that all streams were perceived as a single stream before being separated into two in the brain. I also learned, that this assumption may not necessarily be true.

Galvin, J. J., III, Fu, Q., & Oba, S. (2008). Effect of instrument timbre on melodic contour identification by cochlear implant users. *The Journal of the Acoustical Society of America*. 124 (4). doi: 10.1121/1.2961171

1. State the purpose of the study

    The purpose of this study was to determine how timbre cues affect the melodic contour identification in individuals with cochlear implants in comparison to normal-hearing listeners.

2. Describe the participants:

    The subjects of the research study were eight CI users and eight normal-hearing listeners. Of the CI participants, six were familiar with the melodic contour identification task from previous studies and two had greater music experience. Of the NH participants, none had experience with melodic contour identification, two were active musicians and five had had previous music instruction.

3. State the independent variable(s).

The independent variable was the instrument in which the melodic contour was presented to the participant and the interval between successive notes.

Musical experience was also an independent variable.

4. State the dependent variable(s).

   The dependent variable is the correct identification of the melodic contour.

5. Identify the experimental design.

   Stimuli were presented to the participant via a single loud speaker at 70dBA in a sound treated booth. CI users used their assigned processors with the settings for loud speech. For CI users with hearing aids, the hearing aid was turned off, but the ear was not plugged. For each instrument, there were 9 contours (rising, flat, falling, flat-rising, falling-rising, rising-flat, falling-flat, rising-falling, flat falling) and 5 intervals (1, 2, 3, 4, and 5 semitones) making 45 possible stimuli which were presented at random. Each note was presented for 25ms with a 50ms interval between. The instruments were organ, glockenspiel, trumpet, clarinet, violin, and piano.

   Subjects were to selected from the nine melodic contours which one they thought they heard.

6. Summarize the results of the study.

   - CI users
     - Mean melodic contour performance was 62.3% with the best performance on organ and the worst performance on piano.
     - The use of different instruments (timbre) significantly affected melodic contour performance for 5 participants.
     - Interval spacing had a significant effect on performance.
     - The interaction between instrument used and interval spacing was significant
   - Normal Hearing
     - Mean performance was 86.8% with the best performance on organ and the worst performance on piano
     - Instrument had a significant effect on performance
     - Intonation had a significant effect on performance

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The study shows a functional relationship between the timbre of the instrument or the interval between successive notes and the melodic contour identification.

   - Mean performance for CI users was poorer than that of normal hearing listeners

- Instrument timbre was shown to affect MCI performance, but it was not consistent across subjects
- Degree of musical experience before and after implantation was shown to be a predictor of MCI success.
- Performance with 1 semitone intonation was significantly poorer than the other intervals.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

    - Because the data is not consistent across CI users, it shows that individual listeners may use different cues to extract melody.
    - This study is significant because it gives evidence that the simplification of the complex stimulus patterns produced by instruments may help CI users perceive melodies.
    - Musical training may help improve music perception for CI users. More research is needed to determine what that training would include.
    - From this study, I learned that the timbre of an instrument influences a listener's ability to extract melody in normal hearing listeners and some CI users.

Miller, S. E., Schlauch, R. S., & Watson, P. J. (2010). The effect of fundamental frequency contour on manipulations on speech intelligibility in background noise. The Journal of the Acoustical Society of America. 128 (1). doi: 10.1121/1.3397384

1. State the purpose of the study

    The purpose of this study was to investigate how different fundamental frequency manipulations effect speech intelligibility in background noise.

2. Describe the participants:

    The subjects of the research study were fifteen native American-English speakers ages 18 to 30 with normal hearing and no history of speech-language or neurological disorders.

3. State the independent variable(s).

    The independent variable is the manipulation of the speech stimuli's the fundamental frequency.

4. State the dependent variable(s).

    The dependent variable is speech intelligibility.

5. Identify the experimental design.

    Each of six fundamental frequency had 30 unique sentences spoken by five native speaking females. The six conditions were unmodified, flattened, exaggerated by a factor of 1.75,

modulated at 2.5 Hz, modulated at 5.0 Hz, and inverted. The speech shaped noised was created using a spectrum of unmodified sentences which was played with the speech at a -3 to -2 signal-to-noise ratio.

Listeners sat in a sound attenuated booth and listened to the stimuli through the left earphone. They practiced with one sentence from each modification condition both with and without noise. The listener pushed the button to hear the first sentence. The listener was to write down what they heard as well as repeated it out loud and then push the button to hear the next sentence. 180 sentences were played to the listener in random order.

Three additional listeners, heard the 180 sentences without noise, to show that even with the fundamental frequency modification the sentences were still be intelligible.

6. Summarize the results of the study.

   - Flattening and exaggerating the fundamental frequency decreased average speech intelligibility by about 13%.
   - Frequency modulating and inverting the fundamental frequency contour lowered speech intelligibility by 23%.
   - The keywords at the end of a sentence appeared to be less intelligible than earlier keywords in the normal condition; the opposite trend appears for the inverted fundamental frequency condition.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The study did show a functional relationship between the fundamental frequency manipulations and the speech intelligibility.

