RESEARCH QUICK TAKES

2.4: After the fitting—How machine learning can help

Brian Taylor & Gus Mueller

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Let's start with a few terms that are used relating to hearing aid technology:

Artificial Intelligence (AI): Refers to systems or machines that mimic human intelligence to perform tasks and can iteratively improve themselves based on the information that they collect. This includes the theory and development of systems that are able to perform tasks such as visual perception, speech recognition, decision-making, and translation between languages.

- In 1952 Arthur Samuel wrote the first computer learning program. The program dealt with playing the game of checkers. Samuel's work revealed that an IBM computer improved at the game the more it played, studying which moves made up winning strategies and incorporating those moves into its program.
- Forty-five years later, the game was chess, and IBM's Deep Blue beat Garry Kasparov, the world's champion at the time.
- And, in 2011, IBM's Watson beat its human competitors on the popular television game show Jeopardy.

Let’s start with a few terms that are used relating to hearing aid technology:

Machine learning: Is about extracting knowledge from the data. It is a subfield of artificial intelligence, which enables machines to learn from past data or experiences without being explicitly programmed. Machine learning enables a system, including hearing aids, to make predictions or decisions using historical data without being explicitly programmed. Machine learning usually uses a massive amount of structured and semi-structured data so that a machine learning model can generate accurate results or give predictions.

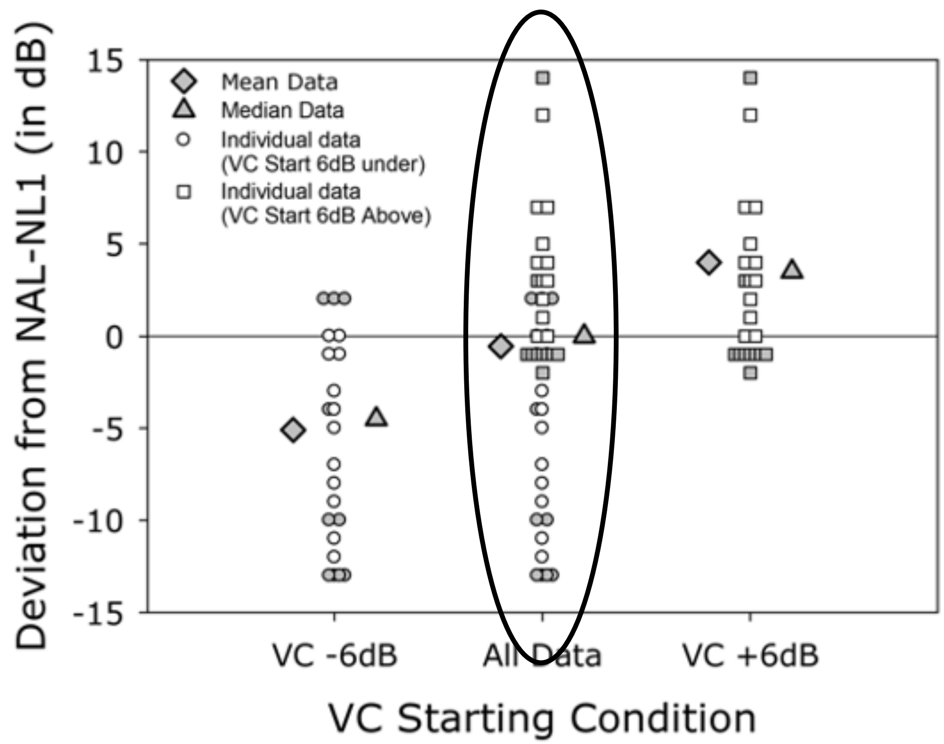
Let’s start with a few terms that are used relating to hearing aid technology:

Deep Learning or Deep Neural Network: Part of a broader family of machine learning methods based on artificial neural networks with representation learning. The word "deep" refers to the number of layers through which the data is transformed. Deep learning systems have a credit assignment path depth—the chain of transformations from input to output, which describe potentially causal connections between input and output. Deep models are better able to extract features than shallow models, and hence, extra layers help in learning the features effectively.

Generation I (2006) of Siemens/Signia machine learning: Value for establishing patients' preferred listening levels

Importantly: The NAL-NL2 targets are a range, not a specific dB level.

As shown in the Figure, learning can find the preferred level for a given patient. Note that that NAL indeed is average—but the range of preferred levels is large.



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Research from Catherine Palmer and colleagues using Generation II of Siemens/Signia machine learning

Thirty-six participants, all new users, were fitted bilaterally to the NAL prescription. One group (n=16) used learning for one month, the other group (n=16) used learning for two months.

General findings:

- After learning, average gain for soft inputs was slightly below the NAL, more so for the two-month group.
- Average gain for average-level inputs was the same for both groups, and was the same as the original NAL
- Performance on a speech-in-noise test was the same before and after learning for both groups.

