SSW REPORTS ...

COCHLEAR IMPLANTS

Vol. 22 No. 1 February 2000

COCHLEAR IMPLANTS AND CAPD

Jack Katz

We haven't dealt with cochlear implant (CI) and CAP in *SSW Reports*, that I remember. Therefore, it is time to rectify that oversight.

What has a CI in common with CAPD?

On the face of it, this might look like we are mixing apples and oranges. One has a peripheral hearing problem and the other a disorder related to the CANS. To understand this better, let's start at the beginning.

In the first years of a typical child's life they spend much of their time learning the language of their home and community. In time, the child learns to recognize their language and, with practice, learns to process it efficiently. They learn skills and tricks that help them to effortlessly figure out what is said and what it means. New words and concepts are readily absorbed.

On the other hand, the typical person with a CAPD has a more difficult start in life because they do not perceive their language as clearly as the average child does. Because of their inefficient processing, as a result of the variations in central auditory function and/or structure, they fail to learn the sounds of language precisely or to deal with what they hear in an efficacious way.

The individual who has a CI is neither like the normal youngster, nor the like the one who has CAPD. Perhaps the clearest way to understand the problem of a person using a CI is to analyze three scenarios.

1. **The pre-lingually deaf adult**: This individual learns speech and language initially through the benefit of hearing aids because hearing sensitivity was so poor they could not learn to speak without amplification. It is likely that the person had a severe to profound hearing loss in the high frequencies so that even with the best hearing aid available they never perceived high frequency consonant sounds. As they got older, they were able to learn from experience or with therapy that there are high frequency sounds. They also learn about them from lipreading and from co-articulated information embedded in vowel sounds. After many years of hearing aid use, these individuals are unable to understand speech because of severe to profound hearing loss.

When they got a CI and were "hooked up", they were dismayed by what they heard and almost invariably were displeased. Hearing through a CI is nothing like it was hearing thorough a hearing aid. One prelingually deaf person said that his first experience with his implant was extremely unpleasant, in part because it sounded as though everyone had whistles in their throats. He did not realize that these were high frequency consonant sounds that he had never heard before. In time, these became not only pleasant, but vital to his understanding of speech. Clearly, his "new ear" did not match the expectations of his "old brain".

A second prelingually deaf adult when first hearing through his implant continued to respond by raising his hand when the audiologist spoke to him because he could not distinguish puretones from speech. Here again we see that the sound of the CI differs greatly from that of the hearing aid.

A further explanation of this phenomenon lies in the way that the brain develops. The brain devotes a lot of its territory to much used, precise functions, and no territory to functions that the person doesn't have. For example, there is a large area of the cerebral cortex devoted to the thumb and tongue, because of the numerous functions they carry out for us. But essentially no territory would be devoted to high frequency sounds in individuals who could never hear them.

2. The post-lingually deaf adult:

The post-lingually deafened adult is much more fortunate than the pre-lingually deafended adult because he or she has developed normal language and speech. Their listening strategies suit normal hearing and they understand the nuances of speech. When I said we would work on the H-sound, a pre-linually deaf adult said, "but H doesn't have a sound, it's just air". Even after almost 2 years with her implant she did not realize that the H-sound could actually be heard. These are confusions with which post-lingually deafened individuals do not have to deal.

When an individual is suddenly deafened or gradually loses hearing until a CI is needed, they have many resources not available to those without amplification altogether for a long period, or even just to the implanted ear. Not surprisingly the length of time between their last hearing (whether normal or through HAs) is one of the predictive indicators of success with a CI. Others are, neural survival (e.g., VIIIN) motivation, etc.

Often a surgeon will recommend a CI for the poorer ear or the left ear because of fear of damaging the better ear or the dominant one, or to preserve the better ear for a HA. While these are meaningful strategies (especially as CIs continue to improve), in the *short run* this may prove a disadvantage. In some cases the person had not used the poorer ear in many years or ever. Little wonder that the information is sometimes of no value to them at all. One client was ready to "throw the CI in the garbage" because she felt she derived no benefit in communication whatsoever.

At least the post-lingual patient has a firm basis for using the new information provided by the CI.

3. The pre-lingually deaf child:

The pre-lingually deaf child has a great advantage over the other two groups. Their brains are quite plastic as long as they are implanted early. Prior to 2-years of age is thought to be ideal.

All of us learn the language around us and the young deaf child learns what we can call the "CI-speech". What they hear through the implant, while not what the normal ear hears, is close enough to provide much of the critical information for digesting speech. In time and with therapy they show incredible ability in using their implant to understand speech in almost any situation.

The pre-linually deaf child has the best chances to use their device most effectively whereas the pre-lingually deaf adult has the poorest chances of great benefit. But, even with them, "the sky's the limit".