   - Any modification of the fundamental frequency contour degraded speech intelligibility in background noise.
   - Frequency modulation most likely destroyed the normal stress patterns of words so listeners could not establish accurate word boundaries and therefore had poor intelligibility.
   - For the flat condition, stress cues were neutralized, but were not inaccurate or misleading as was the case for the inverted fundamental frequency contour.
   - Exaggerating the fundamental frequency contour also lowered speech intelligibility which was not hypothesized; the chosen exaggeration factor could have interfered with the fine structures of the sentences for persons with normal hearing.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   - More research needs to be completed to determine if exaggerated pitch contours may still benefit speech perception and at what exaggeration factor that occurs.

- This study supports previous studies that unnatural fundamental frequency contours have negative effects on speech intelligibility.
- Previous studies had shown that contour frequencies above 4 Hz did not contribute to intelligibility, however intelligibility was affected by a frequency modulation at 5 Hz in this study.
- From this study, I learned that changing the fundamental frequency contour of a sentence will affect its intelligibility when produced in a noisy environment. I had never even considered this before reading the study.

Moore, B. C. J., & Gockel H. (2002). Factors Influencing Sequential Stream Segregation. *ACTA Acustica United with Acustica,* 88, 320-332.

1. State the purpose of the study

   The purpose of this study was to gather results from various other studies relating to factors that influence stream segregation to determine if any one difference in perception quality is enough to cause stream segregation.

2. Describe the participants:

   The participants were different for each individual study.

3. State the independent variable(s).

   The independent variables were the factors thought to influence stream segregation. These included fusion/fission of sound source, difference in excited channels across frequencies or ears, temporal envelope, fundamental frequency, phase spectrum, interaural time difference, and intensity difference between ears.

4. State the dependent variable(s).

   The dependent variable is the effect these factors had on the ability of individuals to segregate streams. This was measured differently for each.

5. Identify the experimental design.

   The results and ideas presented in over 70 studies were compiled and evaluated together.

6. Summarize the results of the studies.

   - Large frequency separations tend to lead to fission (perception of one stream), while small separations tend to lead towards fusion (perception of two streams).
     - For intermediate frequency separations, perception may be ambiguous: either fission or fusion may be heard depending on the attentional set of the subject and the instruction given.

- It appears that the auditory system starts with the assumption that there is a single sound source and fission is only perceive when sufficient evidence has built up to contradict this assumption usually after about 10 seconds.
- Sudden changes in sequence or in the perception of the sequence (which possible indicate a new sound source) causes the precept to revert to its initial 'default' condition of fission.
- Build-up of stream segregation depends on how the listener is paying attention to the tone sequence, similarly the act of switching attention may cause the build-up of stream segregation to reset.
    - Because attention affects stream segregation, there must be a central mechanism involved.
- Although differences in the excitation patterns of successive sounds can promote stream segregation, overlap of excitation patterns does not necessarily prevent stream segregation. Therefore, peripheral channeling is involved but not required.
- When targets and distracting tones fell in the same spectral region, performance was better than when the targets and distracting tones differed spectral region.
- Temporal envelope can enhance stream segregation.
- A critical factor that affects streaming could be the relative bandwidth of the A and B streams.
- Performance was much poorer when successive sounds differed in phase spectrum than when they had the same phase spectrum.
- F_1 and spectral shape can contribute independently to stream segregation
- Spectral information is dominant in inducing obligatory or primitive segregation, but periodicity can also play a role.
- Both the ear of entry and perceived location affect sequential sound segregation, although ear of entry seems to be more important.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   This research compilation shows that there are other factors which play a strong role in speech segregation besides the commonly accepted peripheral channeling. The studies give evidence of how changing different characteristics of a sound and how it is presented affects an individual's ability to segregate two streams.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   - This study is significant for the CSD field because it demonstrates that there is much more to stream segregation than simply peripheral channels. There is a lot more research that can be completed to continue to understand the various factors discussed in this study and how they interact to affect stream segregation.
   - I learned that there are so many different aspects of a sound that can affect stream segregation. I did not realize so much went into separating sounds. I also did not realize that this much research had been done on the topic of stream segregation.

Nie, Y., & Nelson, P. B. (2015). Auditory stream segregation using amplitude modulated bandpass noise. Frontiers in Psychology. 6:1151. doi: 10.3389/fpsyg.2015.01151

1. State the purpose of the study

   The purpose of this study was to look at the role of spectral overlap and amplitude modulation on stream segregation of noise signals and the build-up effect.

2. Describe the participants:

   For Experiment 1, ten listeners, ages 19 through 32, participated in the study. Five were males and five were females. All were normal hearing listeners.

   For Experiment 2, five female listeners with normal hearing, ages 19-44, participated. These individuals had not participated in Experiment 1.

3. State the independent variable(s).

   For Experiment 1, the independent variables were the spectral separations (100% overlap, 41% overlap, no-overlap), the amplitude modulation (AM0-0, AM25-25, AM25-100, AM 25-300), and stimulus duration (3 pairs or 12 pairs)

   For Experiment 2, the independent variables were the spectral separations (77% overlap and 41% overlap), the amplitude modulation (AM0-0, AM25-25, AM25-100, AM25-300), and stimulus duration (3 pairs or 12 pairs)

4. State the dependent variable(s).

   The dependent variable is the ability of the participant to identify the delay or lack of delay on the final B bursts.