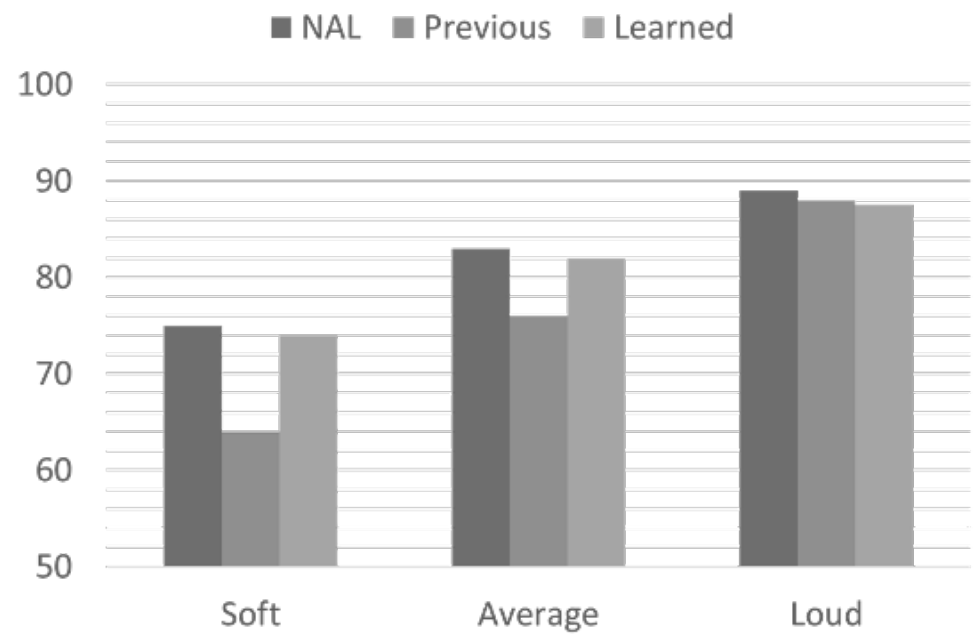
In blinded comparative subjective ratings in the real world—66% of the participants favored the learned setting.

Research showing how machine learning can improve the overall fitting
(from Mueller and Hornsby)

Individuals who had used hearing aids for 2 or more years were fitted with machine learning instruments.

Individuals initially had been significantly under-fit (re:NAL)

Following real-world use of instruments, average use-gain improved by ~10 dB for soft inputs, and ~5 dB for average inputs.



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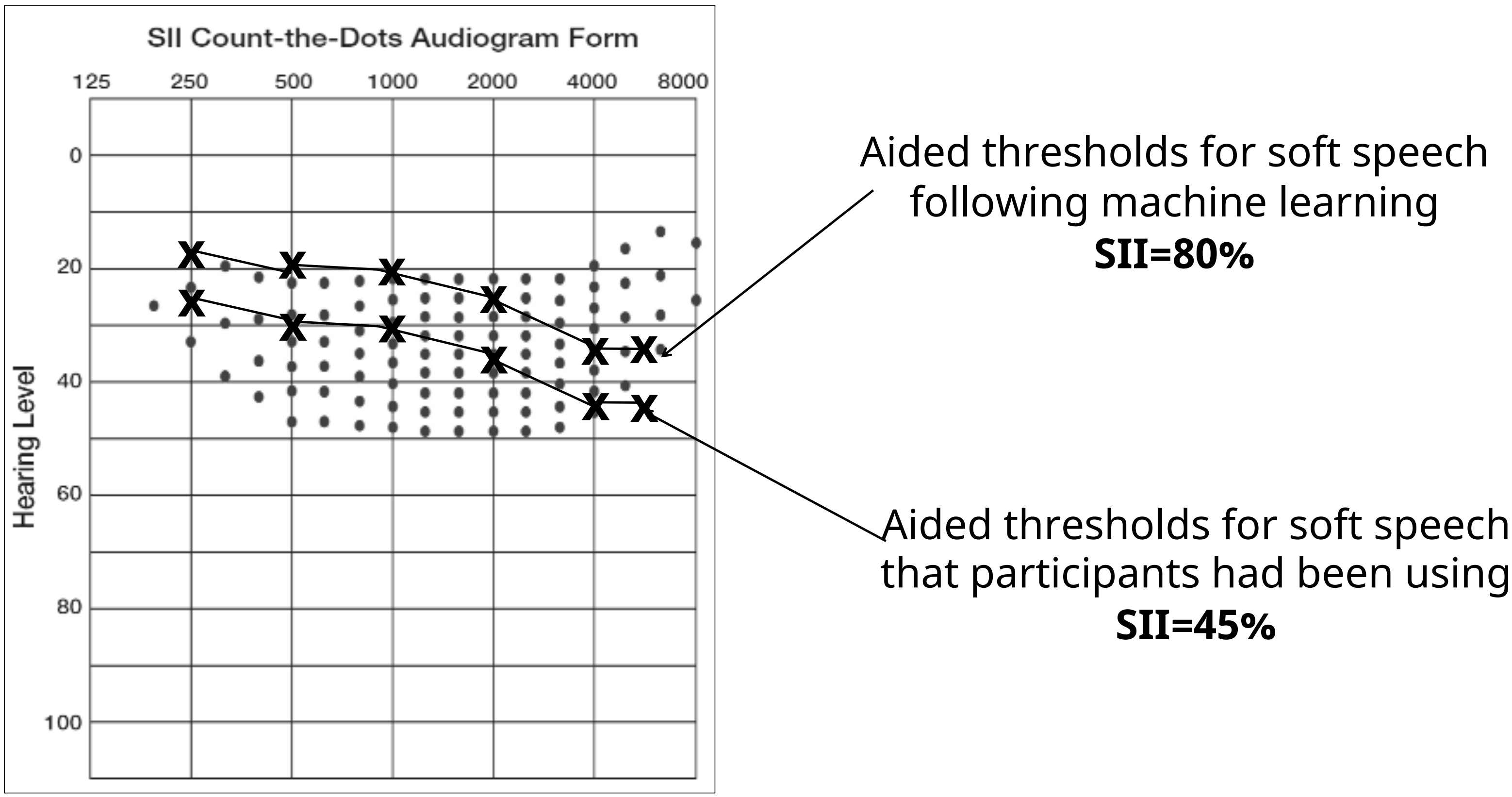
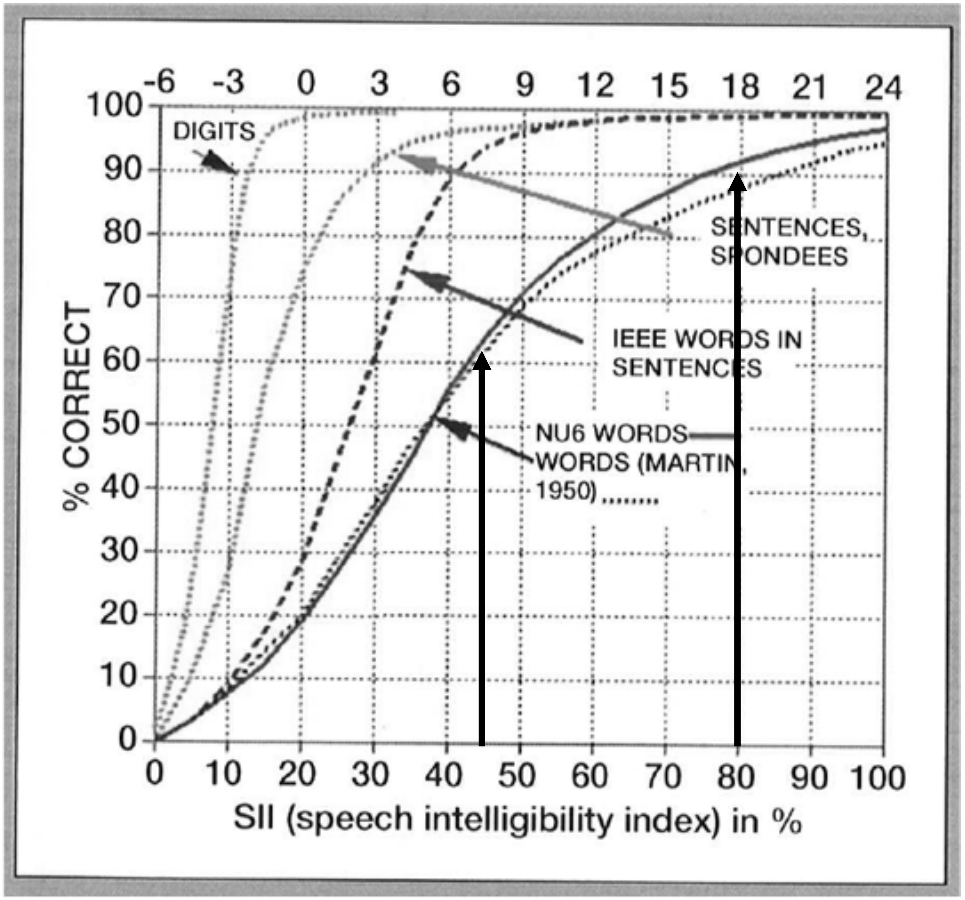
Impact on the SII when machine learning results in ~10 dB increased gain for soft inputs



