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## Chemotherapy Induced Hearing Loss and the Effects It Has on Learning

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Chemotherapy Induced Hearing Loss and the Effects It Has on Learning

Sydney Smith

Program in Communication Disorders

Honors Thesis

Spring 2011

### Abstract

The purpose of this study was to determine whether the chemotherapy drug Cisplatin causes hearing loss significant enough to affect attention. Three groups of participants, all of which will have taken the drug Cisplatin, was sought to participate in this study. Fifteen was elementary, fifteen middle schools aged, and fifteen high school aged. There will be no control for sex or ethnicity. A questionnaire survey will be used to collect the data. The survey was made available through pencil and paper and/or online. Physicians who work with this clinical population was asked to make the survey available to the patients and their family. In addition, the survey was made available through cancer support group links. Analysis was performed in a descriptive manner.

### Chemotherapy Induced Hearing Loss and the Effects it has on Learning

Many prescription drugs have possible ototoxic side effects. From a simple headache to curing cancer, damage to the ears can occur. Some of the possible but unlikely drugs that result in ototoxicity are anti-inflammatory drugs such as Ibuprofen, Motrin, Aleve, etc. Some antibiotics, which are used to treat many bacterial infections, may result in hearing loss as well as loop diuretics which are often used to treat kidney failure. Ototoxicity can occur as a side effect from each of these drugs, but it is rare and often seems to reverse in time. However, ototoxicity caused by chemotherapy agents can result in permanent, non-reversible hearing loss. Some of the chemotherapy drugs that are suspected to result in ototoxicity are Cisplatin, Carboplatin, Nitrogen Mustard, Vincristine, Eloxin, and other platinum based drugs. Some of these drugs are used to treat cancers of the throat, head, those which cause neoplasms (tumors), neurological (brain) cancers, childhood cancers, leukemia, germ cell, and many others. Although these specific chemotherapy drugs are very powerful and highly affective, they are very toxic to the inner ear. The most common chemotherapy drug that results in ototoxicity is Cisplatin. Some of the cancers Cisplatin is used to treat consist of sarcoma, small cell lung cancer, germ cell, lymphoma, ovarian cancer, neurological cancers, and other cancers involving neoplasms. Cisplatin is used to treat a variety of people especially children.

Allen and Helt-Cameron (2009) state that, “many children are diagnosed with cancer each year, and because of medical advances, the survival rate of these children has greatly increased.” This indicates that a large majority of children diagnosed with cancer during adolescence will survive. However, many lasting side effects may persist throughout the survivor’s life. Many people who undergo the chemotherapy drug Cisplatin may experience damage to the inner ear causing sensorineural hearing loss which may result in tinnitus. Tinnitus

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is often associated with hearing loss in the high frequency regions resulting in a perception of ringing within the ears. The constant ringing of the ears that tinnitus causes may be very distracting and may result in the child having poor attention skills. Because of this, the child may fail to succeed in many important levels of learning. The age in which the child is affected by the drug will determine what type of knowledge the child may neglect. The decreased attention can affect the child to the point of him/her being unable to retain information and may cause him/her to fall behind in many areas including speech. Therefore, it is important for Speech-Language Pathologist to be aware of the hearing deficiencies that can result from chemotherapy drugs such as Cisplatin, and it is important that they understand the effects that a hearing deficit, such as tinnitus, can have on the child's cognitive and attention skills as well as their psychological state.

### Review of the Literature

#### *The Effects of Ototoxic Drugs on the Inner Ear*

Ototoxicity is hearing loss due to the toxic particles in drugs such as Cisplatin. Cisplatin is one of many platinum based chemotherapy drugs which often create what is known as "free radicals." In order to be in a more stable position, the free radicals need to interact with other molecules or cells. When interacting with the cell wall of the inner ear, the hair cells (cilia) die or become no longer active (Effects of Chemotherapy, 2011 ). Free radicals have an odd number of electrons making them a very unstable molecule; thus, damage to another cell will often occur. This is due to the high energy, vigorous reaction that a free radical produces upon interaction with other molecules. The damaged hair cells can result in high frequency hearing loss that is irreversible.