5. Identify the experimental design.

   Sounds were presented to subjects in a double walled sound attenuated booth. Stimuli were presented through headphones at 70 dB SPL. Listeners were asked to focus attention on segregating the two streams in order to detect the delay on the final B bursts. Participants were to respond on the computer “longer” for delayed stimuli and “shorter” for stimuli without a delay. After initial training, participants were asked were presented stimuli sequences in random order.

6. Summarize the results of the study.

   Experiment 1
   - There was no significant interaction between spectral separation and amplitude modulation.

- *d'* values increased as spectral separation between A and B subsequences increased from 100% overlap to no overlap.
- Better performance was demonstrated for AM25-300 and AM 25-100 than AM 25-25, AM0-0.
- No significant difference was seen between AM0-0 and AM25-25 or AM 25-100 and AM 25-300.
- Listeners performed better in the 12-pair condition than the 3-pair condition.
- A significant interaction was revealed for spectral separation and duration as well as for all three variable together, but not for just duration and amplitude modulation.

Experiment 2

- Listeners again performed better in the 12-pair condition than the 3-pair condition.
- Duration is significantly related to both spectral separation and amplitude modulation. The three-way interaction was not significant.
- Amplitude modulation rate contributed to build-up effect comparably at both spectral separations.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The study shows a functional relationship between spectral separations, amplitude modulation, stimulus duration and participants ability to segregate streams demonstrated in their identification of the delay or lack thereof in final B bursts.

   - When AM-rate difference is 2 octaves or larger, it can be a cue for listeners to segregate streams.
   - Spectral separation elicits the build-up effect seen in the improved performance on the 12-pair condition.
   - Spectral separation may be more perceptually salient for stream segregation than changes in AM-rate separation.
   - The effect of amplitude modulation on build-up effect may be dependant on spectral separation seen in the significant interaction between spectral separation, amplitude modulation, and duration but not amplitude modulation and duration.
   - The larger the spectral separation the better the performance.
   - Both spectral separation and amplitude modulation rate contributed to the build-up of stream segregation when the spectra of the stimuli are minimally to moderately separate.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   - This study is significant for the CSD field because it shows that listeners may incorporate both spectral separation and amplitude modulation when one alone may be ambiguous. The cues may have an additive effect.

- It is also significant because it demonstrates that cochlear implant users may be able to segregate auditory streams if the spectral separation and amplitude modulation rate cues are adequately large.
- I learned that amplitude modulation and spectral separation have an additive effect that together improves stream segregation. Previously, I would have thought that they would each have their own separate effect.

Nie, Y., Zhang, Y., & Nelson, P. B. (2014). Auditory stream segregation using bandpass noises: evidence from event-related potentials. Frontiers in Neuroscience, 8:277. doi: 10.3389/fnins.2014.00277

1. State the purpose of the study

   The purpose of this study was to measure neural responses in relation to auditory stream segregation with or without clear spectral contrast between streams.

2. Describe the participants:

   Nine adult listeners, five females and four males, participated in the study. All of them were right-handed with normal hearing.

3. State the independent variable(s).

   The independent variables were the presence or lack of spectral separation created via bandpass filters, and voluntary attention.

4. State the dependent variable(s).

   The dependent variables were the event related potentials in the EEG results (P3b, mismatch negative/N2b, etc.) and the behavioral response *d'* values.

5. Identify the experimental design.

   Sounds were presented to subjects while in an acoustically attenuated and electrically-isolated chamber. Stimuli were presented at 60 dB above the participant's threshold at 1000 Hz through an insert earphone in the right ear. 120 stimulus sequences of twelve pairs of A/B bursts were presented per block. 50% of stimulus had a delay on the final B burst and 50% did not. Four blocks were completed with each participant consisting of both passive and attentive listening each paired with spectral separation and no spectral separation. For the passive listening, participants were asked to ignore acoustic stimuli while watching a muted movie with subtitles. For the attentive listening, participants were asked to push a key on a computer keyboard when they heard the delay of the final B burst. Continuous EEG was recorded. Event related potential and global field power were calculated and recorded.

6. Summarize the results of the study.

- P3b in Attentive Condition
  - Significant P3b responses were observed both with and without spectral separation in the attentive listening condition.
  - There was a strong positive posterior parietal distribution which peaked earlier for stimuli with spectral separation than those without separation.
  - For P3b, there was no significant amplitude difference between stimuli with and without spectral separation.
  - A positive potential maximum moved from the frontal area to the potential parietal area
- Mismatch Negative/N2b in Attentive Listening
  - There was a small MMN/N2b component at the centro-frontal sites preceding the Pb3 response.
  - The N2b component was not significantly different from the zero baseline in both stimuli with or without spectral separation.
- Mismatch Negative in Passive Listening
  - There was no presence of MMN during passive listening for the conditions with no spectral separation between the A and B sequences
  - With spectral separation, a discrepancy was seen between the GFP which showed significant mismatch negativity and the Fz channel that did not.
- Behavioral Data
  - *d'* values were higher for stimuli with stream segregation than those without
- Brain-Behavioral Correlation
  - There was a significant correlation between P3b latency and *d'* scores.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The study did show a functional relationship between event-related potentials, stream segregation, and attention.