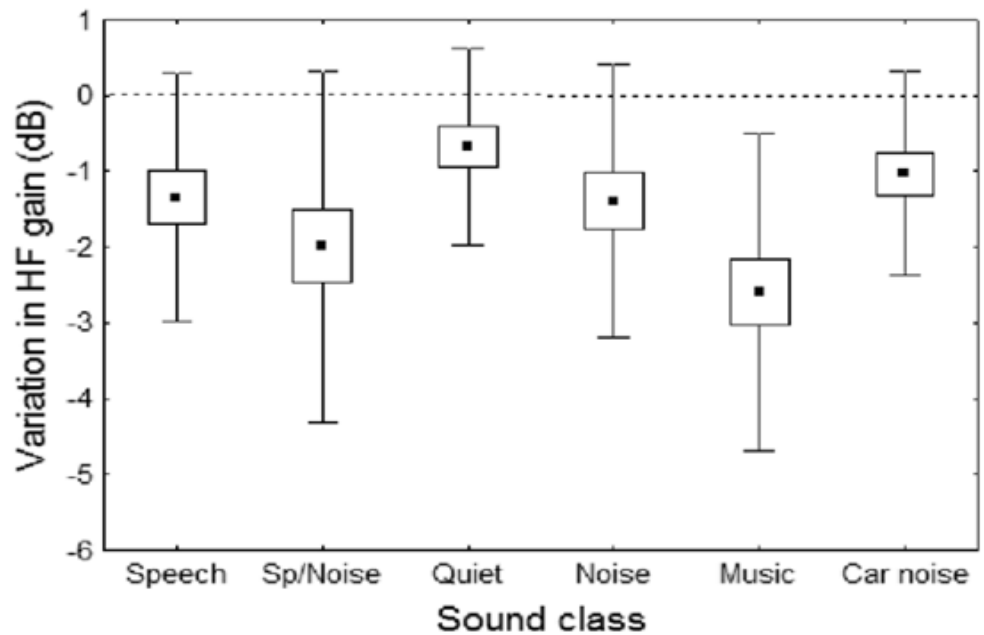
Does 10 dB matter?



