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Publication date:
2015

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Citation (APA):

Encina Llamas, G., Epp, B., M. Harte, J., & Dau, T. (2015). Evaluation of peripheral compression and auditory nerve fiber intensity coding using Auditory Steady-State Responses (ASSR) [Sound/Visual production (digital)]. 5th International Symposium on Auditory and Audiological Research, Nyborg, Denmark, 26/08/2015

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James M. Harte, Interacoustics Research Unit
Torsten Dau, Technical University of Denmark

27th of August, 2015

International Symposium on Auditory and Audiological
Research (ISAAR) , Nyborg (Denmark)

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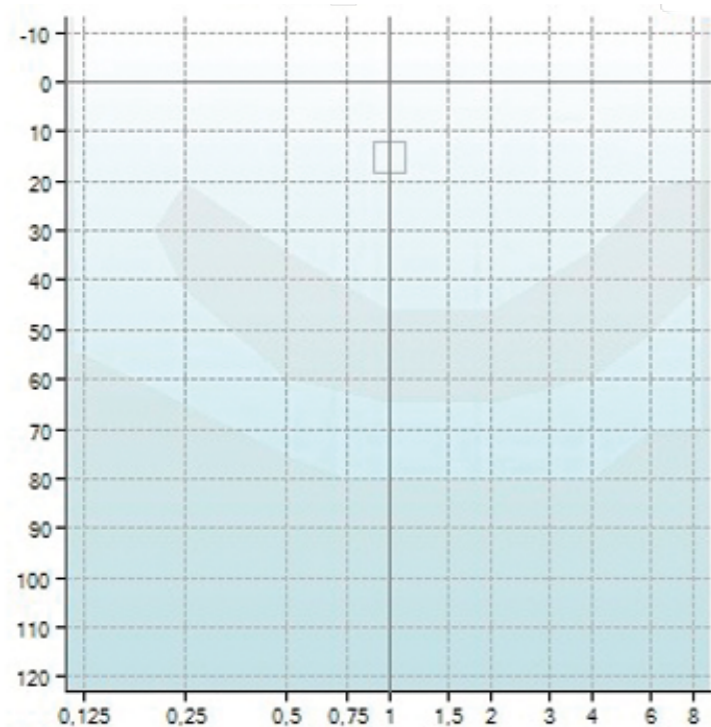
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The need for SUPRA-threshold evaluation

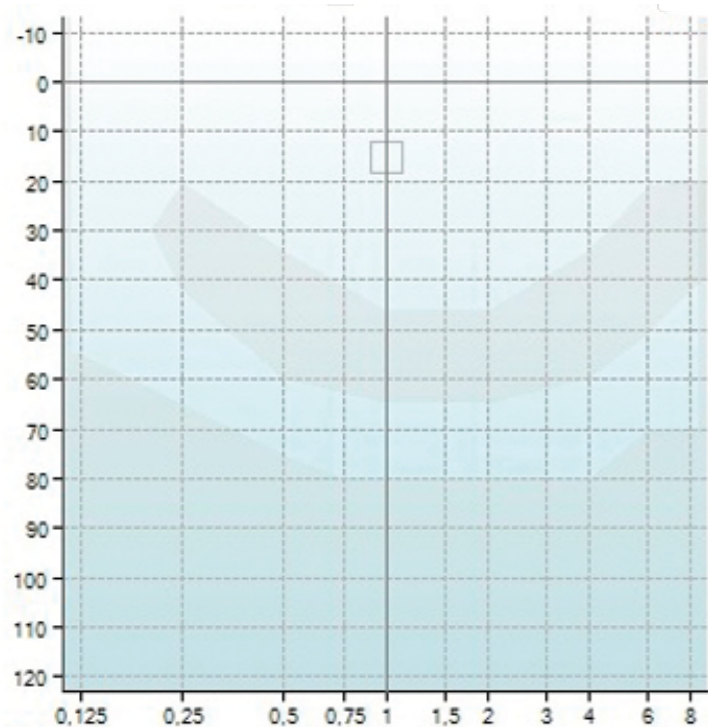
Humans in clinics:



5-10% of patients self-report hearing difficulties while showing normal audiograms

Saunders and Haggard (1989, 1992); Kumar *et al.* (2007); Hind *et al.* (2011)

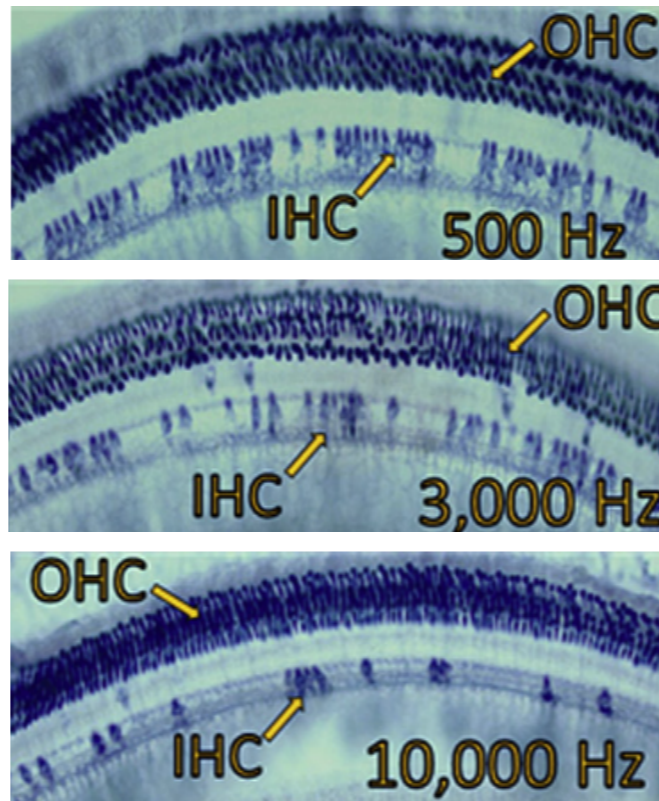
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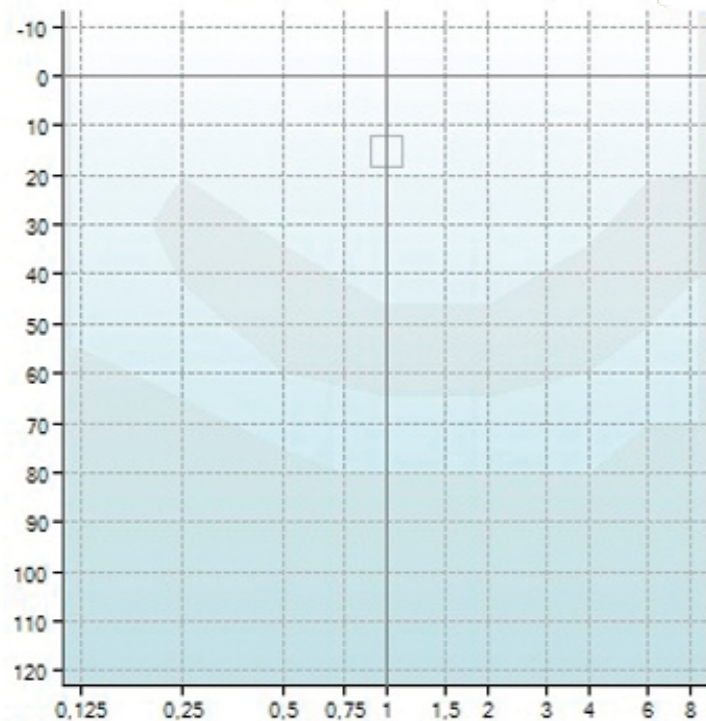
Physiological studies in animals:



Normal behavioral thresholds with **80% loss** of **IHCs**

Lobarinas *et al.* (2013)

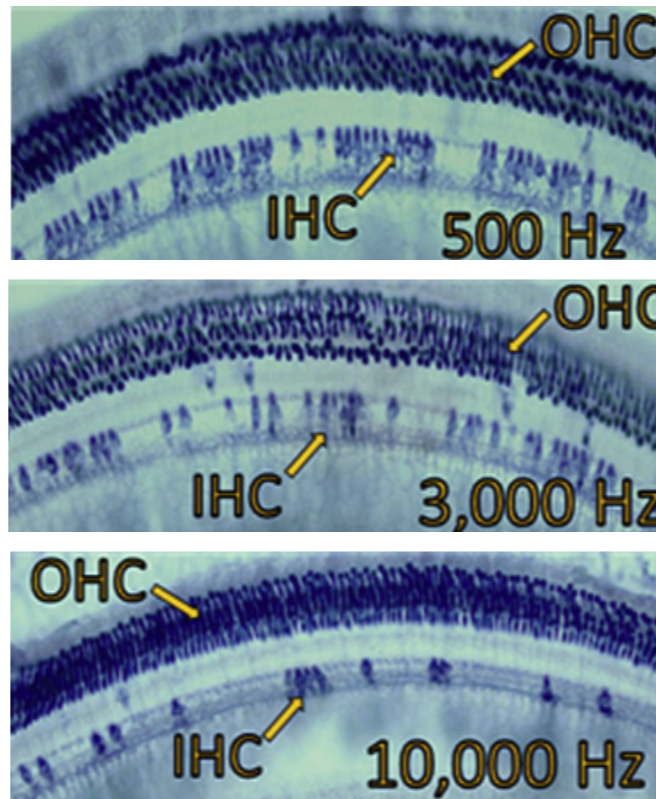
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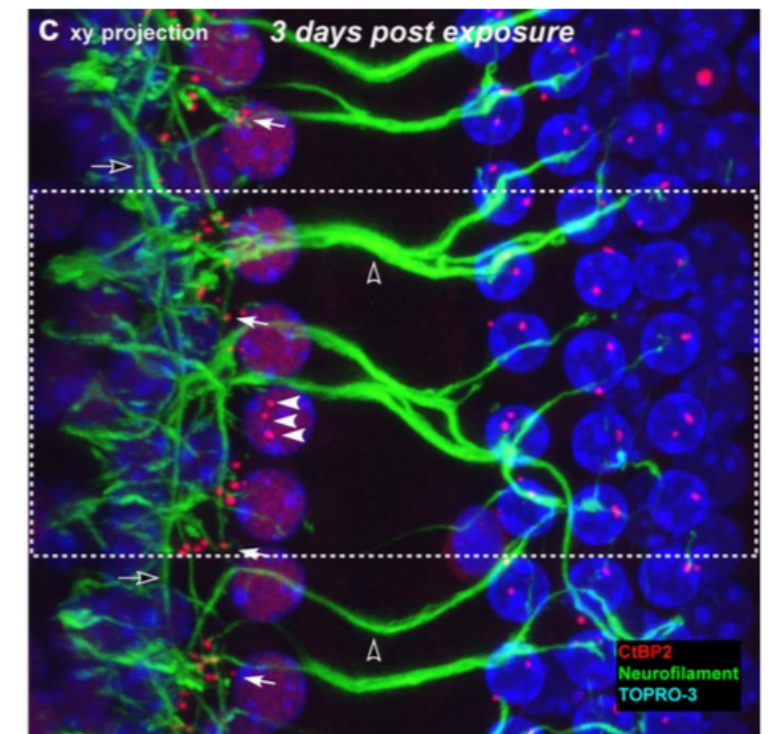
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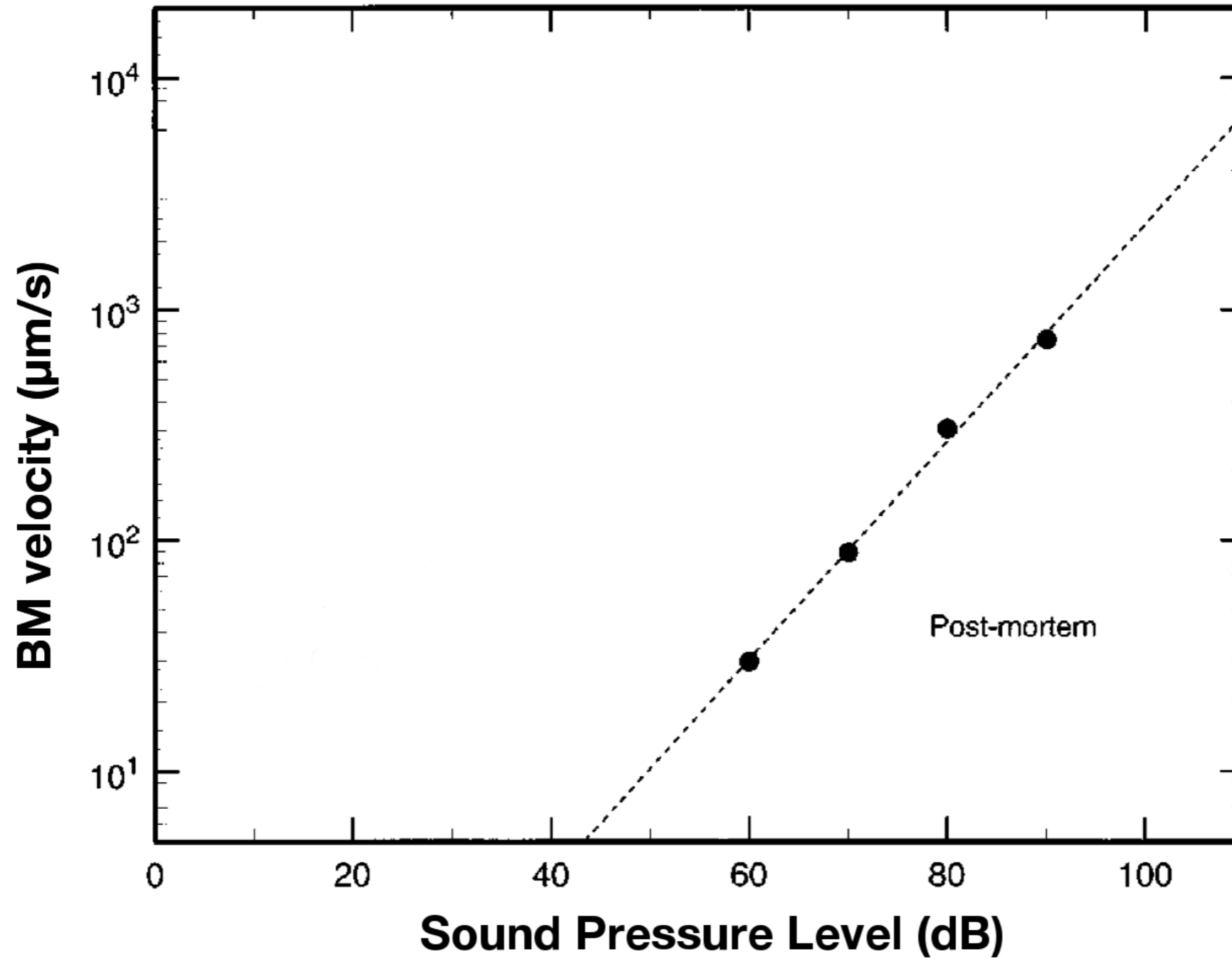