   - Spectral separation between A and B bursts is necessary for stream segregation during passive attention.
   - Spectral separation improved performance for attentive listening.
   - This stimulus paradigm can elicit reliable event related potential measures.
   - Rhythm is not an adequate cue for stream segregation in passive listening, however, when listeners focused attention on following the rhythm it can be used to segregate streams.
   - Spectral separation is necessary for auditory streaming in passive listening.
   - Even when the frequency separation was degraded using a band-pass filter, there was evidence for segregation in passive listening.
   - Attentive listening is necessary for stream segregation when there is no spectral separation between A and B bursts.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

- This study is significant for the CSD field because even with degraded frequency separation, stream segregation is still possible even with passive listening. This may indicate that cochlear implant users with similar degraded spectral separation are also able to segregate streams with passive listening.
- This paradigm yielded measurable neurophysiological responses, which can be used in future research in the field.
- I learned that stream segregation can be measured objectively using EEGs to look at brain wave responses. All previous studies I had read were subjective and used only participant responses to measure segregation.

Sarah Troy's Article Summaries

Moore, Brian C. J. and Gockel, Hedwig (2001). Factors Influencing Sequential Stream Segregation. *ACTA ACUSTICA UNITED WITH ACUSTICA, VOL. 88 (2002), 320-332.*

1. State the purpose of the study

   The purpose of the study was to find out the factors that influence streaming and to test the hypothesis that the extent to which sequential stream segregation occurs is directly related to the degree of perceptual difference between successive sounds. The study focuses on the fact that fission, or sounds perceived as different streams, can occur with sound that have very similar power spectra because many other factors are involved in stream segregation.

2. Describe the participants.

   The participants were different for each individual study.

3. State the independent variable(s).

   The degree of perceptual difference (ex: differences in excitation, differences in envelope, differences in fundamental frequency, differences in phrase spectrum, and differences in lateralisation) between the sounds is the independent variable.

4. State the dependent variable(s).

   The extent to which stream segmentation occurs is the dependent variable.

5. Identify the experimental design.

   This paper examined multiple research studies and experiments done in which the stream segregation of participants was measured to see which perceptual differences in sequences influenced the stream segregation and how these differences influenced it.

6. Summarize the results of the study.

   The results of this study have confirmed that any sufficiently salient perceptual difference—including but not limited to difference in excitation and peripheral channeling—may lead to stream segregation.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   Yes, it did because the study proved that the type and degree of perceptual differences between the sounds did influence the extent to which stream segmentation occurred.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Science and Disorders, and what you learned from the study.

   This study is significant because it is still widely believed by many in the field of Communication Sciences and Disorders that the largest factor influencing sequential streaming is peripheral channeling. In fact, I only really knew about that being a factor. However, this paper reviewed many other factors (ex: differences in excitation, differences in envelope, differences in fundamental frequency, differences in phrase spectrum, and differences in lateralization) that also influence stream segregation. This review found that small perceptual differences can improve performance in tasks where segregation is beneficial and larger perceptual differences can produce obligatory stream segregation.

Nie, Y., Zhang, Y., Nelson, P. (2014). Auditory stream segregation using bandpass noises: evidence from event-related potentials. *Frontiers in Neuroscience, Volume 8, 1-12.*

1. State the purpose of the study

   The purpose of the study was to examine auditory stream segregation of noise stimuli with and without clear spectral contrast and to measure the neural responses in the stream segregation.

2. Describe the participants.

   The participants consisted of nine (five females and 4 males) right-handed adult listeners who were all between the ages of 19 and 39 years old. The participants' hearing threshold were all measured prior to the study and were no greater than 20 dB HL at audiometric frequencies of 250, 500, 1000, 1500, 2000, 3000, 4000, 6000, and 8000 Hz on the right side.

3. State the independent variable(s).

   The independent variables are the noise stimuli with or without clear spectral contrast and the attentive and passive listening conditions.

4. State the dependent variable(s).

   The dependent variable is the neural responses measured through event related potentials in the EEG results.

5. Identify the experimental design.

   Sequences of twelve pairs of alternating (A and B) bursts of noise were presented to the normal-hearing participants to elicit stream segregation. The duration of an A or B burst was 80ms including 8-ms rise/fall time. The B burst sequences maintained an onset-to-onset interval of 340 ms except for the last (12^{th}) B burst whose onset was either delayed or not delayed. The A bursts were randomly placed between two successive B bursts. The

successive B bursts in each sequence maintained the same amount of temporal separation with manipulations introduced on the last stimulus. The A and B bursts were then further manipulated by using either band-pass filtered noises widely spaced in center frequency or broadband noises. Listeners were seated in an acoustically-attenuated and electrically-isolated chamber. Stimulus presentation used the EEvoke software and sounds were presented through an insert earphone to the right ear. The sound level was set at 60 dB above the participant's hearing threshold for a 100 Hz sine wave tone and administered for both passive and attentive listening conditions in four stimulus blocks lasting about 2 hours long. Event-related potentials to the last B bursts were analyzed to compare the neural responses to the delay vs. no-delay trials in both passive and attentive listening conditions.