Research from the NAL for Generation III of the Siemens/Signia product: First machine learning to include gain, frequency shaping *and* signal classification (From Keidser et al)

Hearing aids enabled learning of the compression characteristics in four frequency bands and in six different sound classes.

Participants wore the hearing aids programmed to the NAL-NL2 for 3 weeks and then trained the devices from the prescribed response for three weeks.



And then . . .
A unique application of machine learning: Own Voice Processing (OVP)

At the time of the fitting, using a simple and fast training procedure, the hearing aids “learn” the patient’s voice. From that point forward, whenever the patient’s voice is detected, the programming automatically changes to reflect the intensity and spectrum of the own-voice signal.

The moment that “own-voice” is not detected, or even when there is a pause, the hearing aids immediately revert to the original programmed settings. This change is seamless, and easily adapts during a quick back-and-forth conversation.

How the feature works . . .

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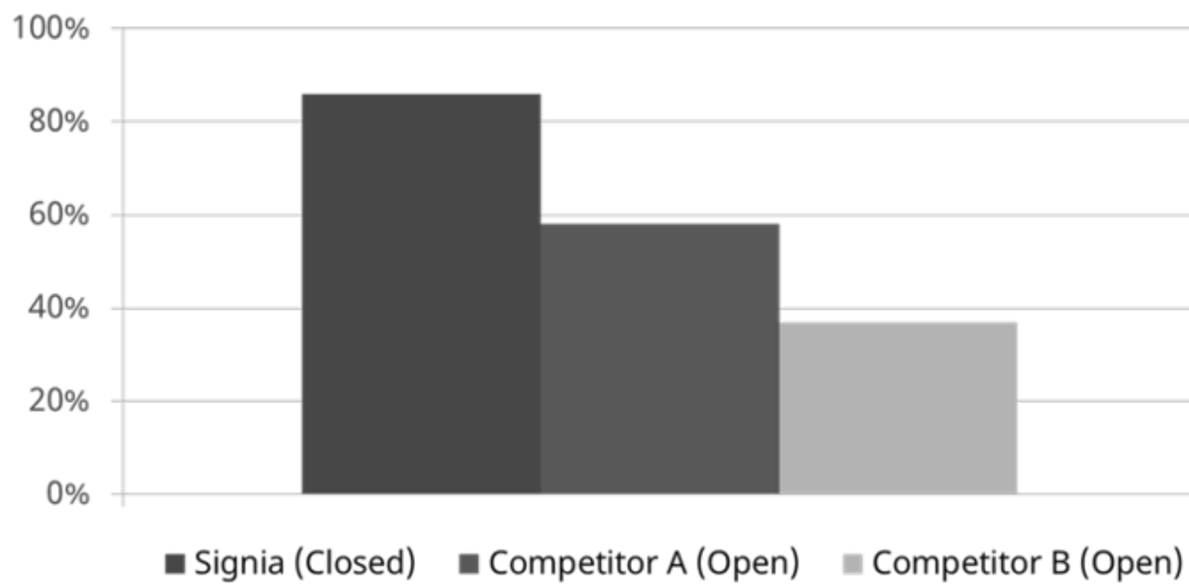
Signia OVP with CLOSED fitting results in better own-voice satisfaction than competitor products using an OPEN fitting (all hearing aids fitted to NAL-NL2 prescriptive targets).



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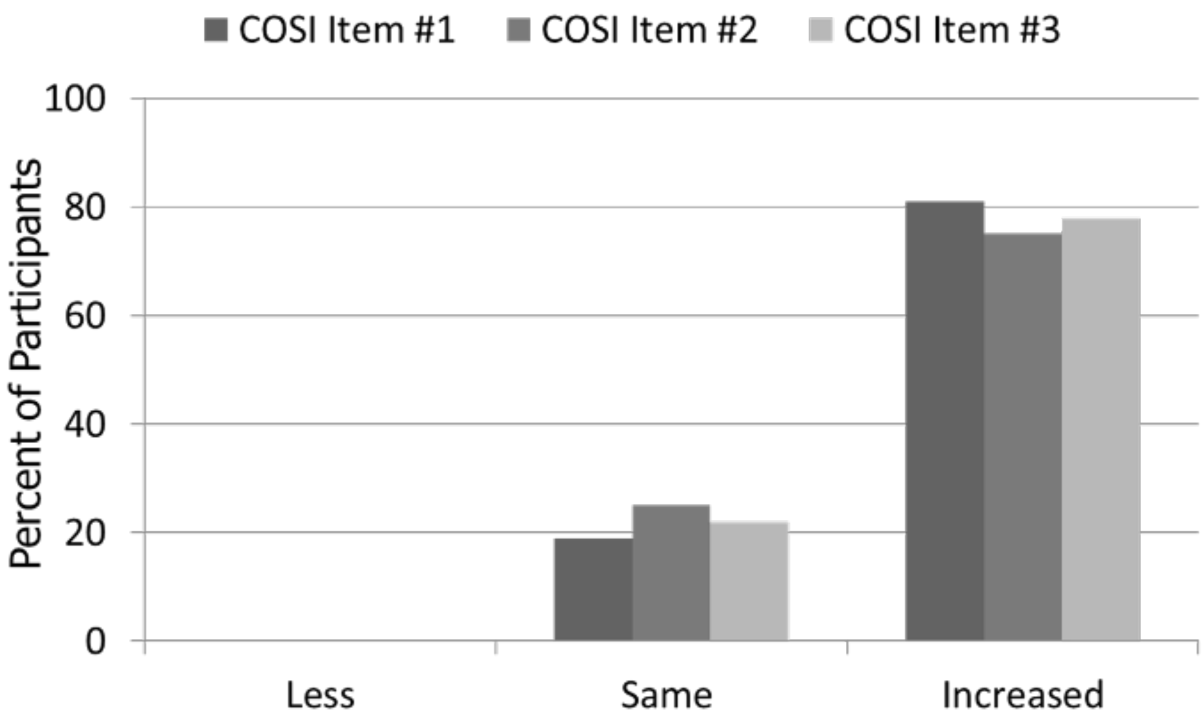
When COSI items all related to “increased talking/communication” Signia OVP resulted in benefit for nearly all particpants for all items