Auditory nerve fibers (ANF) **deafferentation** is **not reflected** as permanent threshold elevation

Kujawa and Liberman (2009), Lin *et al.* (2011), Furman *et al.* (2013)

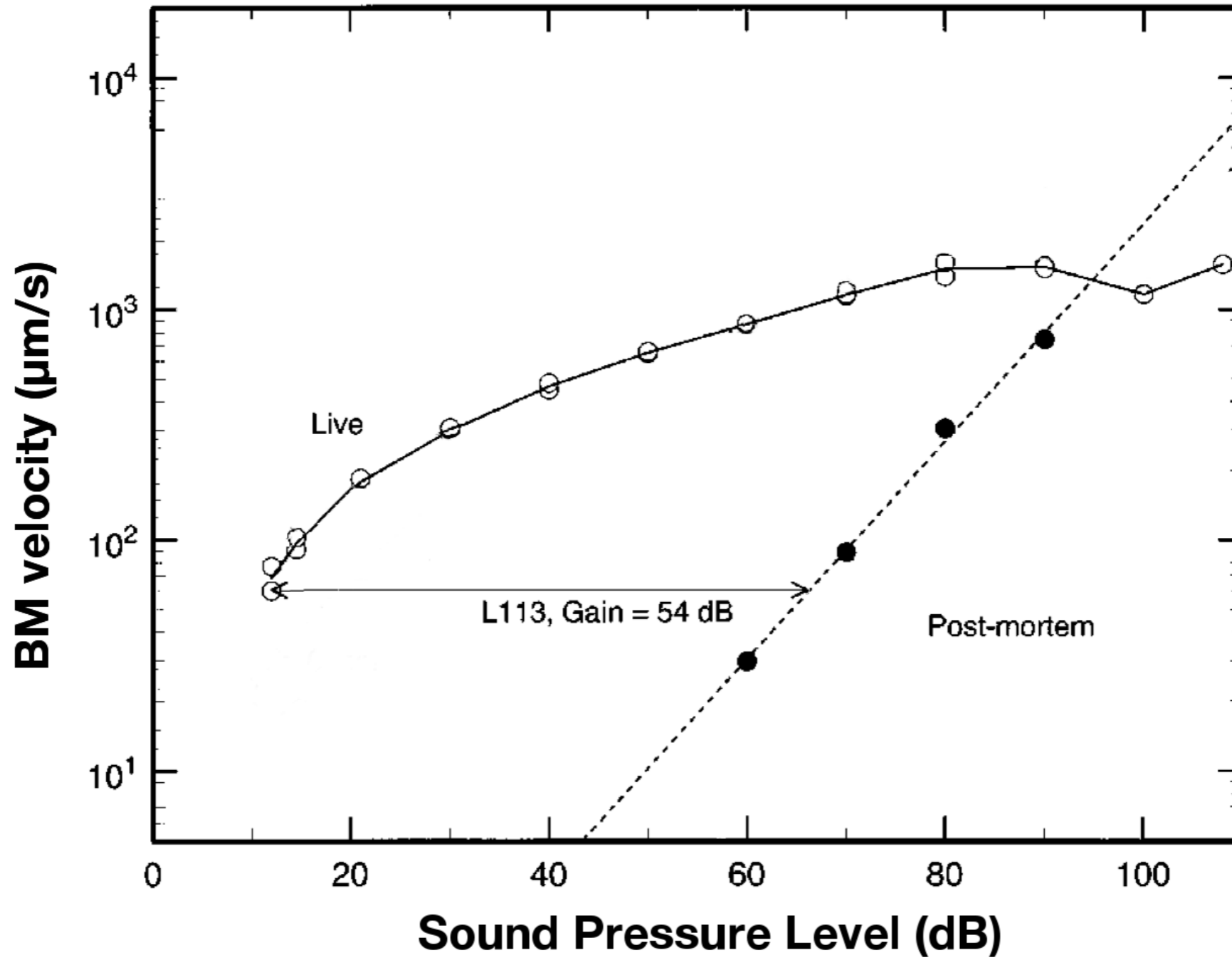
Compression: Animal data

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Ruggero *et al.* (1997)

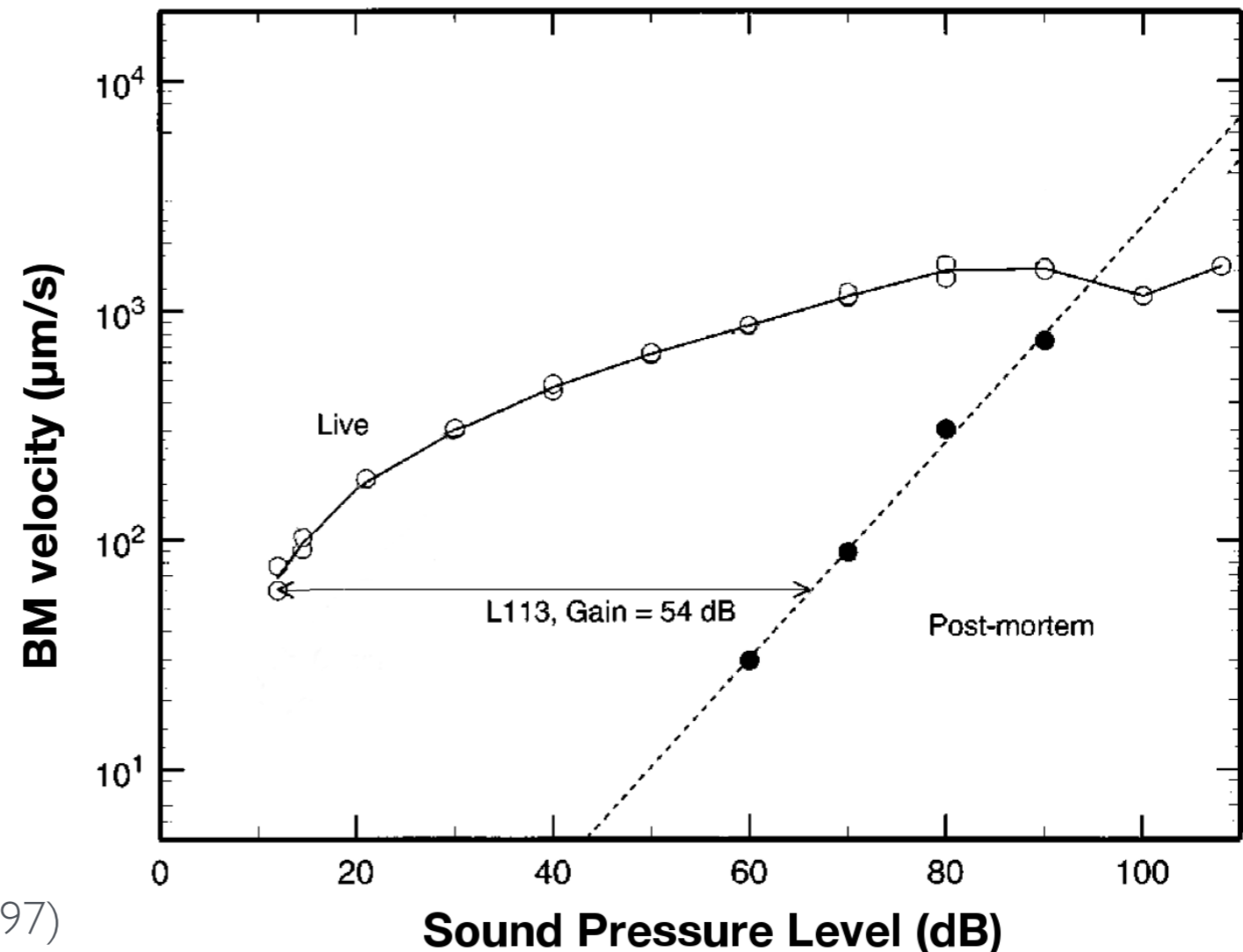
Compression: Animal data



Ruggero *et al.* (1997)

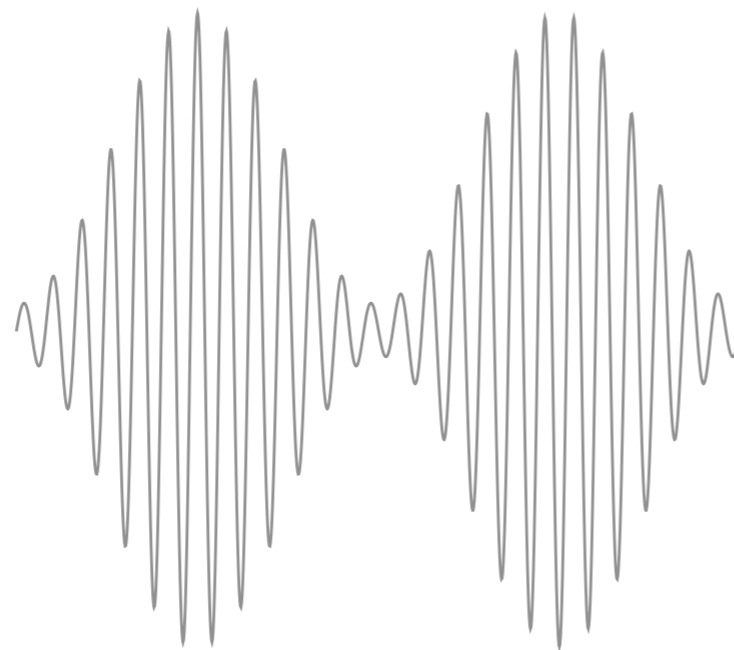
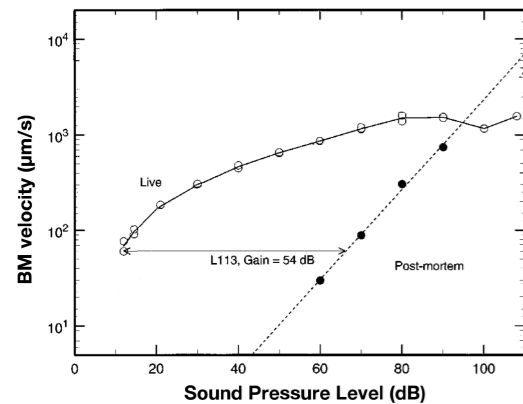
Compression: Auditory Steady-State Responses

- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.



Ruggero *et al.* (1997)