This hearing loss can lead to many hearing deficiencies such as tinnitus, fullness of the ear, sensorineural hearing loss, problems with balance/coordination, possible deafness, etc. A

study by Slattery and Warchol (2010) looked at the effects that the chemotherapy drug Cisplatin has on the avian inner ear. The research showed that after the inner ear has been extensively exposed to Cisplatin, there is often hair cell death in the cochlea affecting both high and low frequency regions. It also showed that the hairs were unable to be restored leaving permanent damage to the inner ear, severely impairing the avian ear. The amount of damage that occurs is thought to be somewhat dependent on the amount of the drug that is given and the extent of treatment.

The combination of drugs required for treatment may also affect the severity of damage. Cisplatin is often combined with other chemotherapy agents to create a more effective treatment plan; however, some combinations can lead to more vigorous side effects. Also, when taking the drug, it is recommended to not pair the drug with other general medicines such as Tylenol or Advil. This can cause faster and more severe damage to the inner ear. The damage will likely become an issue in the child's cognitive development and may cause many hearing related problems.

#### *Why Hearing Loss Caused by Ototoxic Drugs is an Issue*

The ability to efficiently hear is often taken for granted until it becomes impaired or lost. Hearing is used in every part of life and is very important for the development of language and social skills. If a patient who received the drug Cisplatin develops a hearing loss, especially at a young age, social and cognitive advancements may be altered. In many cases, ototoxicity is frequent and creates permanent damage. Upon the evaluation of Cisplatin induced ototoxicity, McFarland, Littman-Power, and Kelly (2000) found that high frequency hearing loss was evident in 39% of all patients. In addition, hearing loss in the speech range is shown in 88% of all children treated with Cisplatin for brain tumors. This may result in psychological and

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neuropsychological issues, which could possibly affect the patient's therapy and quality of life in regards to hearing and speech.

Not only can this drug result in high frequency hearing loss, but also sensorineural hearing loss. Many studies have shown the effects of ototoxic drugs on the ear causing sensorineural hearing loss. A study by Lackner and colleagues (2000) examined 223 children who were treated for childhood cancer with a median age at diagnosis of 7.2 years. The median time from treatment was 5 years. Twenty-two of the study's participants had received Cisplatin. Pure tone audiometry testing for late effects showed that 18 of the 22 children (81%) had bilateral sensorineural hearing loss, with 5 using hearing aids. Another research team led by Gilmer-Knight (2005) looked at the incidence of hearing loss in children and young adults treated with Cisplatin chemotherapy. They used pure tone audiometry to measure the hearing abilities of 67 children treated with Cisplatin. The children and young adults ranged in age from 8 months to 23 years of age. They found 41 of the 67 treated children (61%) experienced sensorineural hearing loss. Both of these studies show significant hearing loss in the patients. Depending upon the severity, the hearing loss may greatly affect the child's learning abilities and speech performance. The hearing loss can cause the child's attention span to be impaired resulting in learning and cognition impairments.

### *Hearing Loss and its Effects on Attention and Cognition*

If hearing loss occurs, the child's social and cognitive development may be impaired. The ringing and/or fullness of the ears that is often associated with sensorineural hearing loss may cause the child to lose the capability to retain information because of his/her lack of ability pay attention in louder more crowded environments. This can become an issue with the child in the school setting. The ringing of the ears or muffled sounds that are produced can become a

distraction to the child causing him/her to lose attention and fall behind cognitively. Rossiter, Stevens, and Walker (2006) performed a research experiment to see if there is a relationship between tinnitus and poor cognition or learning skills. They tested 19 participants who have experienced tinnitus for at least three months. What they found was that the participants with tinnitus had a much shorter reading recall span, and when they were asked to repeat a part of a sentence that was read to them, their reaction time and accuracy was very low as well. The patients also suffered from depression and anxiety due to the tinnitus. Depression and anxiety often occurs in patients with hearing loss especially those who once had complete hearing capabilities. This may be because they once had the ability to obtain information in most settings. However, now that the ability is impaired, they fail to notice a lot of important information causing their social skills to decrease.