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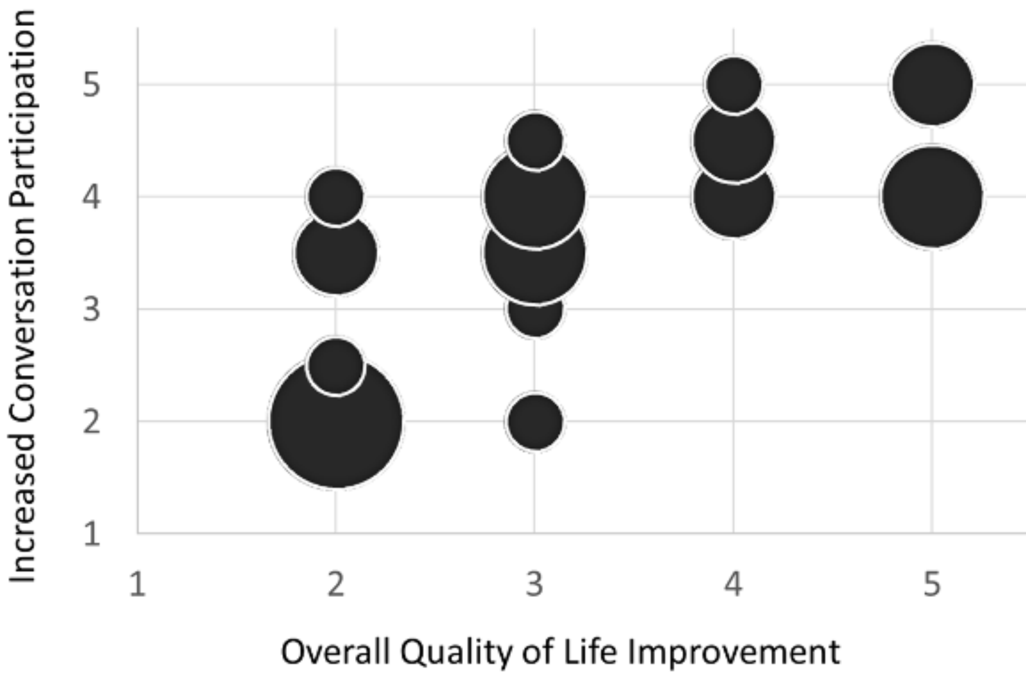
And the really good news: Improvements on the COSI were highly correlated with improved Quality of Life!



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RESEARCH QUICK TAKES

2.5: After the fitting—The Signia Assistant

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The Signia Assistant: Most advanced Machine Learning

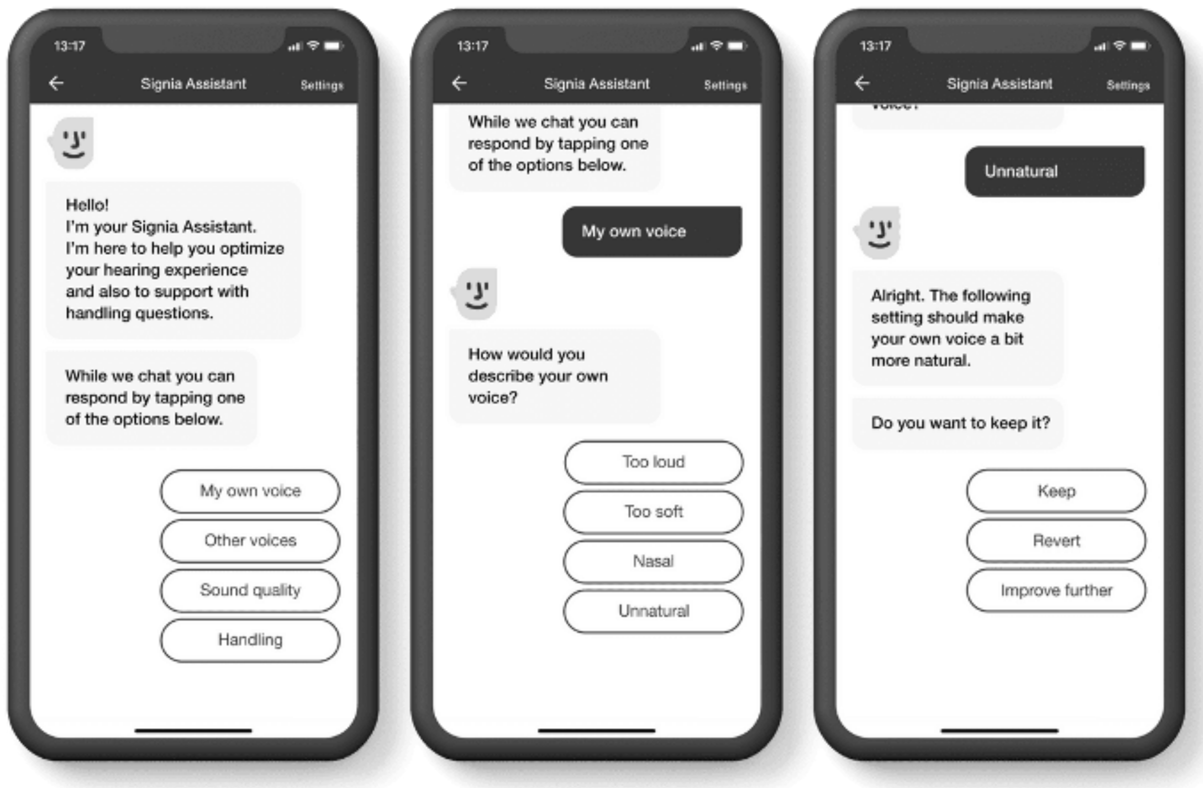
- Deep neural training which includes information about the environment (overall level, acoustic classification, etc), individual hearing loss factors, and known programming alterations that impact speech intelligibility and sound quality.