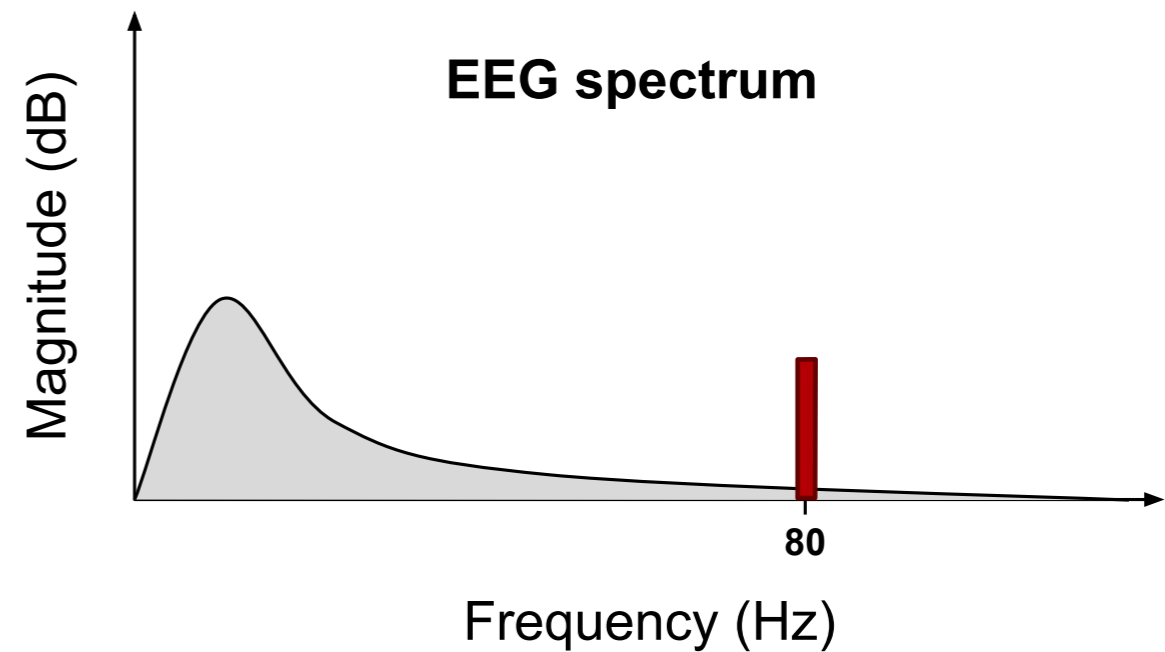
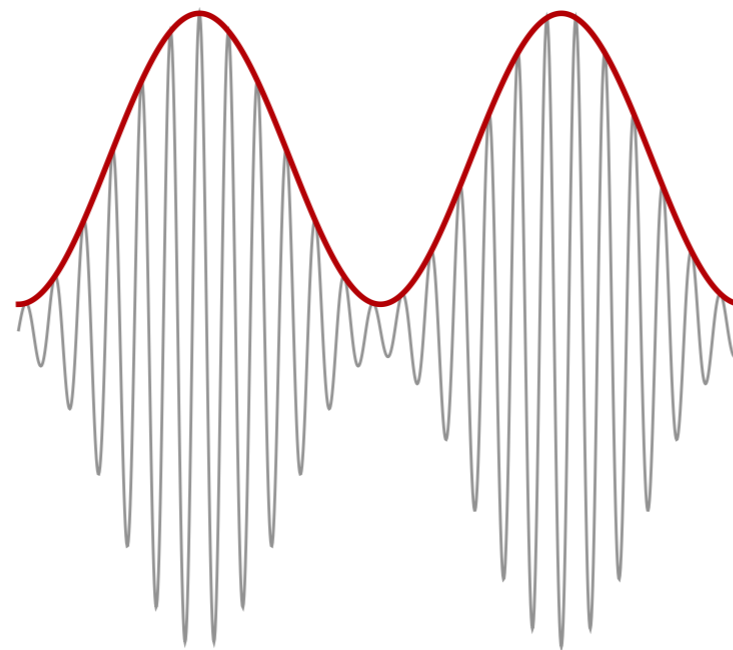
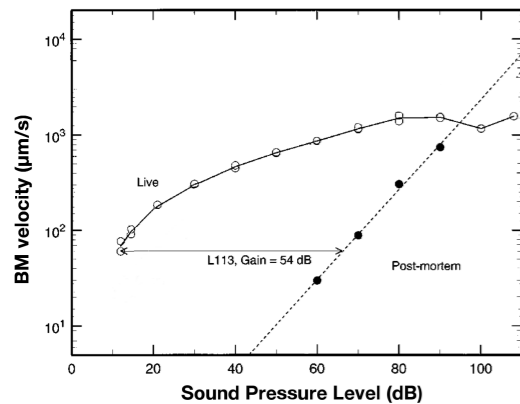
- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.
- ASSR reflect **envelope** coding.



$$A \cdot \sin(2\pi f_c t) \cdot \left[\frac{1 + m \cdot \sin(2\pi f_m t)}{2} \right]$$

1 kHz @ 80 Hz
m = 85%

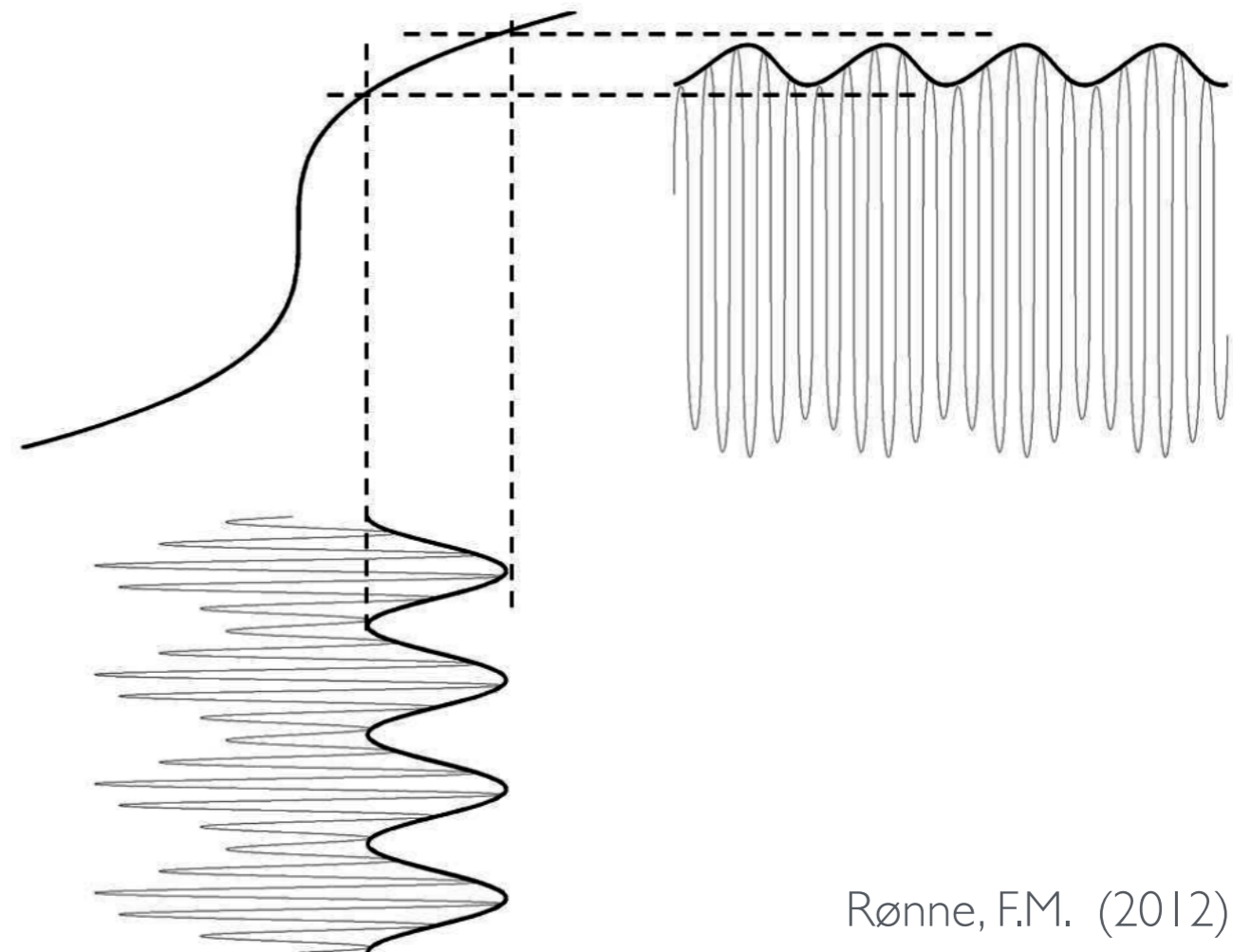
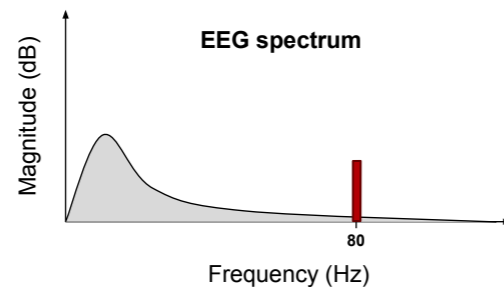
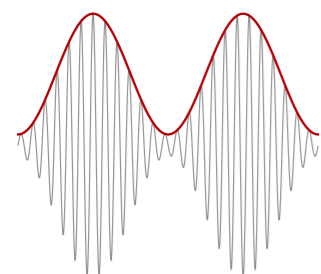
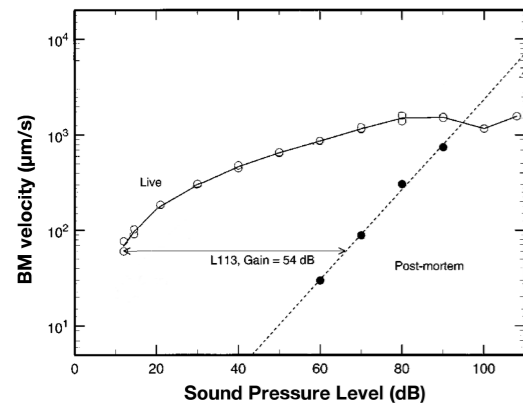
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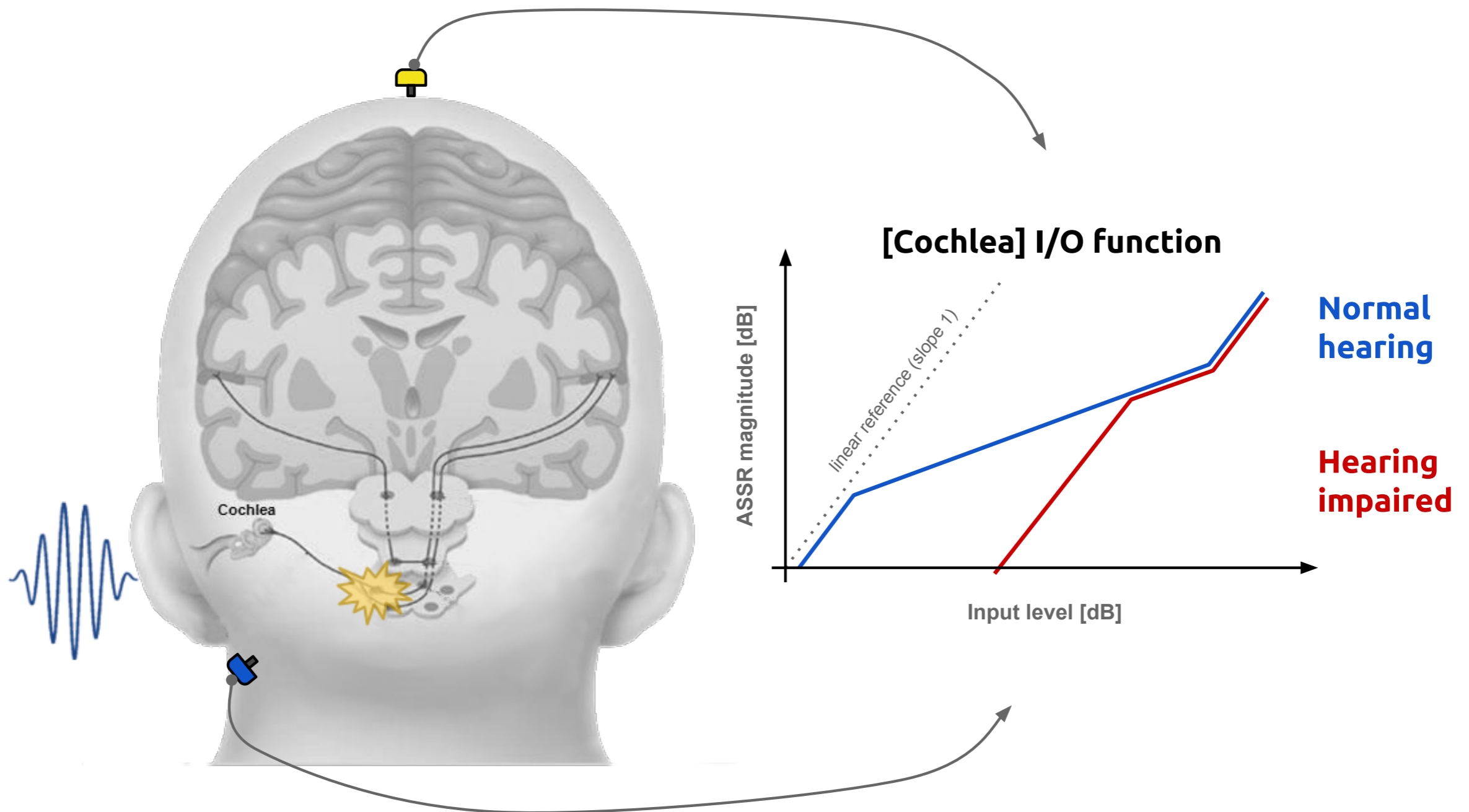
- The **healthy cochlea** shows a **compressive growth** as a function of stimulation level.
- ASSR reflect **envelope** coding.
- Compression **affects** to the **envelope**, hence it should affect to **ASSR**.