An effect on the child's social skills may occur, regardless of the age that the hearing loss develops. This may be most evident in the areas of expressive (spoken and written) and receptive language. However, the severity of language miscues is often dependent on the age of the child and level of the hearing loss. A child who acquires a hearing loss before or during the prime age of speech development may be affected more dynamically on the level of speech production than a child in adolescence years. For most patients in which a hearing loss occurs, 25-40% of speech signals are missed; thus, difficulty with faint or distant speech sounds may arise as well as the unawareness of conversational cues (The Effects of Chemotherapy, 2011). This can have an enormous impact on the child's cognitive skills. Without the ability to completely retain the information being transmitted in the school setting, the child will likely fall behind in many areas. Thus, the question is, at what levels of learning and cognitive developments does an occurrence of a hearing loss, from the ototoxicity drug Cisplatin, affect the child more, or is there



even a noticeable difference in the child's cognitive/learning skills after being treated with this medicine.

### *Summary and Questions of the Study*

It is evident from the literature that the drug Cisplatin may cause ototoxic side effects which might possibly lead to many different levels of hearing loss due to death of cilia; this in turn, can result in impairments to the child's social and cognitive development. This leads to the following questions of this study:

1. Is the after effect in terms of hearing loss and attention, due to treatment with Cisplatin, experienced differently depending upon the age of the child?
2. Is there a difference between the perceptions of parents versus children for the impact of Cisplatin on hearing loss and/or attention?

## Methodology

### *Participants*

Forty-five families were, sought for this study, fifteen with children in each of the three age groups at the time of drug treatment. It was planned for the groups to consist of students receiving the drug prior to entering elementary school along with those in elementary school, those receiving the drug during middle school, and those receiving the drug during high school. There was no control for sex. Thus, anyone age-related was considered an applicable applicant. All subjects received the drug Cisplatin for a minimum 3 months. There was no control for how long they have been off the drug.

### *Materials*

A survey was given which could complete in paper/pencil or electronically.

Approximately twenty questions were asked in relation to the drug, hearing loss, and the affects that the hearing loss had on the patient, with emphasis on learning, attention, and comprehension.

### *Procedures*

A survey was produced from the literature regarding the drug Cisplatin and the affects it has on hearing loss. It was created in two different forms. A paper/pencil questioner and an electronic questioner placed on Survey Monkey. The method chosen was dependent on the client's preference and abilities. Physicians who work with this clinical population was asked to make the survey available to patients. In addition, the survey was made available through cancer support group links. A link to the survey website was distributed to the patients if they choose to participate in the electronic survey.

## Results

### *Participants*

Over thirty survey packets were sent to the oncology department at Arkansas Children's Hospital as well as to the audiology clinic located at that same hospital. The survey was also made available online through different cancer support groups as well as on the social media site, Facebook. From this, four dyad pairs responded to the survey. Three of the dyad pairs responded through the pencil/paper method with one dyad pair responding electronically. The demographics of the child respondents differed in terms of chronological age, school grade, age of treatment, and length of treatment. The average age of the child respondents was 15, the school grades ranged from 1<sup>st</sup> grade to a freshman in college, the average age for receiving the drug was 12 to 13 years of age, and the length of treatment averaged about 5 months with a mean of 2.50. All of the participants reported that they had some sensorineural hearing loss within the high frequency ranges. However, two of the participants recorded that they have significant

hearing loss with one being to the severity of needing a hearing aid. The total participants of this study were 8 people, 4 children and 4 adults.

<b>Child Demographics</b>				
	<b>Current Age</b>	<b>School Grade</b>	<b>Age of Treatment</b>	<b>Length of Treatment</b>
<b>Participant 1:</b>	7	1 <sup>st</sup>	3	3 to 6 months
<b>Participant 2:</b>	14	8 <sup>th</sup>	13 & 14	3 to 6 months: Still receiving drug
<b>Participant 3:</b>	17	11 <sup>th</sup>	13, 14 & 15	6-12 months
<b>Participant 4:</b>	18	College Freshmen	17	6 to 12 months