- Assistant provided with a vast number of examples that mimic real hearing aid users giving positive or negative feedback to a change.

- Continues to learn based on individualized choices. Preferred solution will rise in hierarchy.

- Updates and refines solutions based on data collected from around the world

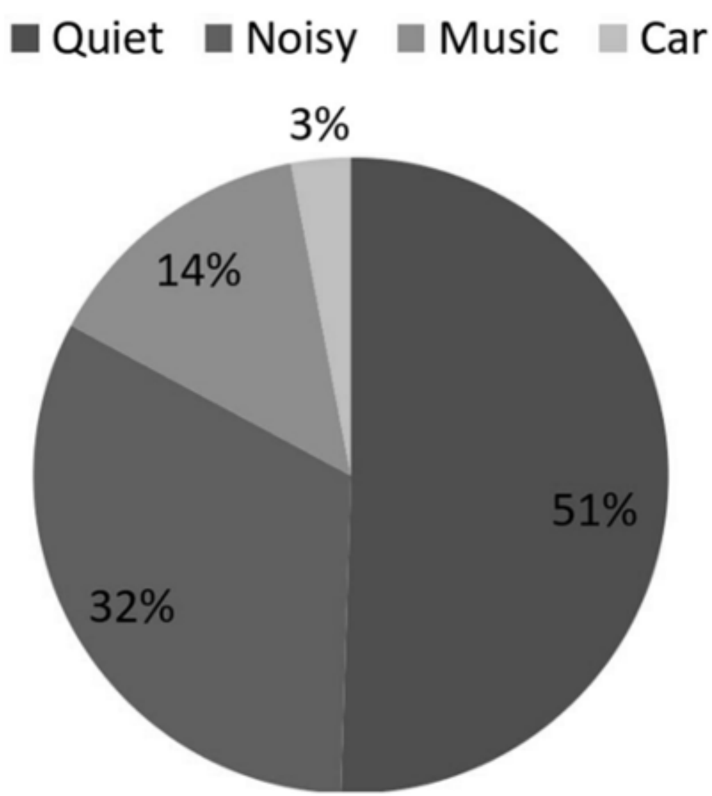
Example of the use of the Assistant for “own voice” issue



Field study with the Signia Assistant

- Individuals fitted bilaterally to NAL-NL2 prescriptive targets
- Prior to field trial, individuals received speech-in-noise testing in the laboratory
- Competed two-week trial. Instructed to experience wide range of listening situations
- Following trial, repeat speech testing was conducted
- Following trial, participants completed surveys of benefit and satisfaction related to use of the Assistant

Summary of signal classification at the time the Assistant was used
Noisy=Both “Noise” and “Speech-in-Noise”



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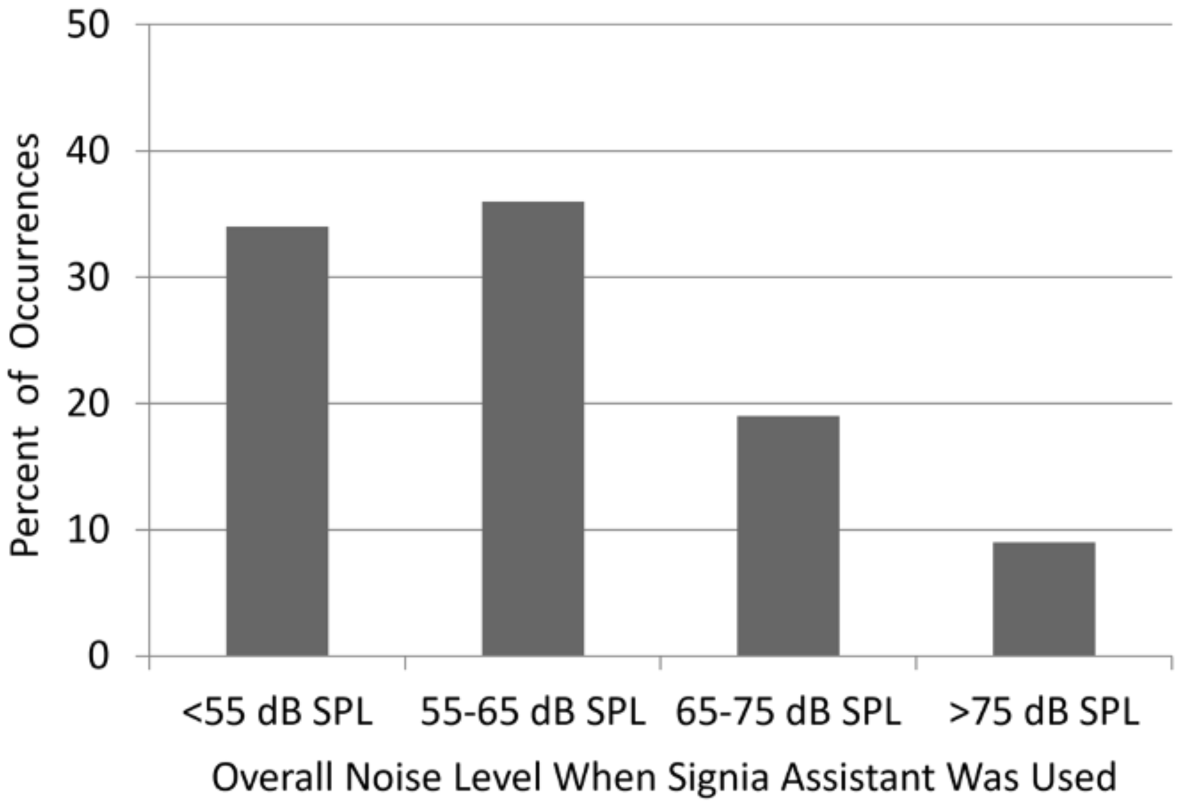
Noise level when Signia Assistant was used