Rønne, F.M. (2012)

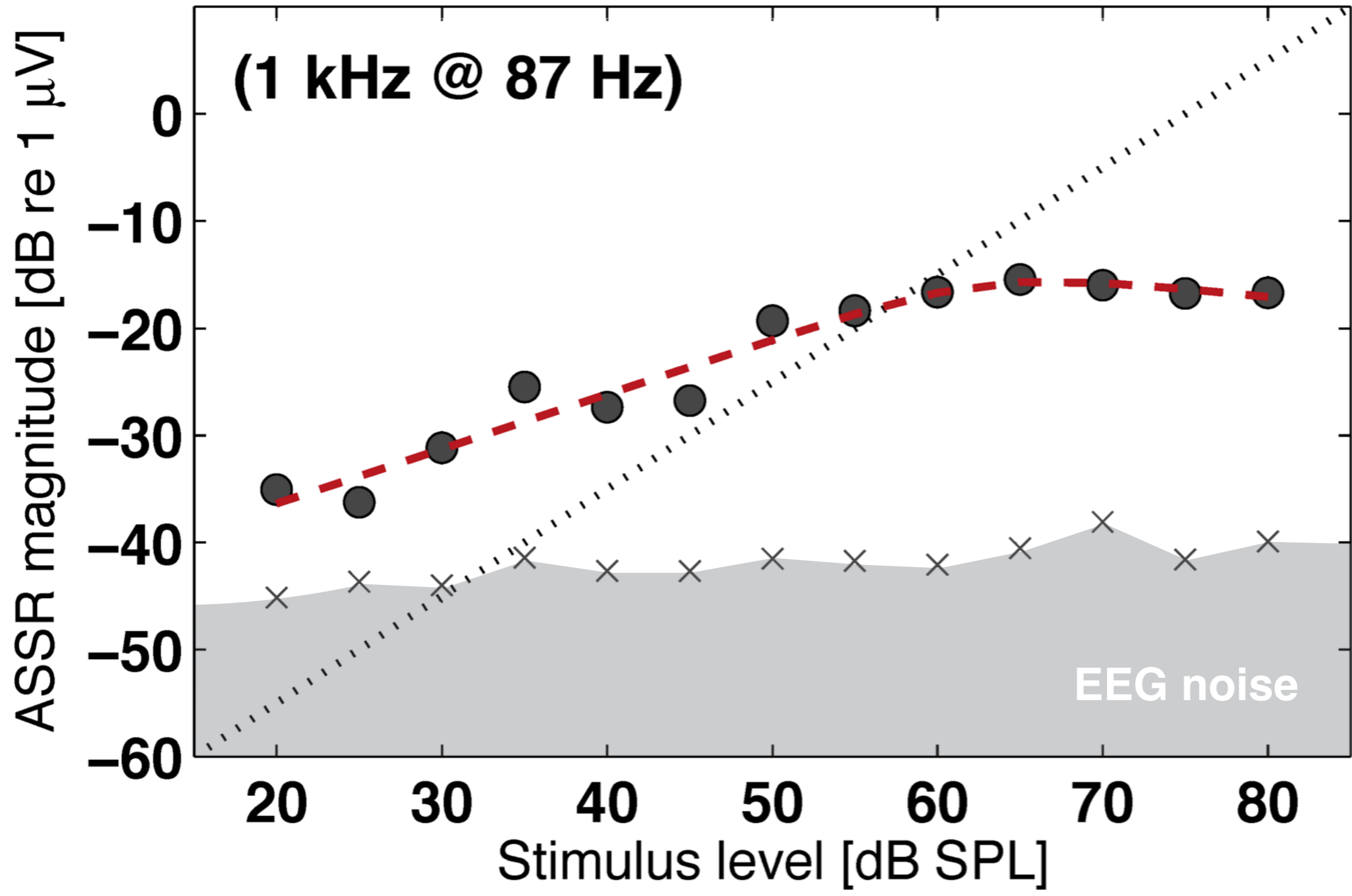
Research question

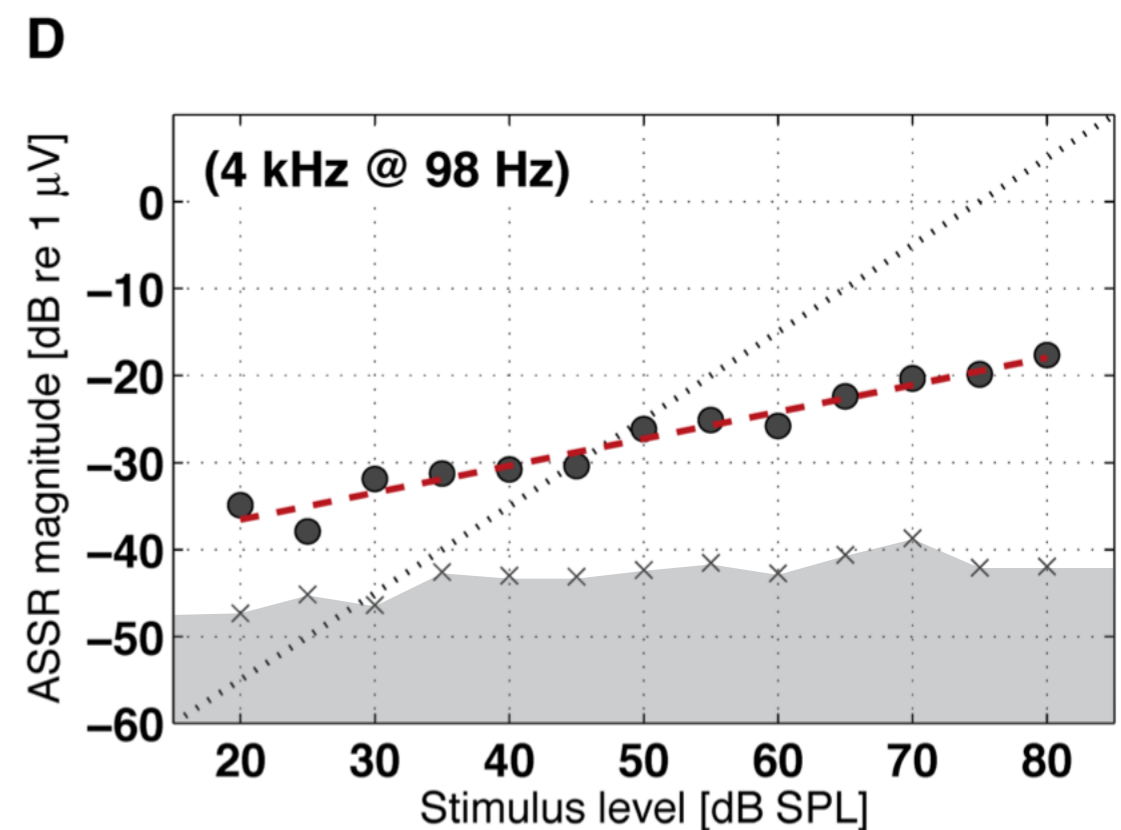
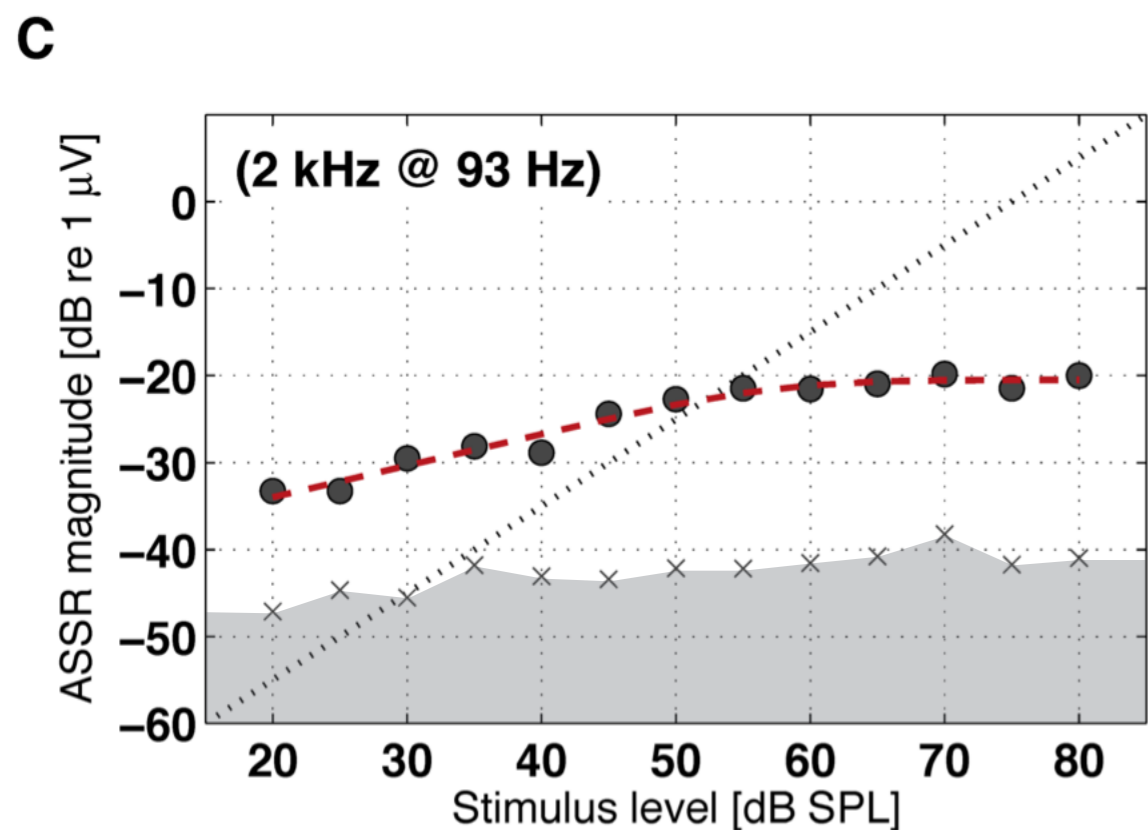
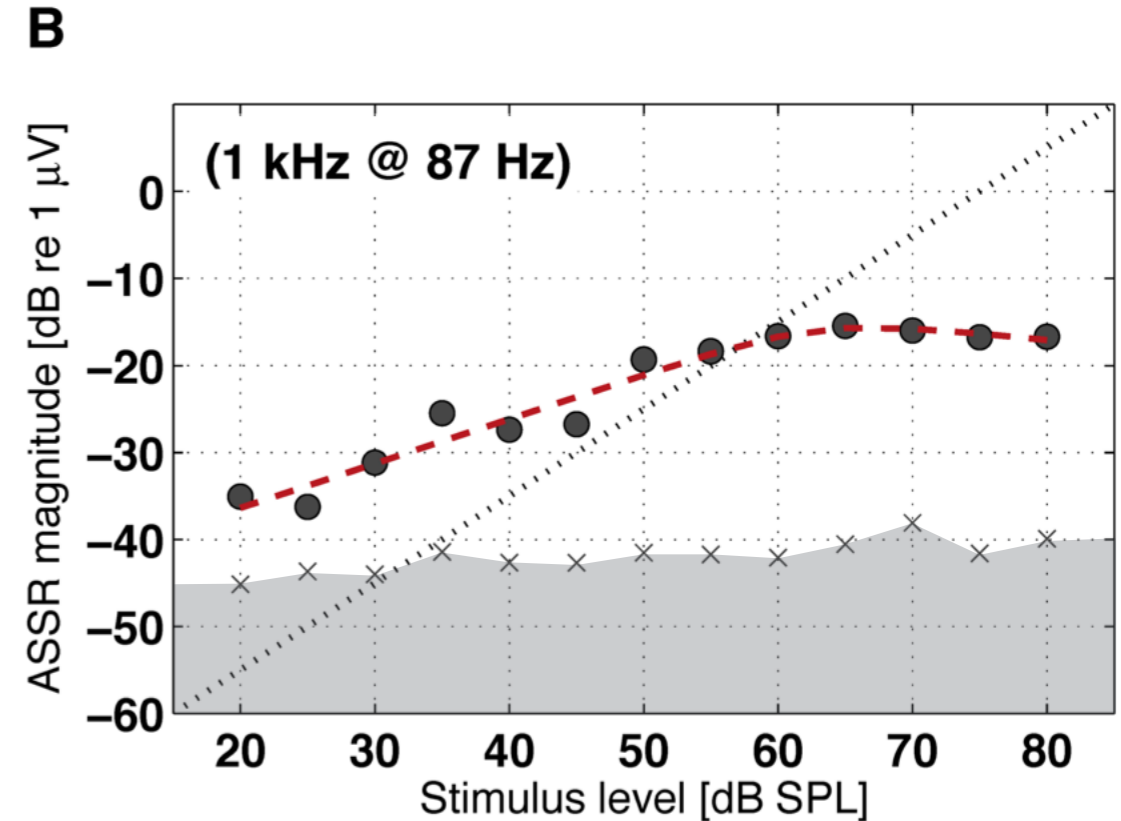
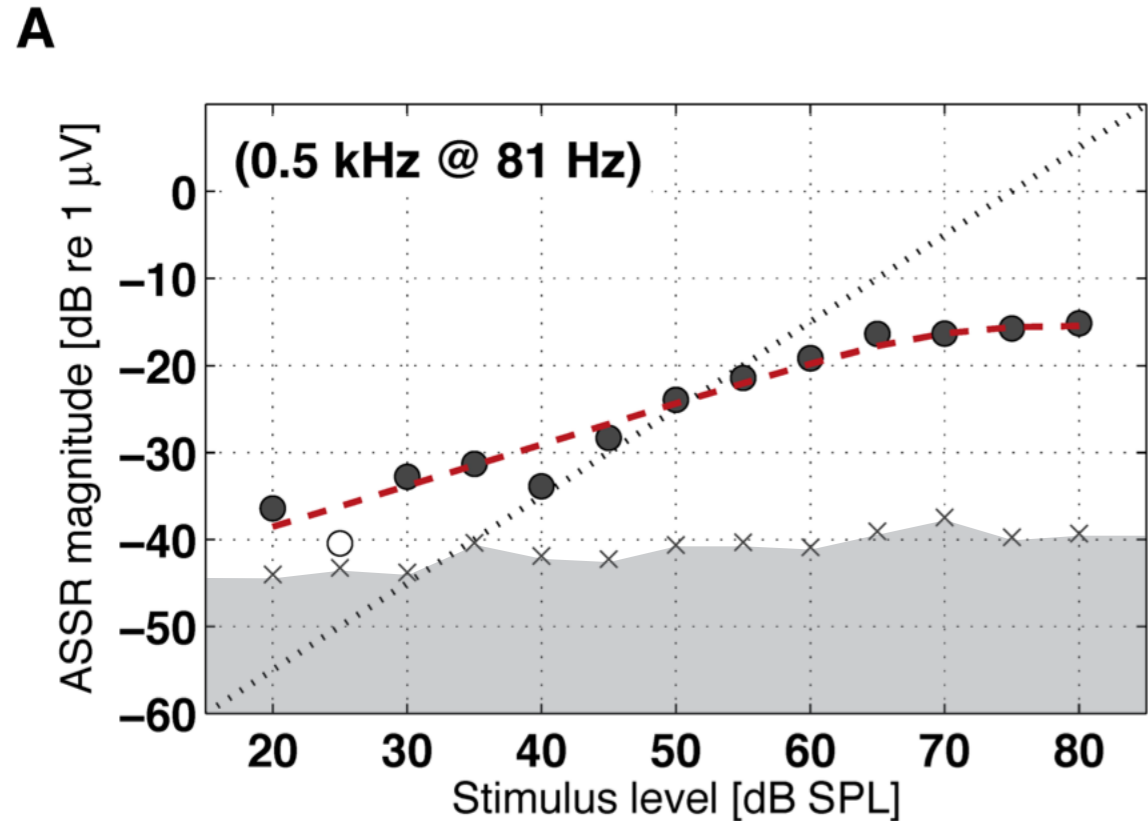
Is it possible to estimate **peripheral compression** using **ASSR**?