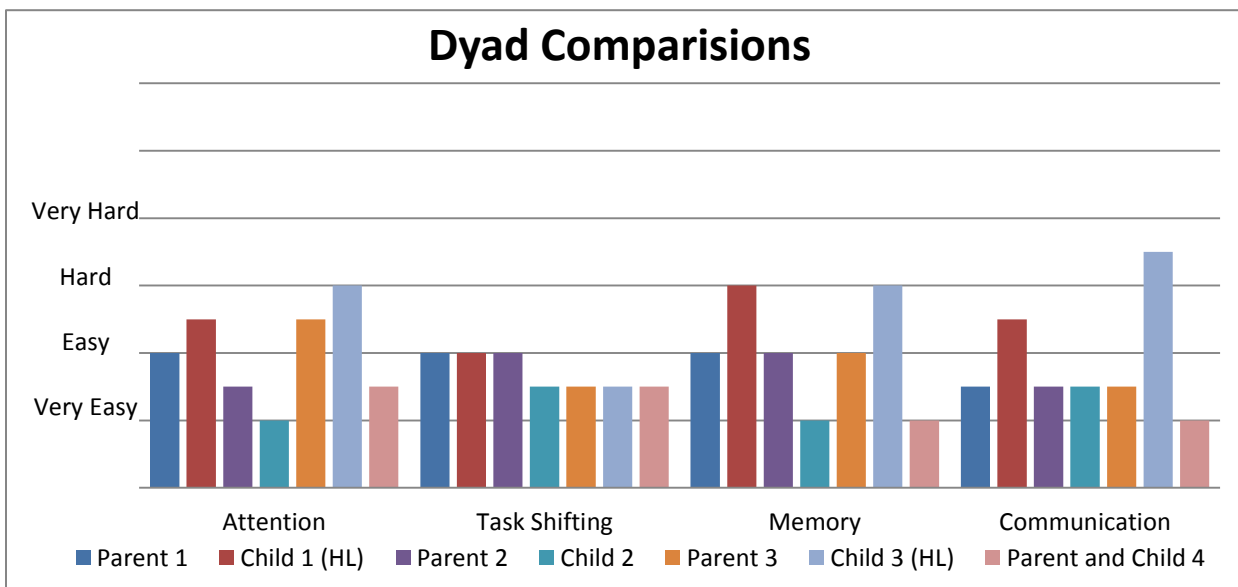
*First Question of Study*

The first question of the study examined whether the after effect in terms of hearing loss and attention, due to treatment with Cisplatin, were experienced differently depending upon the age of the child. In order to answer this, the survey accessed the child’s perceptions on questions regarding the ease to which they pay attention in certain settings. When asked the question, how easy it is to pay attention in school, one participant said that it was easy, two of the participants answered that it is hard, and one inferred that it is very hard to keep focus. When asked how easy it is for the participant to remember things, one stated that it is very easy, another stated that it is somewhat easy, and two of the participants stated that it is sometimes hard. When asked how easy it is for you to express to tell people what you are thinking through words, two participants inferred that it is sometimes hard whereas the other two inferred that it is sometimes easy. Some of the following aspects that two or more believed changed in terms of difficulty after taking the drug were doing more than one thing at a time, remembering to do things at home, describing