6. Summarize the results of the study.

   The findings in both attentive and passive listening conditions indicated that ERP measures might be reliable indirect indicators of stream segregation based on less distinctive spectral separation cues. The results suggested that spectral separation in the A and B burst sequences could be beneficial to stream segregation at the pre-attentive level because a trend for a possible late mismatch negativity or late discriminative negativity response was observed in the passive listening condition only when the A and B bursts were spectrally separate. In the attentive condition, there was an indication of a beneficial role of voluntary attention in stream segregation, due to a response that was consistently elicited regardless of whether there was a separation between the A and B bursts or not. These results suggested that reliable event-related potentials can be used as direct indicators for auditory stream segregation when there is weak spectral contrast. Also, better behavioral performance was correlated with an earlier P3b peak.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   Yes because the results clearly showed a relationship between the neural responses recorded through event-related potential measures and the auditory stream segregation in conditions of clear and unclear spectral contrast.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   The results are significant for cochlear implant studies because as spectral information available through a cochlear implant device is reduced, it may require more attention for CI users to achieve stream segregation.

Bockmann-Bartherl, M., Deike, S., Brenchmann, A., Ziese, M., Verhey, J. L. (21 July 2014). Time course of auditory streaming: do CI users differ from normal-hearing listeners? *Frontiers in Psychology, Volume 5 (July 2014), pages 1-9.*

1. State the purpose of the study.

The purpose of this study is to examine streaming in cochlear implant (CI) users and see if they could perceive alternating sequences as either a single stream or two segregated streams at four different fundamental frequency separation values for alternating A and B harmonic complexes. These results were then compared to those of normal-hearing listeners.

2. Describe the participants.

   The participants were eight CI users between the ages of 60-83 years old, four females and four males. The participants' experience with cochlear implants ranged from 8 months to 16 years so there was a lot of variation with experience levels. All participants used their everyday device settings and just one implant for the experiment.

3. State the independent variable(s).

   The independent variable was the fundamental frequency separation between the alternating A and B harmonic complexes.

4. State the dependent variable(s).

   The dependent variable was the proportion of the 30 sec sequence in which the CI user was able to correctly perceive alternating sequences as one or two streams of sound.

5. Identify the experimental design.

   CI users listened to 30 second long sequences of alternative A and B harmonic complexes at four different fundamental frequency separations, ranging from 2 to 14 semitones, and indicated whether they perceived one or two streams of sounds and also any changes of the percept throughout the rest of the sequence. Sounds were presented to the CI users in a free-field condition in a sound-attenuated room through a loudspeaker located at the front of the room. The task of the listeners was to indicate their current percept continuously on a computer mouse, using the left button if one single stream of sound was perceived and the right button if two separate, parallel streams of tones were perceived.

6. Summarize the results of the study.

   This study found that the results of those with cochlear implants are similar to the results of normal-hearing listeners in a similar streaming study in that the probability of the first decision to be a one-stream percept decreased and that of a two-stream percept increased as the frequency separation increased. Also, a build-up was found only for a fundamental frequency separation of 6 semitones. These results agreed with the results of normal-hearing listeners, therefore indicating that the quality of stream formation is similar in CI users and normal-hearing listeners.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

The study did adequately show a functional relationship between the changing fundamental frequency separation values and the CI user's ability to correctly perceive alternating sequences as one or two streams of sound. These results were similar to the results in a similar study on normal-hearing listeners. However, since it was a smaller sample size of only 9 participants, more research in this area may need to be done.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   The results of this study are significant in this field because it shows that the perceptual abilities of CI users are very similar to the perceptual abilities of normal-hearing listeners in that as the fundamental frequency separation the A and B harmonic complexes increases towards the end of the sequence, the more likely the listener will perceive two separated streams percept instead of a one single stream percept. This therefore indicates that the quality of stream formation is very similar in CI users and normal-hearing listeners, something I would not have known before reading this research article.

Deike, S., Heil, P., Bockmann-Barthel, M., Brenchman, A. (31 October 2012). The build-up of auditory stream segregation: a different perspective. *Frontiers in Psychology, Volume 3, pages 1-7.*

1. State the purpose of the study

   The purpose of this study is to test if the phenomenon that streaming sequences are heard as one stream at the beginning but then perceived to have split into two separate streams after some time.

2. Describe the participants.

   There were 22 participants, 9 males and 13 females, between the ages of 19 and 38 years. All of the participants had normal audiograms with absolute thresholds of no more than 20 dB hearing level.

3. State the independent variable(s).

   The independent variable is the amount of fundamental frequency separations between the harmonic complexes.

4. State the dependent variable(s).

   The dependent variable is the proportion of the 30 sec sequence in which the participants' percept of the sound as either one single stream or two separate streams.