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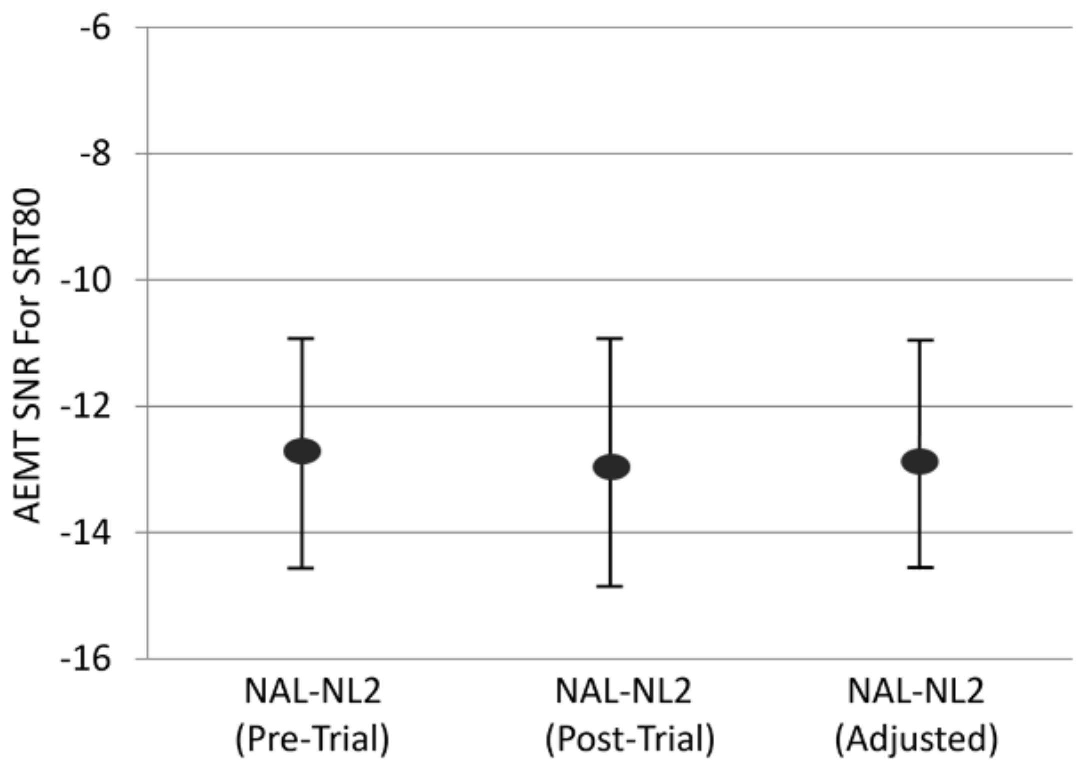
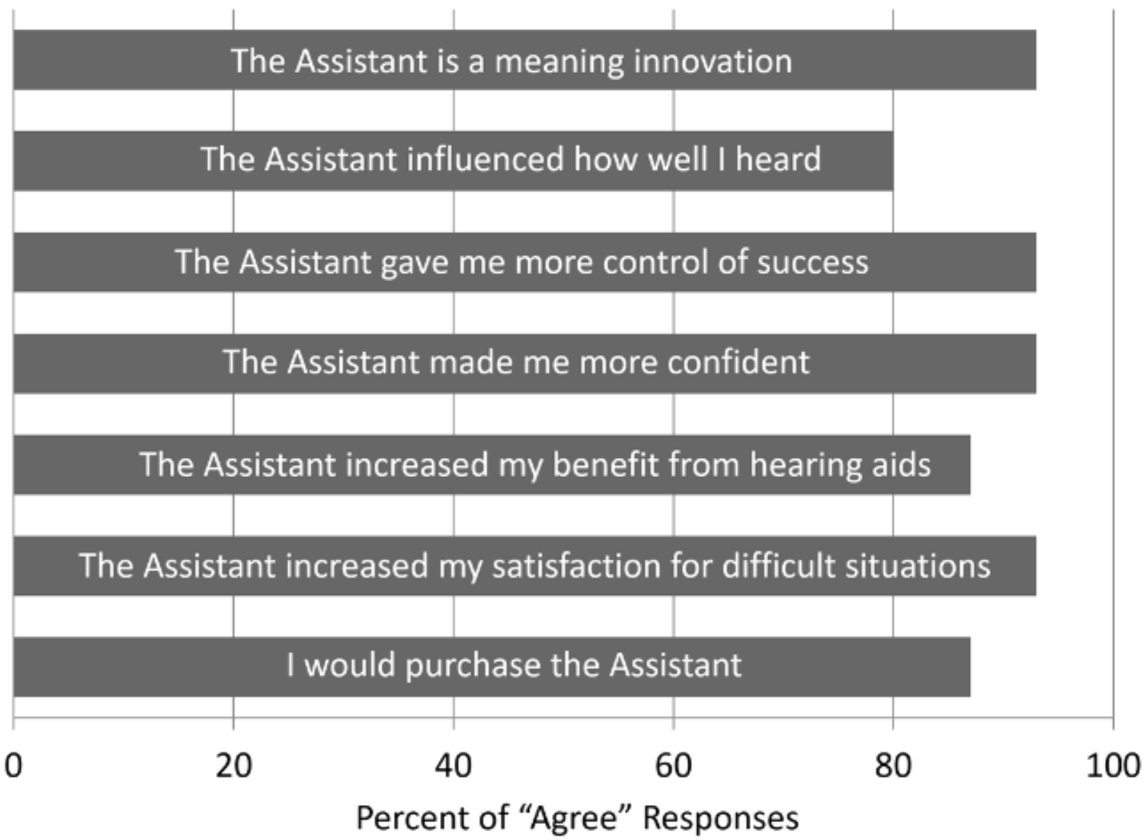
Results for pre-trial and post-trial speech-in-noise testing