Stars and Potential Stars

A "Star" is the designation give to those CI users who excel in their ability to use their new device. Each surgical site is thrilled with the results shown by their Stars. No one seems to know exactly why one person excels and another does not. The extreme frustration of every center is the person at the other end of the continuum, the person who derives little, if any, benefit. I am not sure why they have so much difficulty, especially when their hearing sensitivity with CIs is reasonably good. Based on the cases I have seen, my *guesses* are shown below.

Perhaps it is not surprising that there is no cute term for those who have the misfortune to undergo this extensive surgery, pre- and post-surgical testing, plus the expense and aggravation, and still find little benefit from the device. I will call them "Potential Stars", as I believe that by treating them as if they had severe-profound CAPD they may reach a level commensurate with the "Stars" who do not receive therapy.

1. Age:

Very young and very old individuals have different probabilities for success. However, this is not a major factor as individuals in their 70s appear to do very well, but may not make the rapid gains of younger folks.

2. Education and/or Pre-CI Language Abilities:

Higher education and the ability to use language most effectively appears (in my limited sample) to be an important factor. All of the Stars that I know are well versed in English and generally have advanced degrees.

I have not seen any literature to support my hypothesis, but it also has some logic, that those who used the system best have more skills to apply to the CI signal.

3. Recency and Neural Survival

How recently the person heard is a factor that is related to neural survival, but also how well the person remembers speech and oral language. Clearly the longer the delay in hearing again the less likely the auditory system will be prepared to receive auditory information, whether at the level of the VIII N or brain.

In addition to other factors, my guess is that having the implant in the left ear is not generally as beneficial as the right. At least, that is what logic would suggest. However, this is just one of many factors that the surgeon and patient may consider when deciding on the ear to be implanted.

4. CAPD

I believe, but have no proof, that those who were efficient HA users are much more likely to be good implant users. That could be related to their auditory processing abilities. This theory would suggest if the person had good processing functions pre-viously they would have a much better chance to be effective CI users.

This is **not** to say that other factors are not operating and **not** to say that this cannot be corrected (I think it can).

Whether the person had CAPD prior to the CI is an interesting question, but generally not a testable hypothesis and not a critical concern. We must work with the person in front of us regardless of the etiology to improve their ability to communicate.

CAP Therapy for CI Users

Why CAP therapy for patients with CIs? All of the factors we have discussed can be explained by a mismatch between the "new ear" and the "old brain". To me that translates into a Decoding (DEC) problem. A DEC problem generally involves inefficient phonemic processing.

This does **not** imply that there is anything wrong with the person's CANS. Anyone who has a CI may have trouble using what they hear in a most efficient way.

We have had great success over the years retraining the auditory system to DEC speech more efficiently by use of Phonemic Synthesis and other auditory procedures. So it is logical to think that this might help the CI user as well.

Therapy Cases

The therapy program we use with CI patients differs from the ones we use with CAPD cases, in that the CI patients are usually much more severe. It would not be an exaggeration to consider the average CI at least severely impaired in DEC and more likely profoundly impaired.

With CAPD cases, even children, we can begin with Phonemic Synthesis (PS), albeit with pictures. This is almost always beyond the ability of the CI user who begins therapy. Therefore we start at lower levels (introduction, discrimination, focusing, and memory) before working on PS. These therapy procedures are detailed elsewhere (Katz, 1998[1]).

Case #1 Jack (Pre-lingually deaf adult)

A 24-year-old man, had received his CI 6 months before therapy began. As in almost every other adult we have seen, no therapy had been provided prior to our work. This is an important finding. The NIH Consensus Statement (1995) as well as the other literature I have read, state that therapy is an important part of the overall CI procedure.

Jack's case is described in further detail in the Katz, 1998 article. He was found to have a severe hearing loss about the age of 2-years. He wore a hearing aid in the right ear until he was implanted with a Nucleus-22 in the right ear.

Jack was the "Star" at the medical center where he was operated on. Indeed, his skills were most impressive. In 1990, Osberger pointed out that the average WDS for adults with CIs across studies up until that time was only 14% (for both pre- and post-lingually deaf). Jack's recorded WDS of 10% was quite good, considering he was pre-lingually deaf. When looking at the sounds correct in those NU-6 words, Jack scored 32% correct. Another test that was used was the Phoneme Recognition Test (PRT) that is made up of 34 sounds of English, presented twice in a random order. The listener is asked to say back what is heard. On this test Jack received a score of 42%.

Based on these findings, it was clear that Jack was deriving considerable benefit from the implant especially when we realize that he was pre-lingually deaf. According to the Consensus Statement, we can generally expect pre-lingually deaf individuals to get only environmental sounds and an assist with their lipreading, but this young man was responding (although at a low level) even in open-set tasks.