5. Identify the experimental design.

Participants listened to ABAB sequences where A and B are harmonic complexes of seven different fundamental frequency separations ranging from 4 to 12 semitones. These were presented binaurally through headphones at a comfortable level through Presentation while the participants were in an acoustically shielded room. The stimuli were digitally synthesized in Matlab. The harmonic tone complexes were the fundamental frequency and four partials with frequencies from 2 to 5 F0. The tone complexes were presented in ABAB sequences of 30 second duration with a presentation rate of 6 Hz. The participants then had to specify as soon as possible whether their initial percept was that the sound was one single stream or two separated streams of sound. The participants also had to indicate if there were any changes during the sequences.

6. Summarize the results of the study.

   The results of the study concluded that the time elapsed before making a perceptual decision does not impact whether the stream sequence is perceived as one single stream of sound or two separate streams of sound. The participants did not generally indicate a one-stream perception of sound early on. Instead, the study instead found that the change in the fundamental frequency separation between the A and B harmonic complexes influenced the percept of sound more, with the probability of a one stream percept decreasing and that of a two-stream percept increasing as the fundamental frequency increases. Also, participants seemed to take more time then expected to make their decision. For six semitones, at first there is a one-stream dominance which balances out to both perceptions by the end of the sequence.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   Since there was a high test-retest reliability, clear and consistent results, and the sample size was a larger size than other studies, I do believe that the study adequately shows a functional relationship between the independent variable of the changing fundamental frequency separation and the dependent variable of the percept of sound as one or two streams. However, some aspects of this study should be further explored in future studies, such as whether or not build-up actually occurs.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   There has been an assumption in the field of Communication Sciences and Disorders that participants will generally perceive one single stream at the beginning of sound sequences. However, this study did not agree with that assumption and instead found that the fundamental frequency separation more greatly influenced the perception as either one or two streams of sound. These newfound results may change the ideas and assumptions in the field and show how important it is to perform multiple experiments in order to make sure that a phenomenon and assumption is true.

Nie, Y., Nelson, P. (07 August 2015). Auditory stream segregation using amplitude modulated bandpass noise. *Frontiers in Psychology, Volume 6. 1-11*.

1. State the purpose of the study

   The purpose of the study was to investigate the roles of spectral overlap and amplitude modulation (AM) rate for stream segregation for noise signals. The study also tested the build-up effect based on these two cues.

2. Describe the participants.

   For the first experiment, there were ten participants between the ages of 19-32 years old. The participants were all normal-hearing listeners with hearing thresholds no greater than 20 dB HL on the right side.

   For the second experiment, there were 5 female listeners between the ages of 19 and 44 years who all had normal hearing.

3. State the independent variable(s).

   The independent variables in both studies were the spectral differences, the AM-rate differences in noise signals, and the stimulus durations.

4. State the dependent variable(s).

   The dependent variables in these studies are the stream segregation skills of the listeners as well as the build-up effects.

5. Identify the experimental design.

   Prior to the data collection, participants were to practice the experimental task with two 40-trial sessions of 12-pair sequences, one for both the no-overlap condition and the overlap condition. In the experiment, IBM SPSS statistics version 21 was used to analyze the data. Data was analyzed using the linear mixed-model approach. Participants were presented with stimulus sequences consisting of two interleaved sets of bandpass noise bursts (A and B bursts). The A and B bursts differed in spectrum, AM-rate, or both and the amount of difference between the two sets of bursts was varied. Long and short sequences were examined for the build-up effect for segregation based on spectral and AM-rate differences. The stimuli were processed live through a SoundMAX Integrated Digital Audio sound card installed in a Dell computer. Listeners performed the experimental tasks inside a double-walled sound attenuated booth. Stimuli sequences were presented to the right ear through headphones at 70 dB SPL for each noise burst.

6. Summarize the results of the study.

The results of the study showed that stream segregation skills increased with more spectral separation. The study also found that larger AM-rate separations were associated with stronger segregation skills. Spectral separation was found to elicit the build-up effect for the range of spectral differences assessed in the study. In addition, the study found that AM-rate separation interacted with spectral separation suggesting an additive effect of spectral separation and AM-rate separation on segregation build-up. Spectral separation does elicit a build-up effect seen in the improved performance on the 12-pair condition. These results suggest that when normal-hearing listeners direct their attention towards segregation, they are able to segregate auditory streams based on lessened spectral contrast cues that vary by the amount of spectral overlap. The study also found that, regardless of the spectral separation, normal-hearing listeners are able to use AM-rate difference as another (but weaker) cue. Based on the spectral differences, normal-hearing listeners can segregate auditory streams better as the listening duration gets longer. However, AM-rate differences appear to only elicit build-up when in combination with spectral difference cues.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The study adequately showed a functional positive relationship between the stream segregation skills and an increase in either spectral separation or in AM-rate separations. However, there are some alternative explanations of the results, such as the argument that these results could be explained by stream segregation based on other cues that do not involve stream segregation such as rhythmic cues, cues from focusing on the last pair of A and B bursts instead of focusing on the ongoing sequence, and spectral cues introduced by the AM by generating distortion products. Therefore, more experiments should be done to continue to prove the relationships found in this study.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   The results add on to previous experimental study results that also concluded that both spectral and temporal cues can elicit stream segregation. This study investigates further to show the effects of build-up of segregation based on spectral separation and AM-rate separation. This study also suggests that cochlear implant users might be able to segregate different auditory streams if the spectral and modulation rate differences are adequate. Cochlear implant users may also use spectral and AM-rate cues together when the task focuses on stream segregation in order to elicit the build-up effect. These further suggestions from the study could have an impact on the field of Communication Sciences and Disorders because it could lead to new experimental studies and new findings for cochlear implant users.