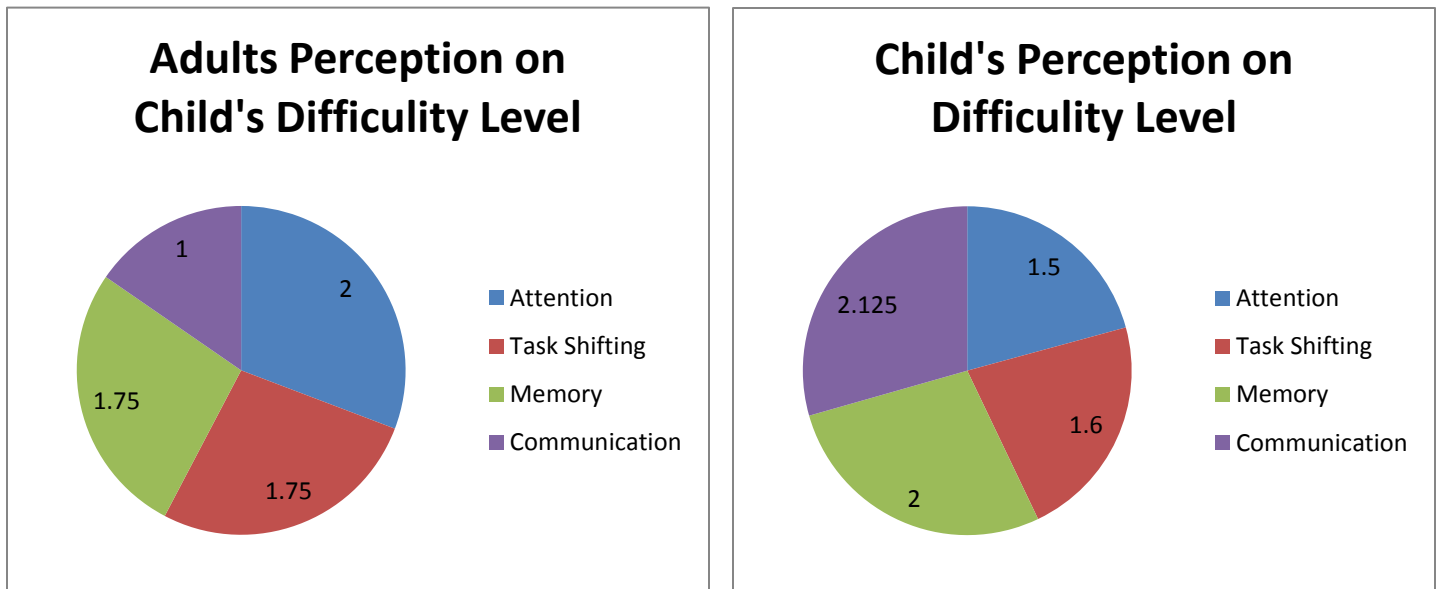
things to other people, saying words clearly, how well they can hear without some sort of listening device, and how well they can listen and fully understand when more than one person is talking.

*Second Question of Study*

The second question of the study examined if there is a notable difference between the perceptions of parents versus children for the impact of Cisplatin on hearing loss and/or attention. The parents were asked to assess their child’s hearing loss and attention skills in a similar manner to the method completed by the child. The perceptions of the parents and children were first examined by using paired data from dyad sets. The results were assessed on the topics of attention, memory, ability to shift between tasks, and ease of communication with other people. From these, it has been concluded that the children perceive that their difficulty level in performing tasks are almost identical to that of their parents except in the areas of communication. These results can be seen in the following table below:



The data was then analyzed in a second way, all adults compared to all children. This was done to determine if the overall perception of the children was different than the overall perception of the adults. The results can be seen the tables below and will be further discussed in the following section.



### Discussion

The purpose of this study was to determine whether the chemotherapy drug Cisplatin causes hearing loss significant enough to affect attention. As can be seen from the results of the first question of study, at least 50% of the participants inferred that they have a somewhat difficult time keeping focus on tasks at school and home when asked questions about attention abilities. Those with the a more severe hearing loss tended to answer that the tasks were more difficult for them whereas those with only slight hearing loss, in the high frequency ranges, tend to perceive many of the tasks as being easier. This infers that there is a positive correlation between the degree of hearing loss and the ability to retain information and keep attention. This

assumes that there is a stronger relationship between the variables of degree of hearing loss and inability to maintain focus than that of age and difficulty level.

The results of the second question of study revealed that the dyad pairs differ very little in the way that they perceive the effects that the hearing loss had on the child's attention, task shifting, and memory skills. However, when the area communication skills were assessed, the results were a little uneven. The majority of the children felt as if the effects of the medication altered their ability to communicate more than the parents perceived it to. Another interesting finding was that in the areas of attention, memory, and communication skills, the children who experienced a more severe hearing loss answered in a way in which assumes that they perceive the difficulty in these areas to be greater for them. This continues to support the assumption that the degree of hearing loss has a strong positive correlation with the difficulty of performing cognitive and communicative tasks.