Results: A representative NH subject (N=13)

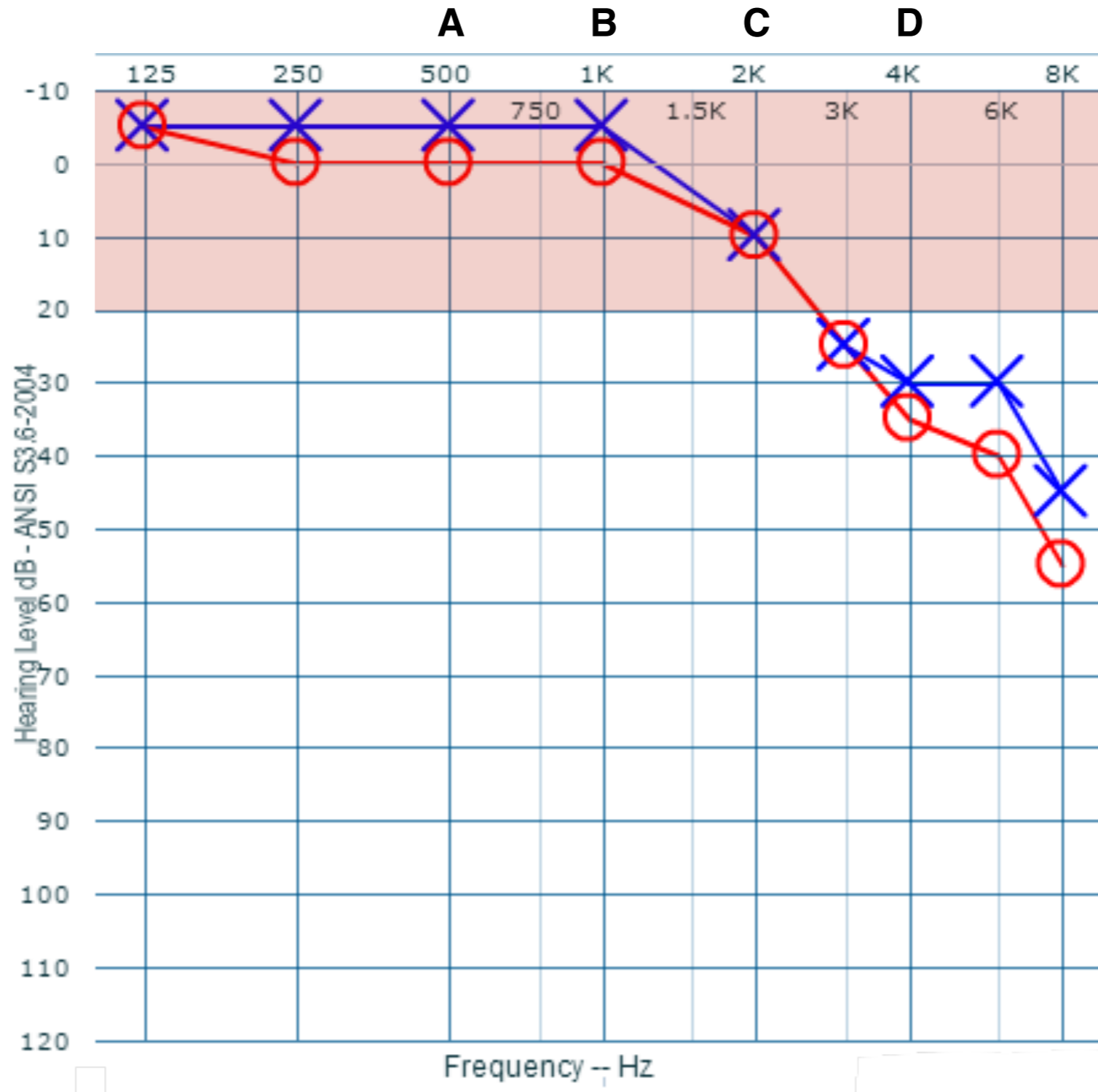
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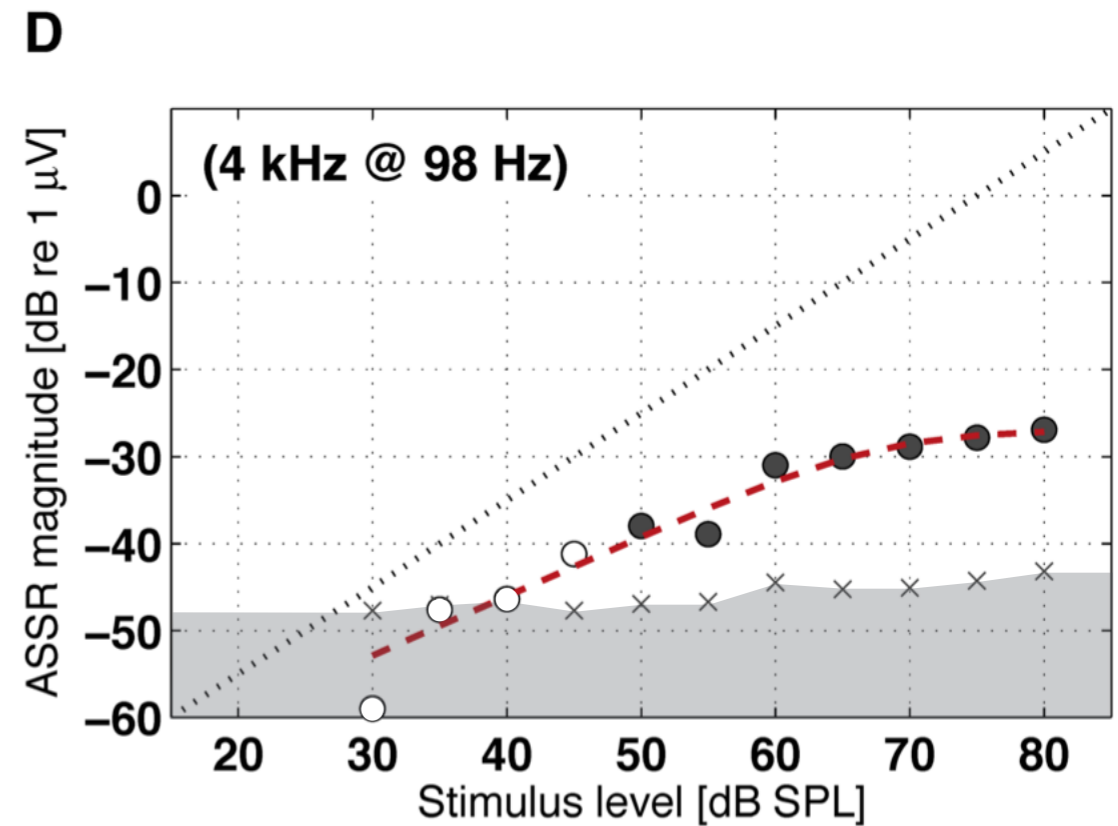
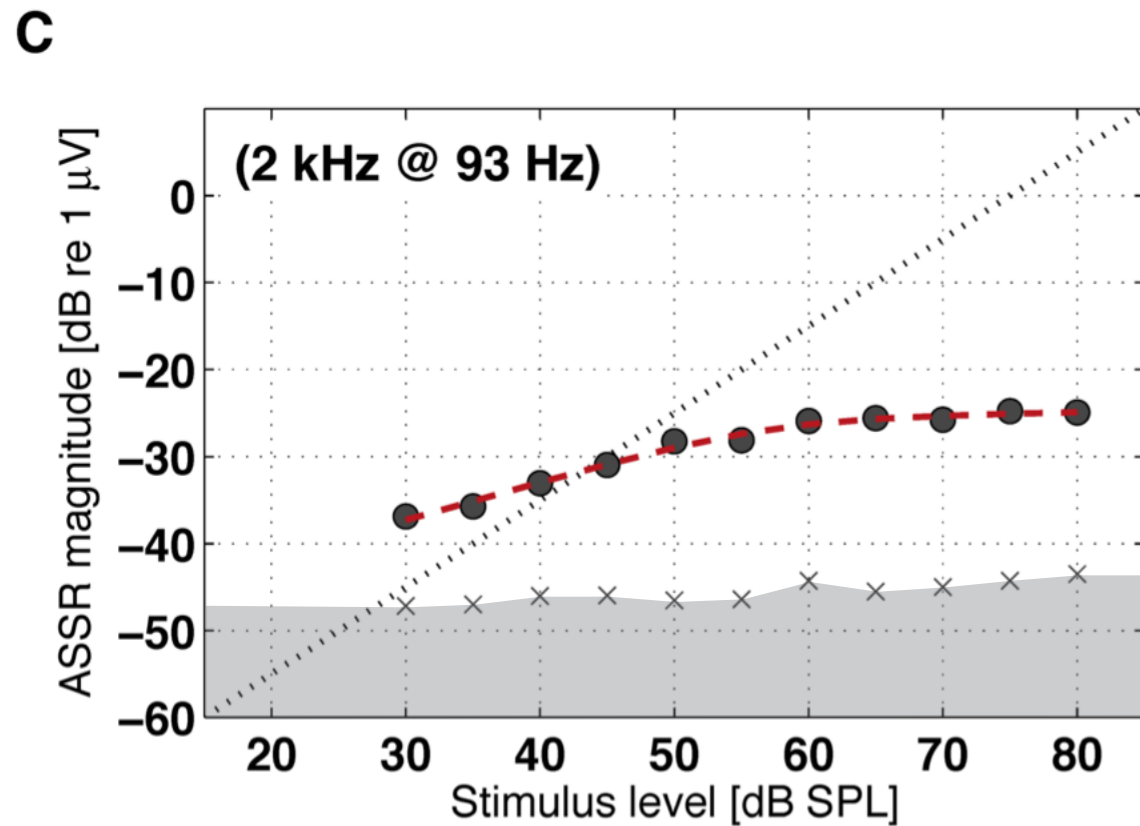
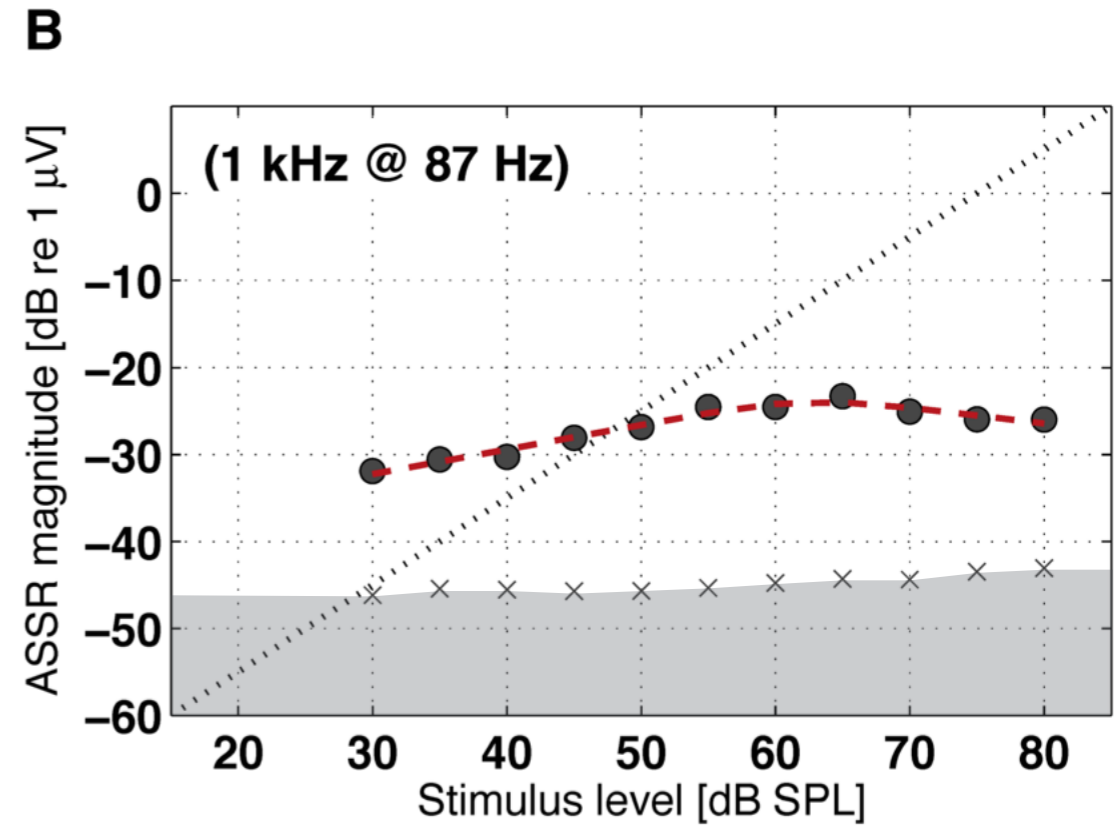
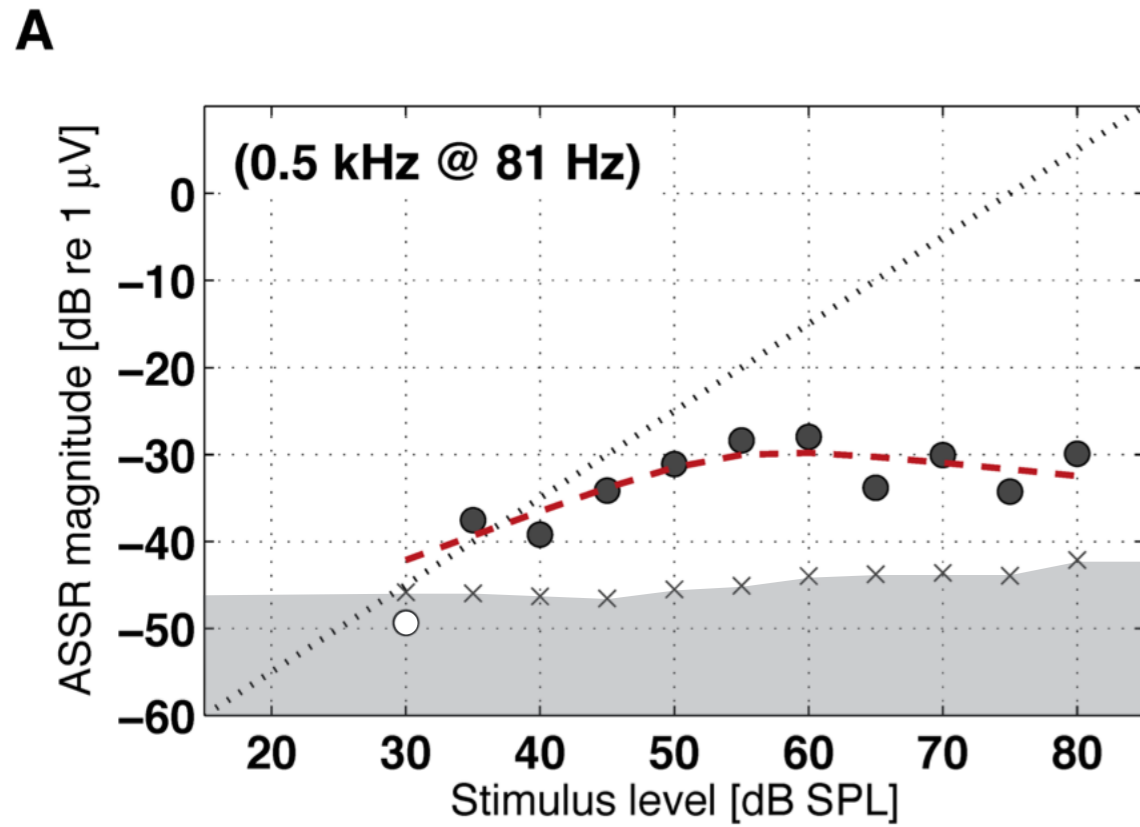