Results from survey following the field trial



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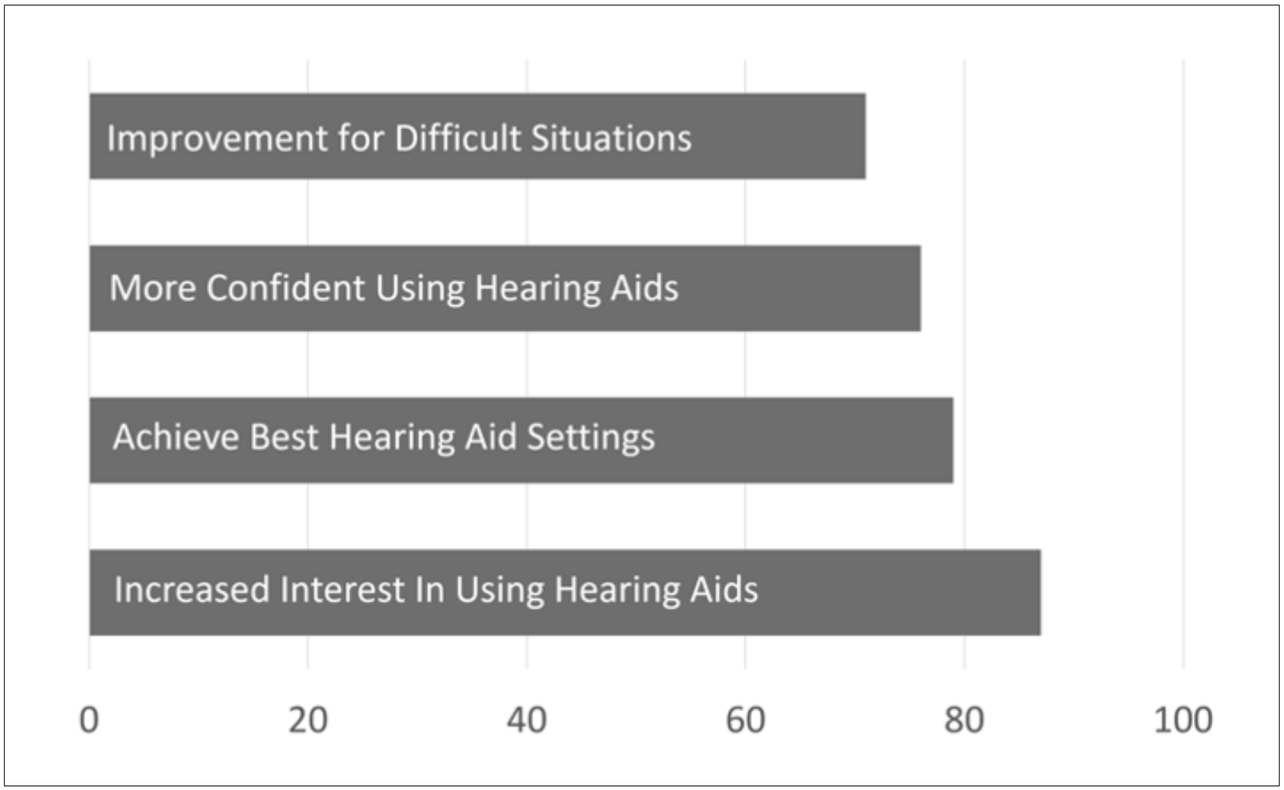
Study #2: Results following the field trial



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Study #2: HCPs re: Assistant Use (Percent of Respondents)