Upon separating the data into two groups, one containing adults and the other containing all children, and assessing the results in this manner, a similar but somewhat more descriptive picture emerged. By viewing it from this angle, it can be concluded that in the areas of attention, task shifting, and memory, overall perception of both the adults and children are very similar to one another. However, as mentioned above and made evident in this method of comparison, the children perceive their overall communicative abilities when conversing with others to be more difficult whereas the parents view the children's communication as being sufficient. However, there was one notable difference between the adult and children perceptions when assessing attention that needs to be addressed. This area involves the setting in which it is believed that the children have a more difficult time keeping focus and remembering tasks. From the questioner the majority of the parents answered that they believe the setting in which their child has the

most difficult time remembering task and maintaining focus is at school. However, the majority of the children believed that they have a more difficult time remembering and maintain focus at home and an easier time at school. This indicates that the effects of the hearing loss may play a greater role in the attention and memory of children while they are in a comfortable setting.

While at school the children likely have the perception that they need to focus to accomplish their assigned tasks whereas at home, they most likely relax and become engaged in other things that make them more distracted.

The current available literature is very limited in the area of comparisons regarding the differences in the perceptions of parents and children when it comes to the effects of Cisplatin on the child's cognitive and communicative skills. However, the literature does assess the effects that Cisplatin is believed to have on attention and communication skills when hearing loss is present. For most patients in which a hearing loss occurs, 25-40% of speech signals are missed; thus, difficulty with faint or distant speech sounds may arise as well as the unawareness of conversational cues (The Effects of Chemotherapy, 2011). This may be a clear indication of why those with a greater degree of hearing loss felt as if they had a more difficult time understand others and being understood as well. They expressed that it is very hard for them to understand what others are saying. This may be due to the absence of speech signals and conversational cues. The literature also looks at some of the effects that the hearing loss and certain symptoms associated with it, such as tinnitus, may have on the patient. Rossiter, Stevens, and Walker (2006) performed a research experiment to see if there is a relationship between tinnitus and poor cognition or learning skills. What they found was that that the participants with tinnitus had a much shorter reading recall span, and when they were asked to repeat a part of a sentence that was read to them, their reaction time and accuracy was very low as well. These finding help

support the results of this study in terms of the child and parents perception of the hearing loss with emphasis on the child's ability to remain focused and remember effectively. However, no found literature examined the differences in perceptions of the parent and his/her child.

#### *Limitations of Study*

Although this study was thoughtfully prepared to reach its aims, many limitations occurred that altered the desired results. The first limitation to the study was the number of received participants. The study was intended to examine a medium size sample of patients, between the ages of (5-17), who have taken the drug Cisplatin as well as their parents or legal guardians. However, the population of the experimental group was much smaller than anticipated. The source that agreed to distribute the surveys to the specific population had some confusion about his role in the research resulting in the project being dispersed at a later time frame than hoped for. After the confusion was settled, the results were very limited because of the availability of the population.

The second limitation to the study was the availability of participants. This study desired a very specific population which made the number of participants somewhat restricted. By seeking participants who are minors, this required parental consent as well as personal consent. It is likely that parents of the population did not agree for their child to participate in the study due to a countless amount of possible variables. It is likely that the sample size would have been larger if all ages of people could have participated in the study instead of such a limited population. Another limitation of the study was time.

Time became a very large variable in the success of this project. Considering the surveys only had a few months to circulate, it is likely that many qualified participants did not have the opportunity to complete the questionnaire. If time would have not been a factor, more cancer



hospitals could have been contacted resulting in a larger population. This also reflects the last limitation which is a lack of resources.

The survey was dispersed to three different sources: a children's hospital, an audiology clinic, and via Facebook. The lack of resources was definitely a factor in the success of the study. Other sources were contacted, but they were reluctant to assist in the distribution of the survey due to unknown reasons.

#### *Future Directions*

The results that were formulated from the small population indicate that there is a correlation between the amount of hearing loss and the ability to pay attention especially in a comfortable (home) setting. Due to these results, this project should definitely be expanded in the future. Future directions for this project would involve distributing the survey to more sources in a larger time frame to ensure a larger population. Another future direction would be to perform a cross-sectional study. In order to do this, the population would be expanded to all ages of people who have taken the drug Cisplatin to determine the differing perceptions in regards to the effects of the drug on the patient's attention and cognition across all ages. If this occurred, a new addition of the survey would need to be formulated to accommodate the adult population, same questions but with different wording.