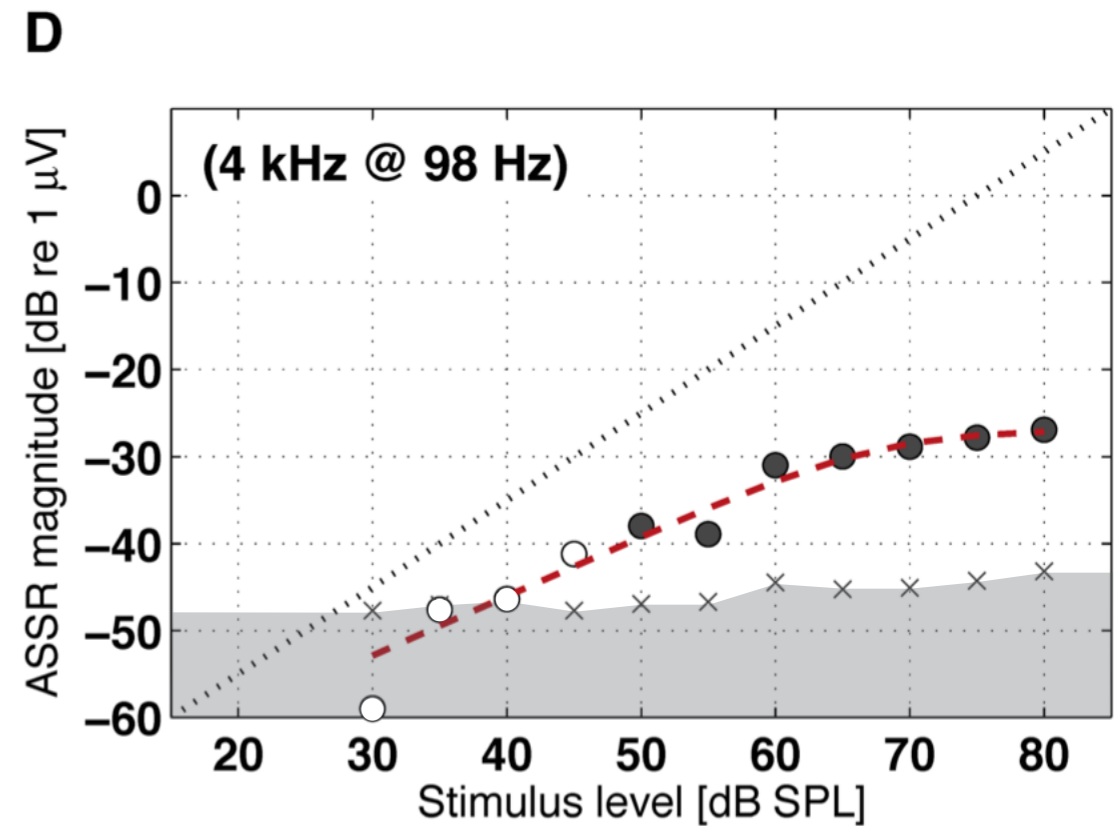
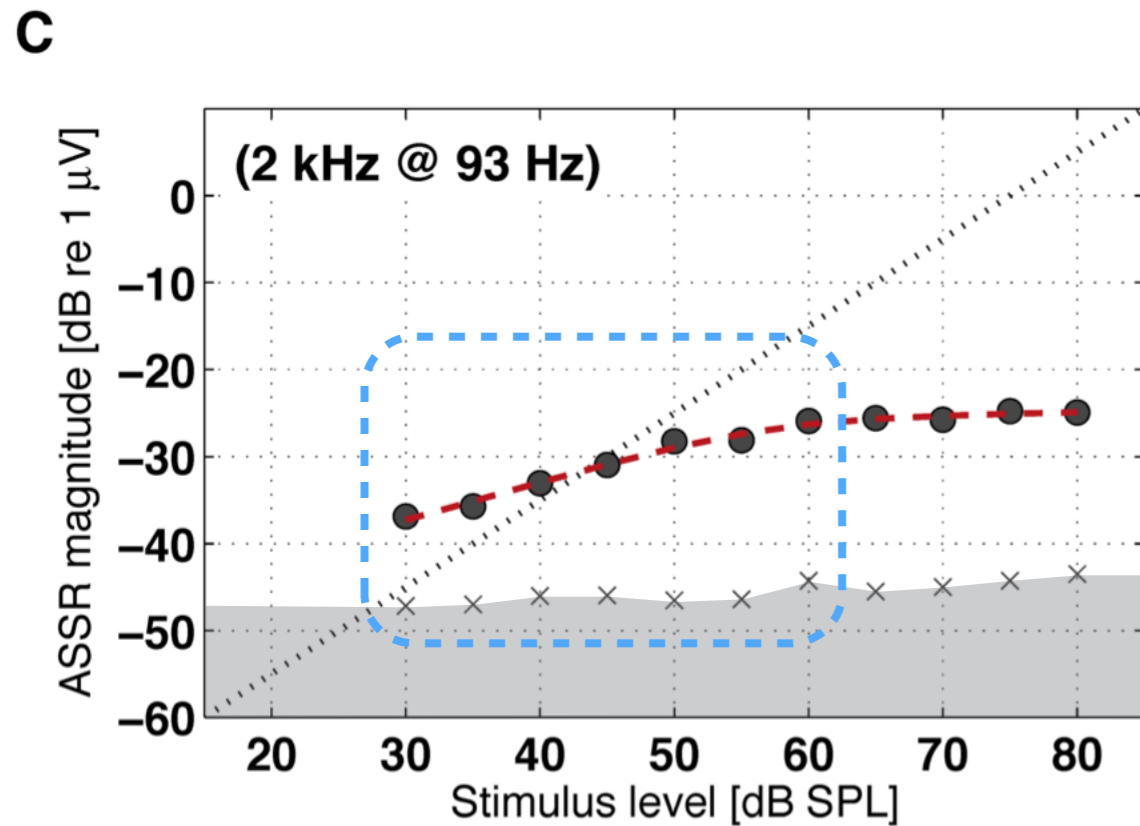
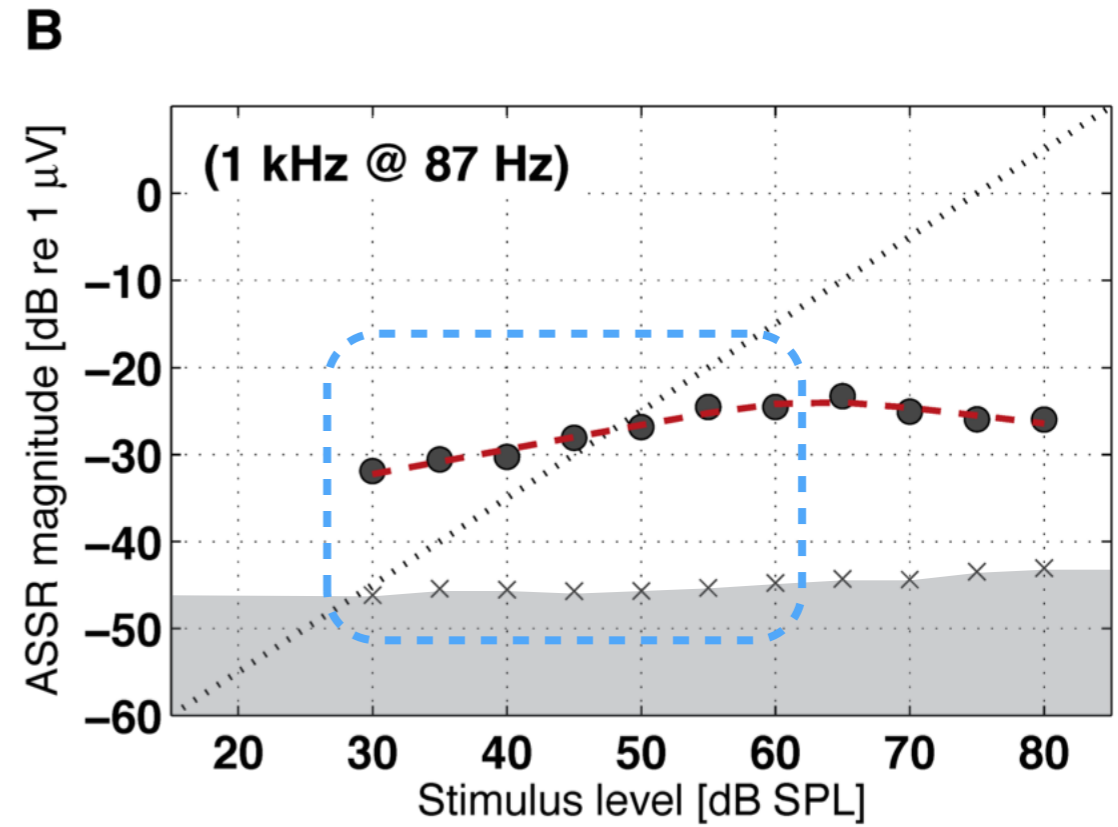
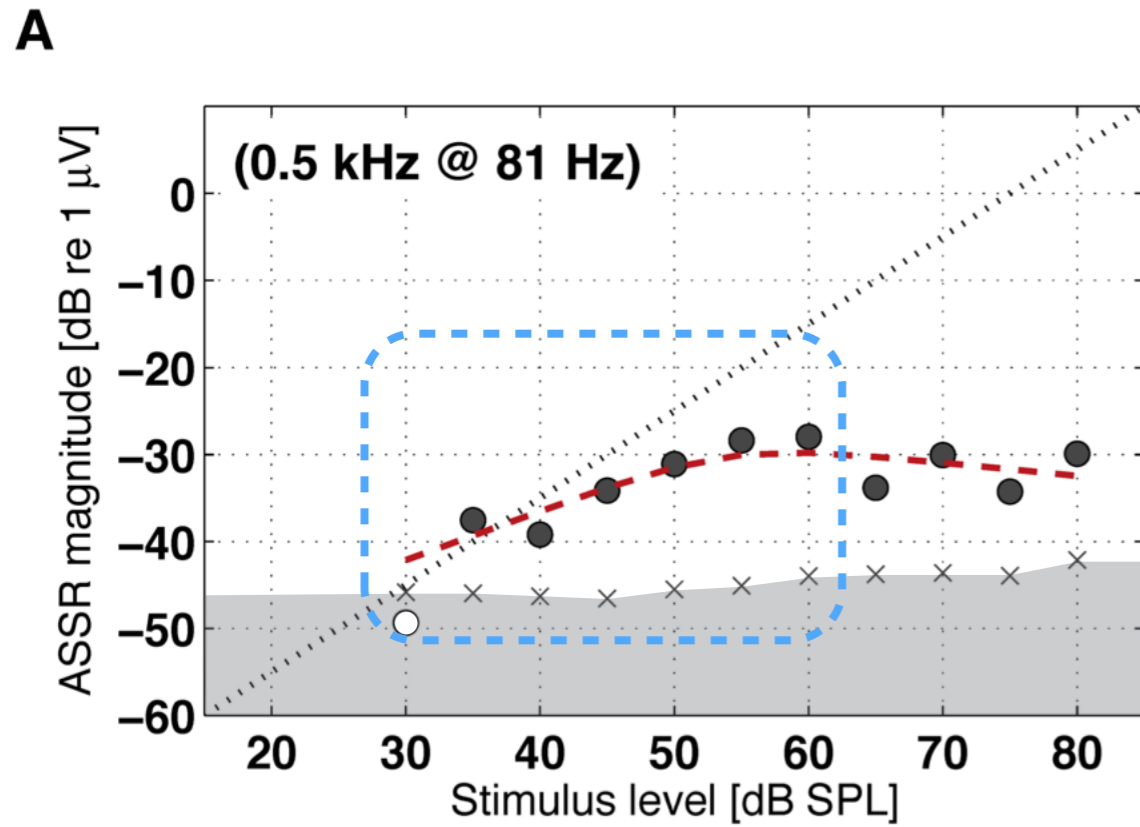