Crew, J. D., Gavin, J. J. III, Fu, Q. (25 September 2015). Melodic contour identification and sentence recognition using sung speech. *Acoustical Society of America.*

1. State the purpose of the study

The purpose of this study is to test the differences in the perception of speech in musicians and non-musicians, with the hypothesis being that long-term musicians have an advantage as the speech becomes more complex.

2. Describe the participants.

   There were 16 participants in this study, eight musicians and eight non-musicians, all between 24 and 47 years old. All of the participants had their hearing tested prior to the study and had pure tone thresholds less than 20 dB between the audiometric frequencies of 125 Hz and 4000 Hz. The musicians had to have been regularly playing a musical instrument at the time of recruitment, whereas non-musicians had to never had any formal or informal instruction on playing an instrument.

3. State the independent variable(s).

   For the sentence recognition task, the independent variable was the shape of the contour: flat, fixed, or random.

   For the melodic contour identification, the independent variable was the word stimulus: fixed word, fixed sentence, random sentence.

   For both tasks, the amount of musical experience is an independent variable.

4. State the dependent variable(s).

   The dependent variable is the sentence recognition and melodic contour identification skills of the participants using the SSC.

5. Identify the experimental data.

   The study uses the Sung Speech Corpus (SSC), a device that contains 50 monosyllabic words sung over an octave range and can be used to test both speech and music perception using the same stimuli. Using the SSC, a five-word sentence can be constructed to use a five-note melody, so that sentence recognition and melodic contour identification (MCI) are both able to be measured using the same stimuli. All stimuli were 500 ms in duration. The fundamental frequency of each word was selected to create a target pitch contour. The stimuli were presented to both the musician and non-musician participants to compare their sentence recognition and melodic contour identification. During testing, a test sentence was presented to the subject who had to respond by clicking on the word that was thought to be perceived within each category. The participants were allowed to repeat the sentence for up to three times and performance was scored based on recognition of the entire sentence. The sentence recognition took about 6-8 minutes to complete each run. Similarly, during MCI testing, the same stimuli was used and as a contour was presented, the participant would have to respond by clicking on one of nine response boxes shown on the computer screen. MCI was scored in terms of overall percent correct, as well as percent correct for each semitone spacing condition. The MCI test took about 4-5 minutes to complete each run.

6. Summarize the results of the study.

   The results indicated that sentence recognition was very good for both subject groups (musicians and non-musicians), with musicians and most non-musicians scoring near perfect scores. Therefore, there was no significant difference between the two groups on sentence recognition. However, on MCI testing, there was a strong musician advantage with musician performance being nearly perfect in all conditions and non-musicians performance being generally worse and with more amounts of variation. The musical effect for MCI performance did in fact become stronger as the stimuli became more complex. Non-musicians performed better with musical contour identification for piano and fixed word than for the fixed sentence or random sentence.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   The results of this study showed a relationship between an increased musical ability and an increased performance on MCI testing, although there was not a clear relationship between musical ability and speech recognition. The contour of the sentence also did not seem to affect the responses of the participants.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   This study showed a clear relationship between the level of musical experience and performance on MCI testing. These results could indeed have a great significance on other types of MCI testing experiments. Prior to reading about this study, I would have guessed that musical ability effected MCI performance, but I would have also thought that it affected sentence recognition in various conditions, which it did not, so I learned a lot from this study. This study is also significant because it shows that the SSC may be a useful device to use while testing bimodal CI listeners.

Galvin, J. J. III, Fu, Q-J., Oba, S. (22 September 2008). Effect of instrument timbre on melodic contour identification by cochlear implant users. *Acoustical Society of America.*

1. State the purpose of the study

   The purpose of this study was to test normal hearing listeners' and cochlear implant (CI) users' melodic contour identification (MCI) for six different instruments. The study investigated whether the CI users' melodic pitch perception was influenced by each instruments' timbre.

2. Describe the participants.

There were eight CI participants and eight normal-hearing participants in this study. All of the subjects had various levels of musical experience.

3. State the independent variable(s).

   The independent variable was the type of instrument (organ, glockenspiel, trumpet, clarinet, violin, and piano) and the timbre of that individual instrument. The interval between the successive notes was another independent variable. Also, another independent variable was the amount of musical experience of each participant prior to this study.

4. State the dependent variable(s).

   The dependent variable was the participants' melodic contour identification performance.

5. Identify the experimental design.

   The stimuli in this study consisted of nine melodic contours: Rising, flat, falling, flat-rising, falling-rising, rising-flat, falling-flat, rising-falling, and flat-falling. Each contour consisted of five notes played in a sequence. Melodic contours were generated for each of the six musical instruments used in this study: the organ, glockenspiel, trumpet, clarinet, violin, and piano. Stimuli were presented to the participants through a single loudspeaker at 70 dB in a sound-treated booth. Each test block per instrument was repeated a minimum of 3 times and the test block order was randomized within and across subjects. During each test block, a stimulus was randomly selected from the one of the nine contours and one of the five intonations (so out of 45 possible stimuli) and the participants had to click on one of the nine contour response choices shown on the screen.