Figure 1.

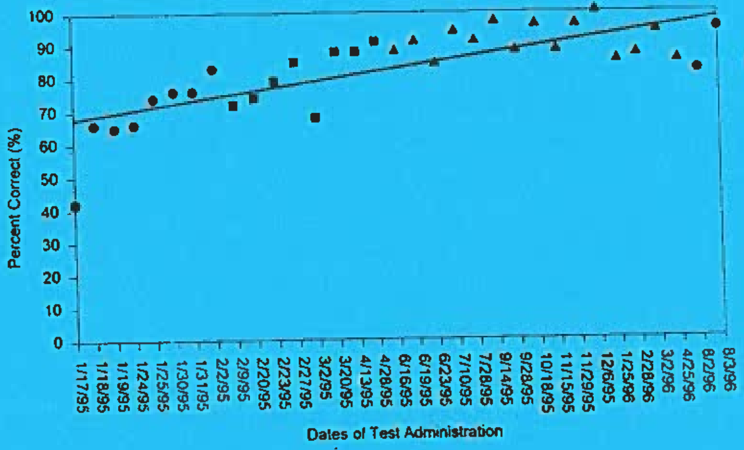


Figure 1 shows Jack's progress on the PRT from January 1995 to August 1996. Toward the end his therapy became sporadic and then stopped. Figure 2 shows his performance on recorded NU-6 lists over that period of time. The results are most impressive:

1. His scores rose from 10 to 72%! A monumental achievement for a pre-lingually deaf person.
2. The therapy dealt with phonemes, not words, yet he was able to generalize this knowledge to words and to the sounds within the words (from 32 to 88%)

---

[1] Katz, J. (1998) Central auditory processing and cochlear implant therapy. In Masters, Stecker & Katz, *Central Auditory Processing Disorders: Mostly Management*. Allyn & Bacon.

Figure 2.

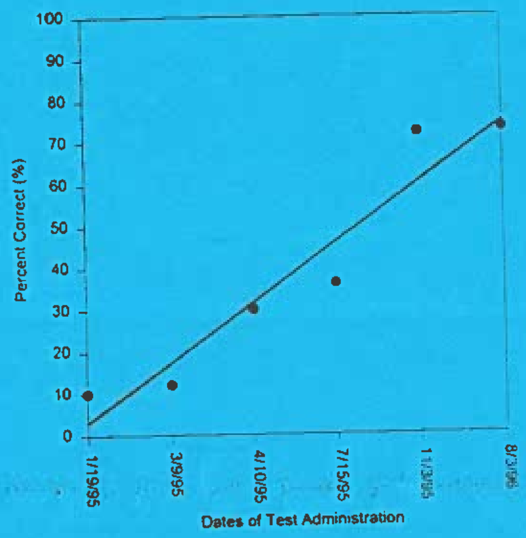
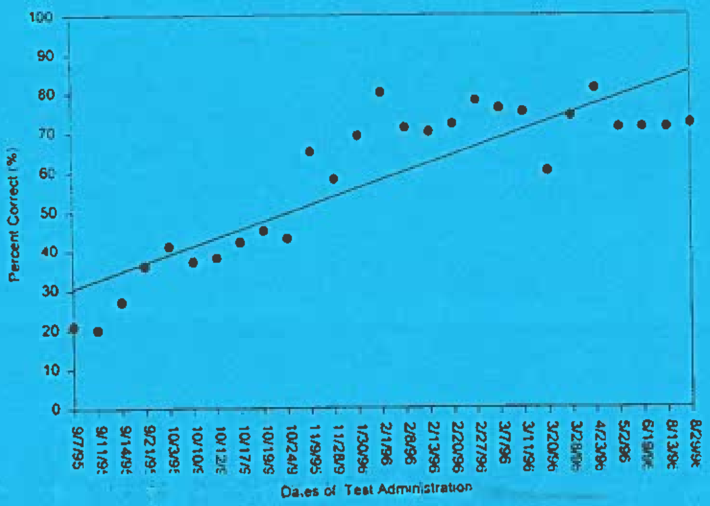


Figure 3.



Jack's excellent results spurred us on to work with other CI recipients.

Case # Carol (Pre-linually deaf adult)

Carol, a 41-year-old woman was referred for therapy. She had a moderately successful result from the CI. But, her aided ear was the right and her CI was on the left. She had never used that ear and thus we can assume that neural survival was minimal. Of course, the VIII N is a peripheral nerve and therefore (presumably) has the potential to regenrate.

When she was first seen 10 months after implantation she had only improved in lipreading and in awareness of environmental sounds when wearing the implant.