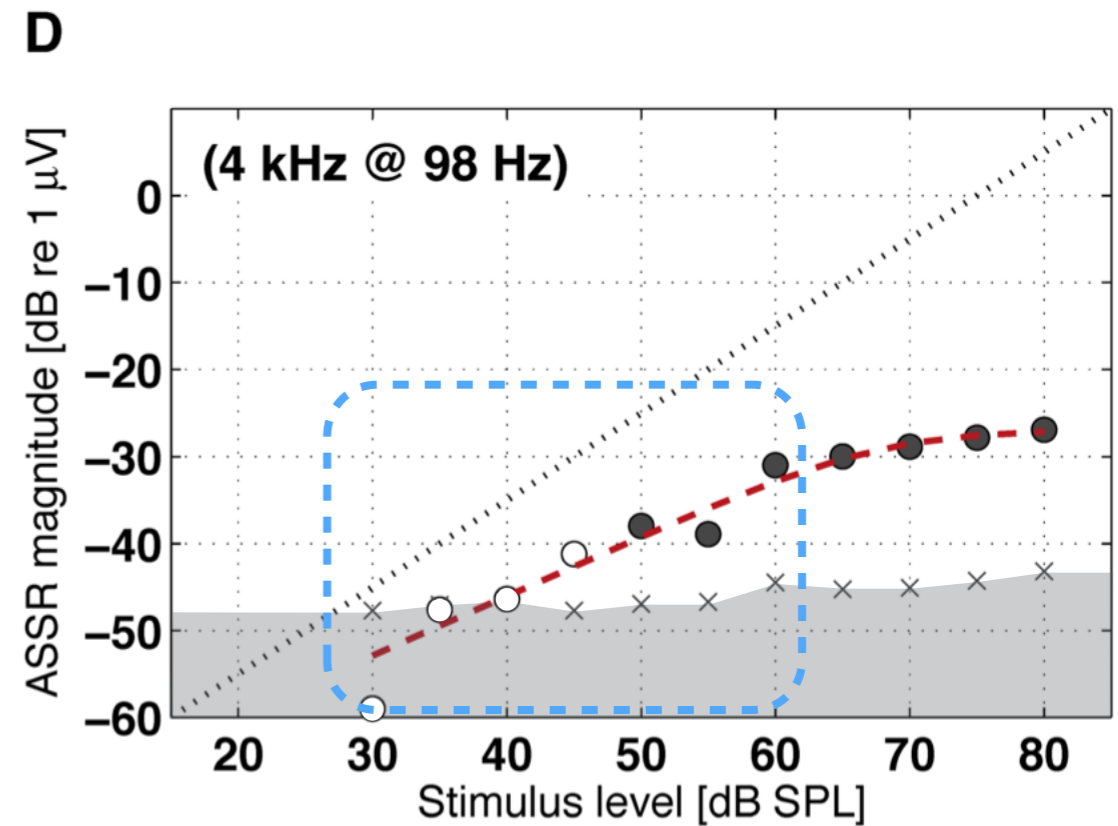
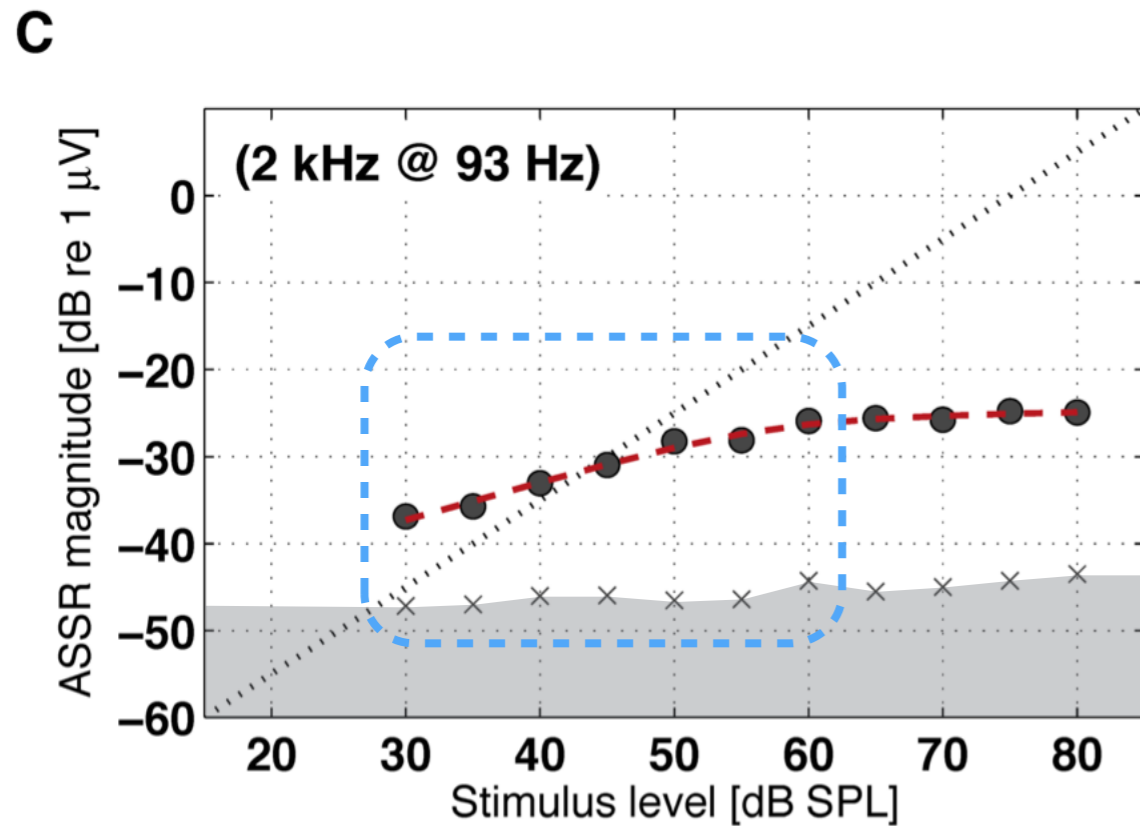
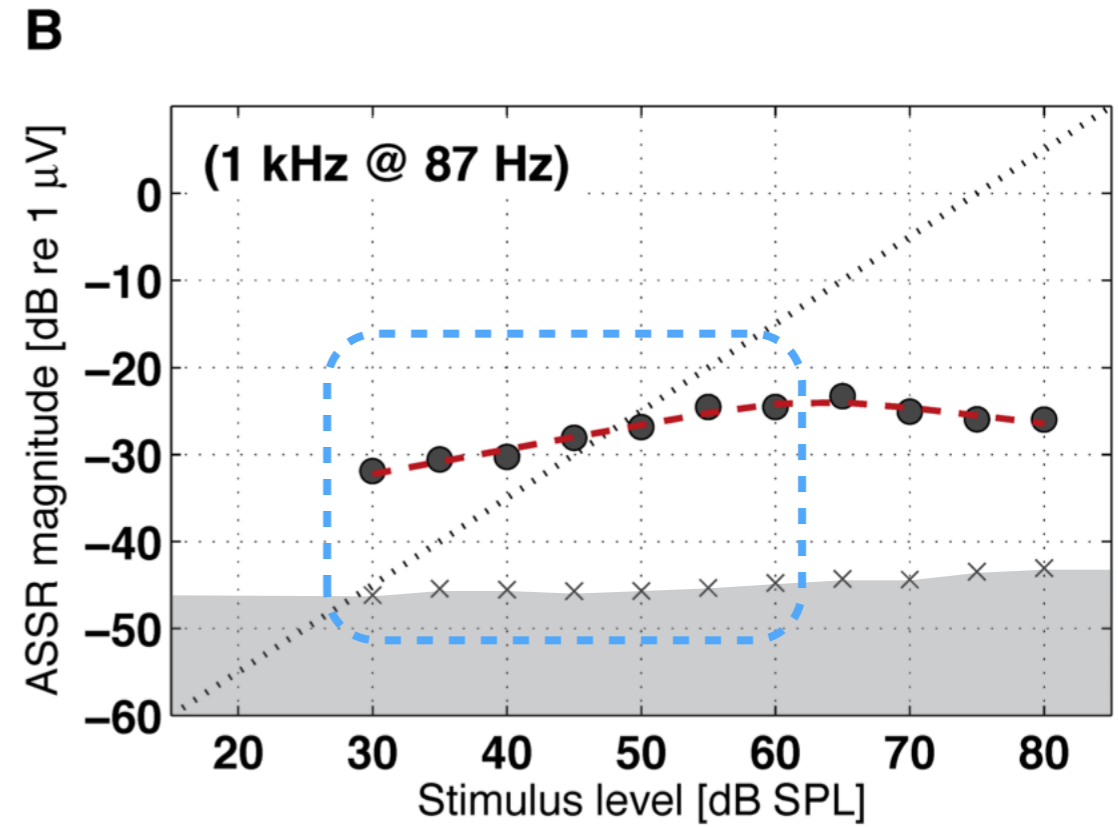
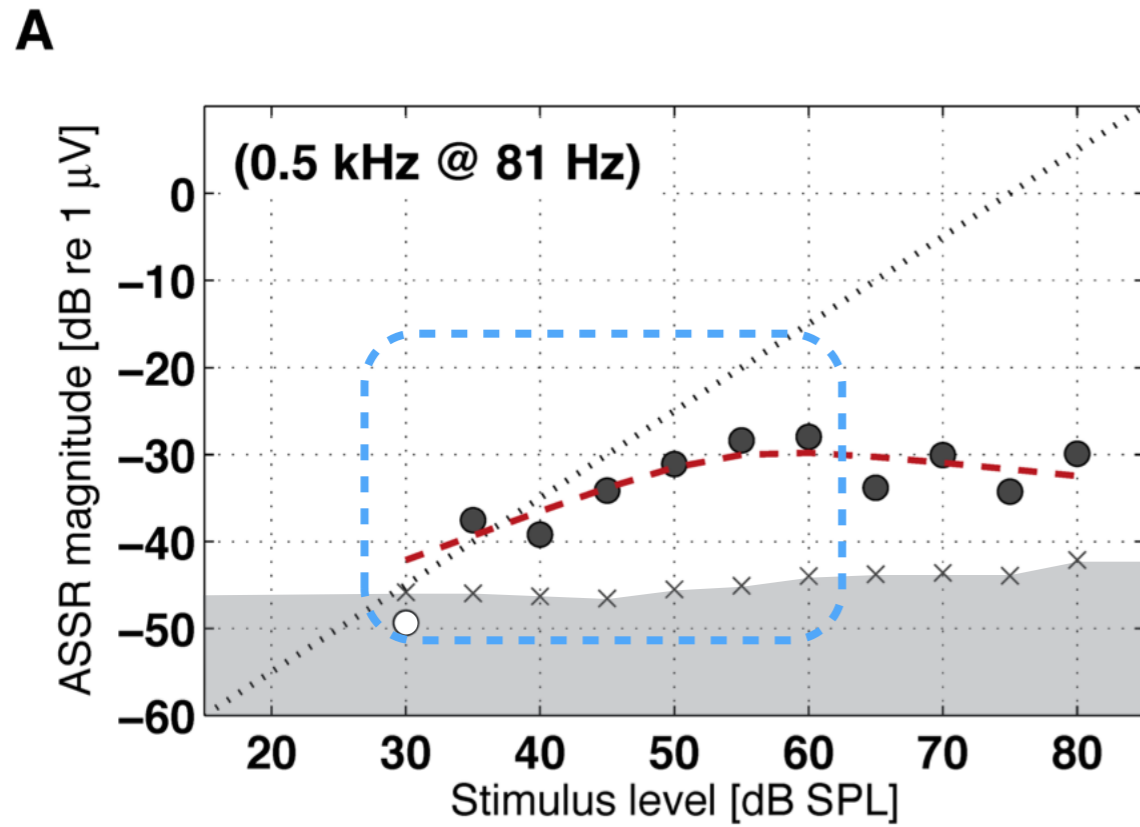
Results: A representative HI subject (N=7)

