**INTRODUCTION**

**Spectral resolution** (hearing sound frequency distinctions) ... is especially important for speech perception but is a major problem for cochlear implants (CIs).

Each electrode should convey a different pitch, but their electrical current fields can overlap and blur the information.

Visual enology: hearing impairment causes blurring of fine details, similar to the loss of visual detail in a degraded image.

CIs cause severe blurring and distortion of fine spectral details in sound, but CI listeners can still achieve considerable success.

**Poor spectral resolution results in more listening effort needed to understand speech, leading to:**
- more need for recovery time after work [1]
- increased incidence of stress-related sick leave [2]
- unemployment in young adults [3, 4]
- early retirement [5]
- feelings of social isolation [6]

A successful treatment for hearing loss should result in:
... better word recognition AND reduced listening effort

Goal of this study:
Build a paradigm to test whether a CI sound processing strategy can improve hearing and reduce listening effort.

**IMPROVEMENT OF SPECTRAL RESOLUTION**

Goal: reduce channel interaction

1. Every other electrode is **disabled**, leaving the remaining electrodes further apart, and less likely to interfere [11, 12].

2. “Holes” created by disabled electrode channels are activated in the implant in the opposite ear.

3. The brain receives complementary sounds from the two ears that should interfere and come together like a zipper.

**METHOD**

**PUPIL DILATION: an index of listening effort [1, 2]**

... also an index of spectral resolution

Pupil dilation increases with increased cognitive load.

Hypothesis: poor spectral resolution results in greater effort needed to understand speech.

Tasks: Listeners with normal hearing (NH) identify IEEE sentences degraded in one of two ways:

1. Noise vocoder with variable number of channels
2. Noise vocoder with variable carrier channel width ("current spread")

As spectral resolution becomes progressively poorer, pupil dilation increases.

Time-series growth curve analysis [10] reveals significant differences between each level in terms of slope of pupil dilation over time.

A CI listener regularly experiences poor spectral resolution;
If we can improve spectral resolution in a CI listener, it should result in smaller pupil dilation.

**PROCEDURES**

**Spectral resolution and pupil dilation**

Monosyllabic word recognition (e.g. "best", "time", "keep")

Open-set response.

More words correct indicate the success of the strategy.

**RESULTS**

**Word recognition**
Few listeners showed substantial change.

**Spectral resolution**
Wide range of improvement and decline, specific to the individual.

**Pupil dilation**
Wide range of improvement and decline, specific to the individual.

**Relationship between spectral resolution and pupil dilation**
Improvement in spectral resolution correlated with reduction in listening effort as indicated by less pupil dilation.
Change in effort with interleaved channels was better predicted by the spectral resolution test than by word recognition.

**CONCLUSIONS**

Degraded spectral resolution causes increased listening effort in NH listeners

Interleaved channels can be beneficial for individual bilateral CI users, in terms of improved spectral resolution and reduced listening effort.

Some individuals showed benefit, others showed decline

Improvements in spectral resolution correlated with reduced listening effort in listeners with bilateral CIs.

Word recognition alone did not reveal much improvement or decline

Spectral resolution and listening effort are not accessible through conventional speech tests, but can be measured using pupilometry.