Testing revealed a WDS score of 0% on recorded W-22 words. On the PRT she had a score of 20% correct (measured after therapy began). Fig. 3 shows that although Carol began at a fairly low level for PRT, over the period of a year she got to 70% correct. Her progress in WDS was from 0 to 42% (and sounds in words she went from 40 to 60%).

When we began working with Carol we were concerned that we had bitten off more than we could chew. But as it turned out she continued to make strides over the therapy period.

Case #3 Joan (Post-lingually deaf adult)

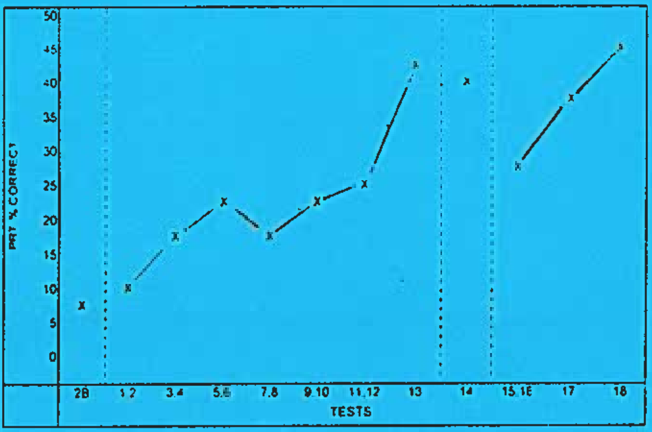
Joan, a 63-year-old woman was referred for phonemic therapy because she had gotten no benefit from her CI in the year that she had worn it. She was extremely frustrated and unhappy with the results. She was a Potential Star!

Testing revealed 9% and 7% correct on the 2 PRT baseline measures, with 0% WDS and only 13% of the sounds were correct. On the CID Everyday Sentences she also scored 0% correct. This was as poor as I had seen and pretty much as poor as one could get.

Figure 4 shows the PRT scores for Joan. "2B" shows the average baseline score for the 2 tests. The other points are primarily averages for 2 successive tests. During the first semester of therapy she increased to 40% correct (#13). She also came in for a 6-week summer session, simply maintaining what she had accomplished the first semester. During the summer there was a death in her immediate family and when she returned her PRT fell to 19%. However, during the next semester her scores increased back up to 46%.

Joan's WDS was 8% of words and 39% of the sounds in those words. Her score on the CID sentences is 38%. These results show a vast improvement in her ability to process

Figure 4



speech from her CI. She is now attempting to use the phone, although it is still very difficult for her. She is able to resume a more normal social life.

Group Data

When we see case reports, we don't know if they were the only ones who performed well or if they were typical. The 3 cases discussed above were shown because we had the most data about them. Below are data for 8 cases for whom we have PRT data after 2 or 3 months of therapy. The average difference was 72 days between test and restest.

PRT	PreTst	PostTst	Improv
MEAN	30.5	60.8	30.3
SD	17.2	16.7	13.4
MinScr	9	31	11
MaxScr	54	88	47

Pretest, posttest and improvement for 8 CI cases who received phonemic therapy. Minimum improvement was 11 and Max was 47.

On the average these individuals doubled their scores in just 2 to 3 months of therapy.

Summary and Conclusions

The purpose of this article was to show that individuals who have cochlear implants can be considered to have a form of CAPD. While most of those we have worked with had normal or better CAP abilities, no doubt, the CI produced sounds that were so different from what they had heard before that it created a major challenge to their ability to decode speech. They could not decode speech sounds quickly and accurately.

Despite good hearing, these individuals have difficulty understanding speech as others would with comparable hearing. Therapy is very important for two reasons:

1. The fine retest results show that audiologists are not only able to diagnose these problems, but also to remediate them.
2. The other reason why it is so important is for theoretical reasons. *If* the clarity of CIs was so good, at this time, that a post-lingually deaf person could quickly regain good WDS, we would not have a strong case for CAPD. But with depressed scores, which are then remediated to a large degree by CAP therapy, that adds much strength to the argument. This is especially true because each of the individuals, when first seen, were 6 months to a year post implant.

Many CAP tests would be far too difficult for the average CI wearer. Their problems are so severe that we can generally demonstrate the difficulty with less demanding tests.

It is likely that almost all CI wearer using current state-of-the-art instruments can benefit significantly from auditory training that emphasizes phonemic understanding. It is hoped that future developments will improve the quality of CIs so much that additional therapy will not be needed, at least for the post-lingually deaf. But in the mean time therapy is strongly recommended.

The patients who are having the most trouble benefiting from the implant are likely to notice the benefits most. Those who are doing very well are less likely to notice the difference.