6. Summarize the results of the study.

   The study found that MCI performance for CI users was best with the organ and poorest with the piano for all of the instruments overall. There was a mean performance across CI participants and instruments of 62.3% correct. However, different CI participants showed different patterns of results across instruments. The study found that the instrument timbre did influence most CI participants' MCI performance. However, CI participants with more experience with music were less susceptible to timbre effects of the instruments, which suggests that music training and experience may help to extract melodic pitch from a variety of instruments or sound sources. Musical experience also influenced the abilities of normal hearing participants. The mean normal-hearing participant was 86.8% correct across instruments and participants, with those with more musical experience scoring higher than those with less musical experience.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   While instrument timbre did greatly influence most of the CI subjects' MCI performance, this pattern of results was not consistent across all of the participants. For example, one of the

participants had the worst performance for the glockenspiel, while the glockenspiel was the best performance for another participant. Therefore, the present data does not show any clear relationship between the type of musical instrument and the MCI performance, although overall, the best performance was with the organ and the poorest was generally with the piano. There was, however, a clear functional relationship between the independent variable of the amount of musical experience prior to the study and the MCI performance of the participant, with musically experienced CI participants performing better than participants with less musical experience. Musical experience also influenced the normal hearing participants' melody identification abilities.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   This study shows that moderate amounts of training with musical instruments and melody identification could improve CI users' music perception. This could help CI users to be able to listen to music and understand contours better.

Miller, S. E., Schlauch, R. S., Watson, P. J. (2010). The effects of fundamental frequency contour manipulations on speech intelligibility in background noise. *Acoustical Society of America, pages 435-443.*

1. State the purpose of the study

   The purpose of the study was to examine how fundamental frequency (F0) manipulations further affect speech intelligibility in background noise.

2. Describe the participants.

   There were 15 participants in this study, all between the ages of 18 and 30 years old and all American-English speakers. All participants had normal hearing sensitivity and no history of speech-language or neurological disorders.

3. State the independent variable(s).

   The independent variable is the fundamental frequency contour condition.

4. State the dependent variable(s).

   The dependent variable is the participants' speech understanding of the words presented to them.

5. Identify the experimental design.

   Speech recognition was measured in noise stimuli with the following contours: unmodified, flatten at the median, natural but exaggerated, inverted, and sinusoidally frequency

modulated at rates of 2.5 and 5.0 Hz (which are rates shown to make vowels more perceptually salient in background noise). Five female, native American-English speakers produced 180 stimulus sentences (six sentences per speaker in each of the six contours, creating 30 unique sentences per F0 contour condition). The stimuli were presented one time randomly to each participant through an earphone into the left ear of the participants as they were seated in a double-walled sound-attenuated booth. Once the participants heard the sentence, they were to record and repeat out loud the sentence that they perceived so that then the examiner could record the sentence as well. The participants were then scored on how many sentences they correctly perceived.

6. Summarize the results of the study.

   The study found that flattening or exaggerating the F0 contour decreased the ability of participants to recognize key words by 13% when compared to the natural produced speech. Inverting or sinusoidally frequency modulating the F0 contour decreased the success of performance by 23% when compared to natural produced speech. Keywords at the end of the sentence appeared to be less intelligible than earlier keywords in the normal condition; the opposite trend appears for inverted fundamental frequency conditions. These results agree with the idea that linguistically incorrect or misleading cues have a more damaging affect on speech understanding than linguistically neutral cues.

7. Did the study adequately show a functional relationship between the dependent and independent variables? Why or why not?

   Yes, this study adequately showed a functional relationship between the fundamental frequency contour manipulations and the participants' ability to understand speech stimuli because participants' consistently had reduced speech understanding abilities in background noise when unnatural F0 contours (ex: flattened or inverted F0 contours) were used. For the flat condition, stress cues were neutralized, but were not inaccurate or misleading as was the case for the inverted fundamental frequency contour. Exaggerating the fundamental frequency contour also lowered the speech intelligibility which was not what was hypothesized; the chosen exaggeration factor could have interfered with the fine structures of the sentences for persons with normal hearing.

8. Briefly state the significance of the study, the implications of the study for the field of Communication Sciences and Disorders, and what you learned from the study.

   While previous studies have explored similar topics and found that speech with flattened or inverted fundamental frequency contours is less intelligible than speech with natural variations in F0, this study further explored these areas and found new results as to how the F0 manipulations affect speech in background noise. Agreeing with the previous studies, this study concluded that speech understanding abilities in background noise also decreased due to unnatural F0 contour manipulation. This study differed from other studies, however, in that this study found that there was a dramatic difference in intelligibility between monotone-pitched speech and inverted F0 contour speech in the presence of just speech-shaped noise. The results of this study can be compared to results of many other studies that have been

conducted to explore the effects of fundamental frequency contours or background noise on speech perception.

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