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## Appendix A

### Child Survey-

#### General

1. How old are you? \_\_\_\_\_
2. Age of receiving drug \_\_\_\_\_
3. How long was your treatment with the drug Cisplatin?
  - a. Less than 3 months
  - b. 3 to 6 months
  - c. 6-12 months
  - d. More than 12 months
4. Are you still taking the drug: yes or no
5. Do you have a hearing loss: yes or no
  - If yes, :
    - a. you hear in all types of places
    - b. you hear in just quite places
    - c. you have a hard time hearing in all places
6. Do you use a hearing aid : yes or no

#### Attention

7. How would you describe your ability to pay attention in school?
  - a. Very easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
8. How often do you become upset when you are trying to learn new things?
  - a. Most of the time
  - b. A lot of the time
  - c. Not very often
  - d. Never
9. How often do you need extra time to understand instructions?
  - a. Most of the time
  - b. A lot of the time
  - c. Not very often
  - d. Never
10. How easy is it for you to do more than one thing at a time?
  - a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
11. How easy is it for you to start a job and then quickly change to a new one?
  - a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard

12. How easy is it for you to remember things?
- a. Very easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
13. What things help you remember what to do each day?
- 
14. How easy is it for you to pay attention to what the teachers ask you to do?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
15. How easy is it for you to pay attention to what you want to do?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard

Speech/Language

16. How easy is it for you to tell people what you are thinking?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
17. How easy is it for you to understand others when they talk to you?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
18. How easy is it for you to understand people in loud places?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
19. How easy is it for other people to understand your speech when you talk to them?
- a. Easy
  - b. Sometimes easy
  - c. Sometimes hard
  - d. Hard
20. Do you see a speech therapist: yes or no

– Thank you for taking the time to complete this survey!

Parent Survey-

1. How would you describe your child's ability to pay attention in school?
    - a. Easy
    - b. Somewhat easy
    - c. Somewhat hard
    - d. Hard
  2. How often does your child become frustrated in regards to school or while learning new material?
    - a. Very often
    - b. Somewhat often
    - c. Sometimes
    - d. Never
  3. How often does your child need extra time to understand instructions?
    - a. Very often
    - b. Somewhat often
    - c. Sometimes
    - d. Never
  4. How easy is it for your child to do more than one task at a time?
    - a. Easy
    - b. Somewhat easy
    - c. Somewhat hard
    - d. Hard
  5. How good is your child's ability to shift between tasks?
    - a. Good
    - b. Somewhat good
    - c. Somewhat bad
    - d. Bad
  6. How good is your child's memory?
    - a. Good
    - b. Somewhat good
    - c. Somewhat bad
    - d. Bad
  7. How easy does your child find it to remember things?
    - a. Easy
    - b. Somewhat easy
    - c. Somewhat hard
    - d. Hard
  8. What kind of methods does your child use to help him/her remember to do daily tasks?
- 
9. How easy is it for your child to focus on school related tasks?
    - a. Easy
    - b. Somewhat easy
    - c. Somewhat hard
    - d. Hard
  10. How easy is it for your child to focus on his/her favorite activities?

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- a. Easy
- b. Somewhat easy
- c. Somewhat hard
- d. Hard

Speech/Language

11. Does your child see a speech pathologist: yes or no
- If yes, what is the reason for treatment \_\_\_\_\_
  - How often does he/she receive treatment \_\_\_\_\_
12. How easy is it for your child to express his/her thoughts through words?
- a. Easy
  - b. Somewhat easy
  - c. Somewhat hard
  - d. Hard
13. How easy is it for other people to understand your child when he/she is talking to them?
- a. Easy
  - b. Somewhat easy
  - c. Somewhat hard
  - d. Hard
14. How easy is it for your child to understand others when they talk to him/her?
- a. Easy
  - b. Somewhat easy
  - c. Somewhat hard
  - d. Hard
15. Please include any additional information about your child's ability to pay attention and about difficulties related to speech, language, and/or hearing below:

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– Thank you for taking the time to complete this survey!