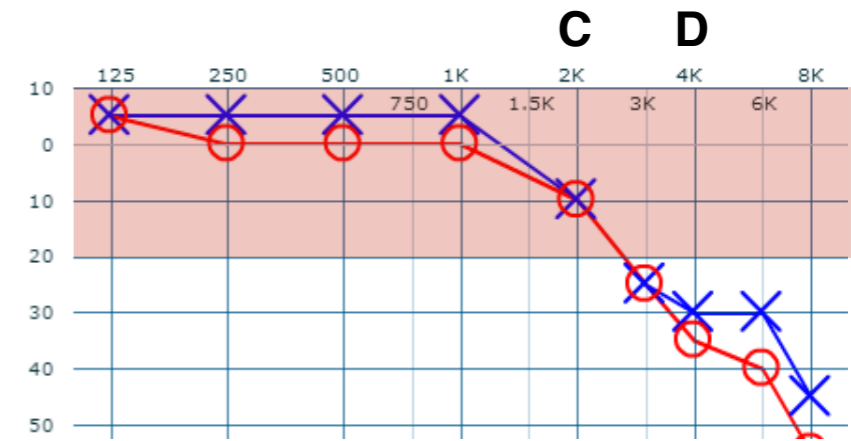
Results: A representative HI subject (N=7)



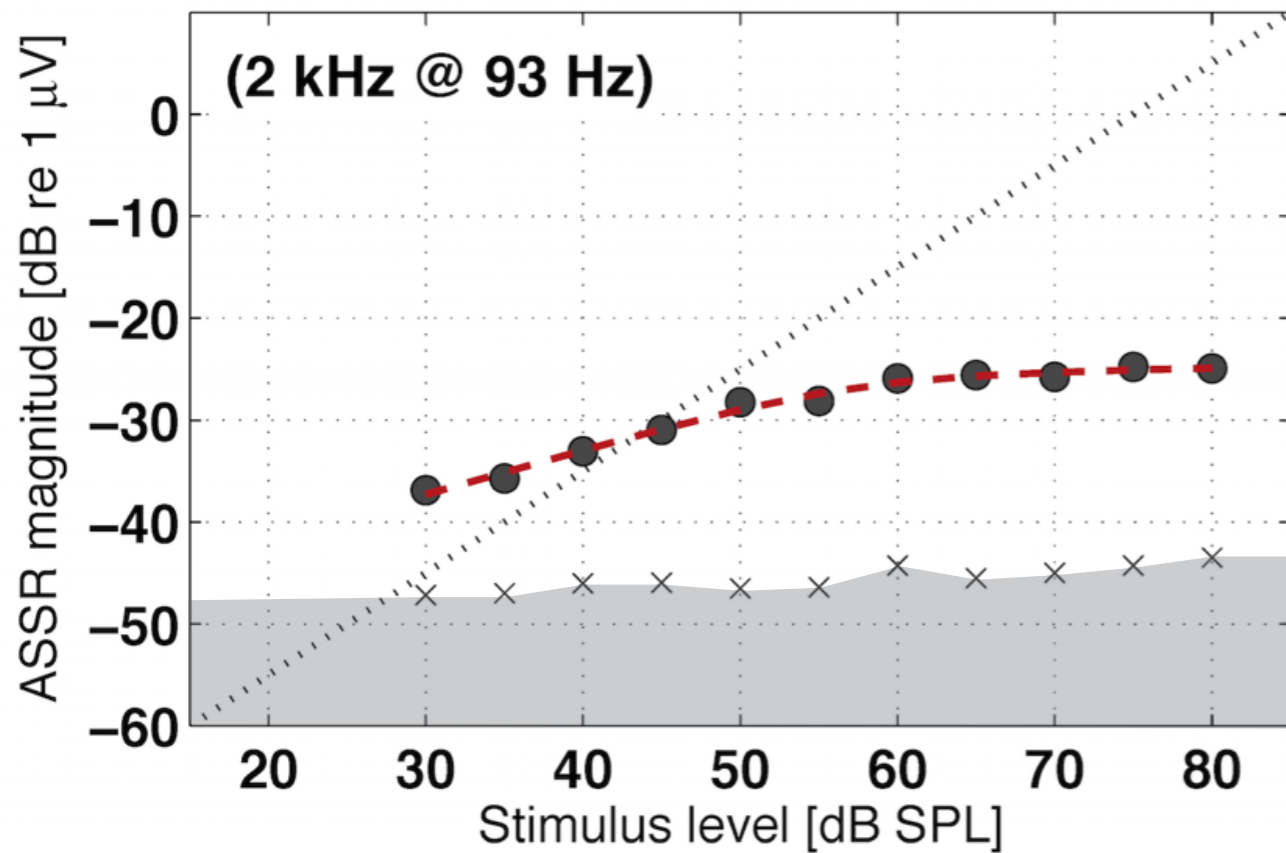






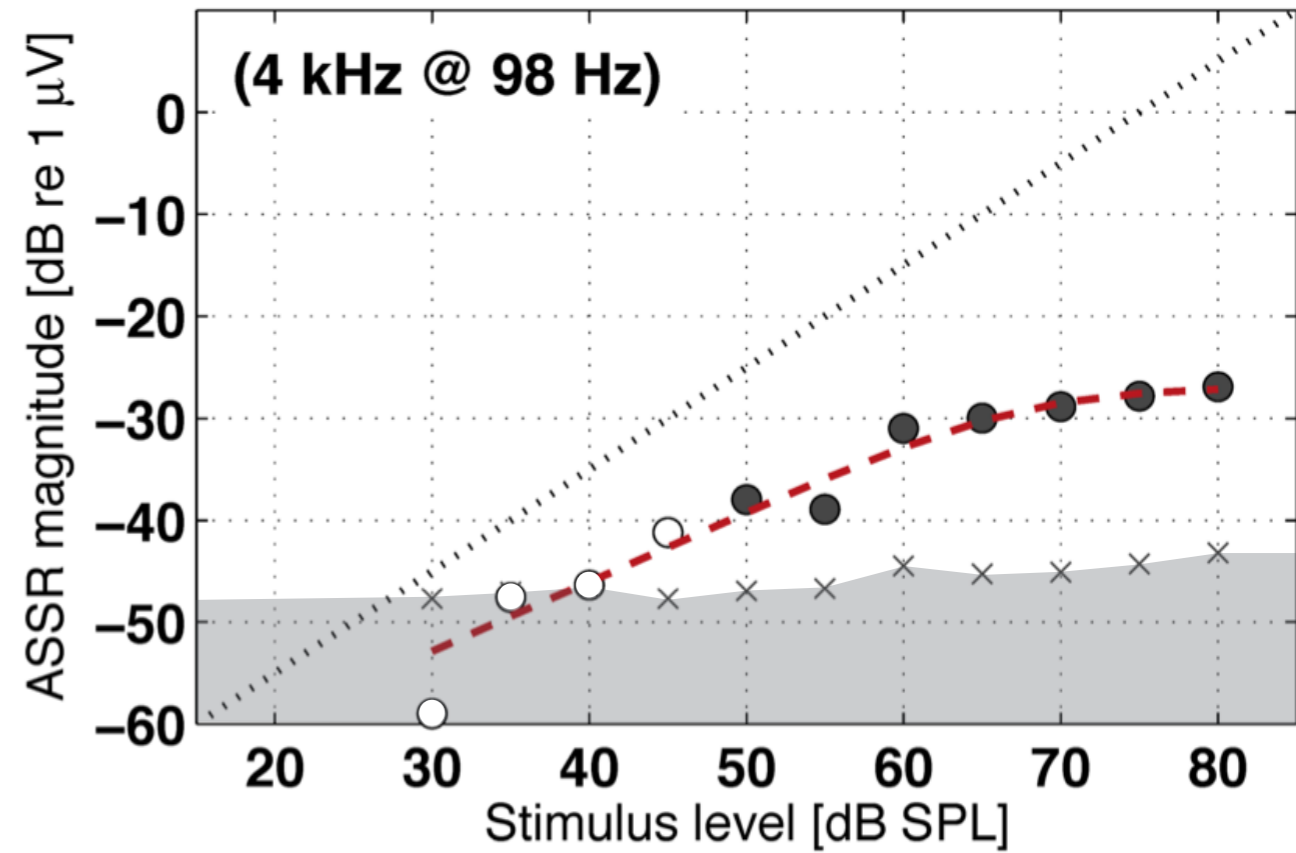


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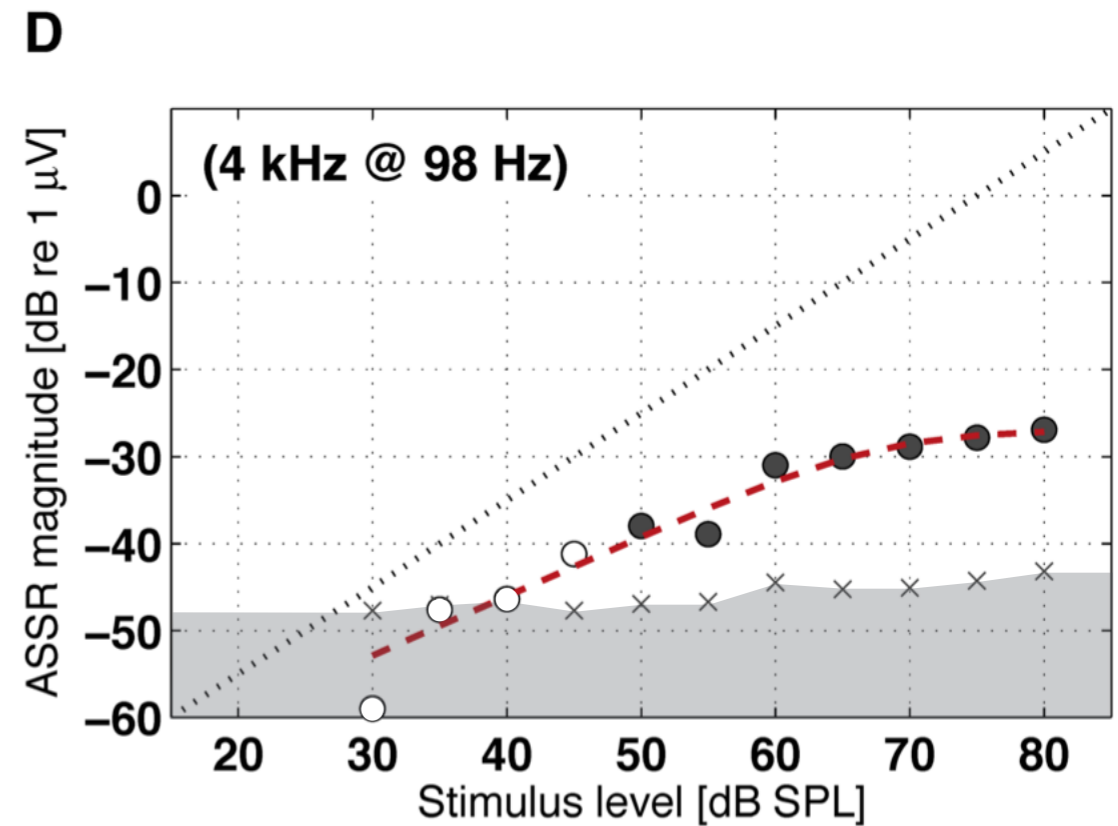
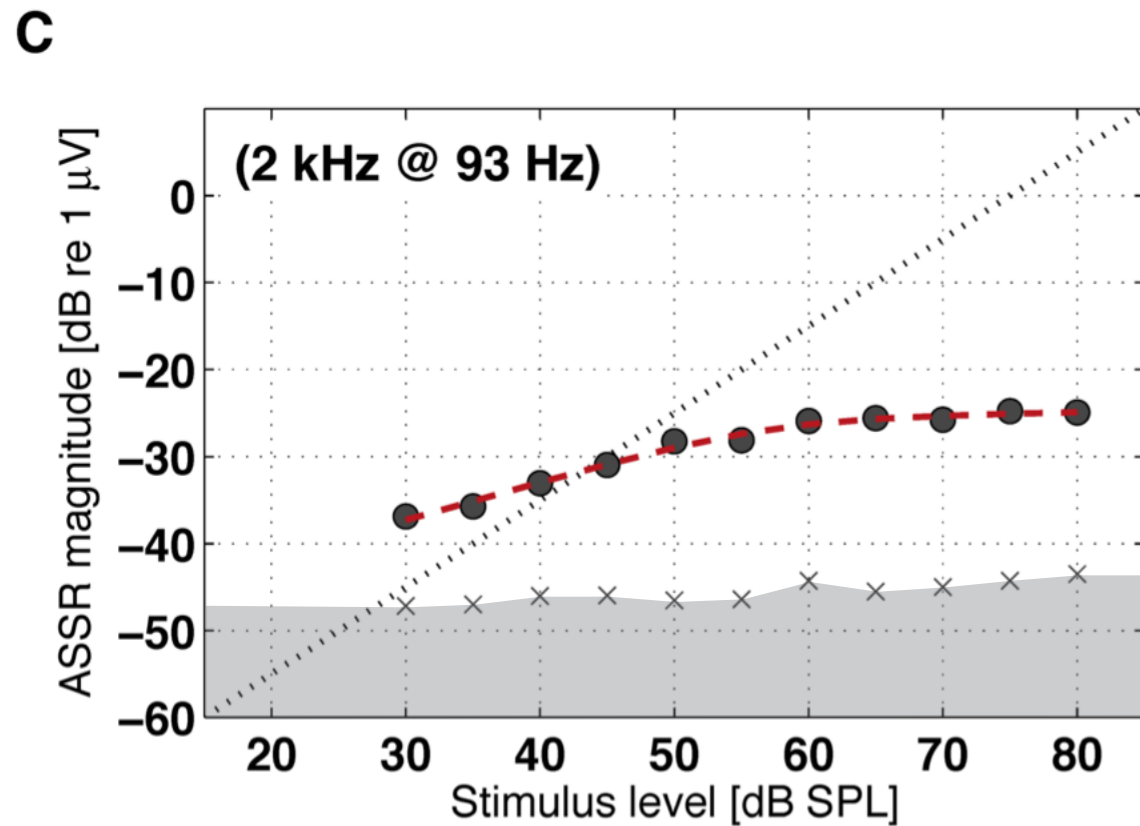
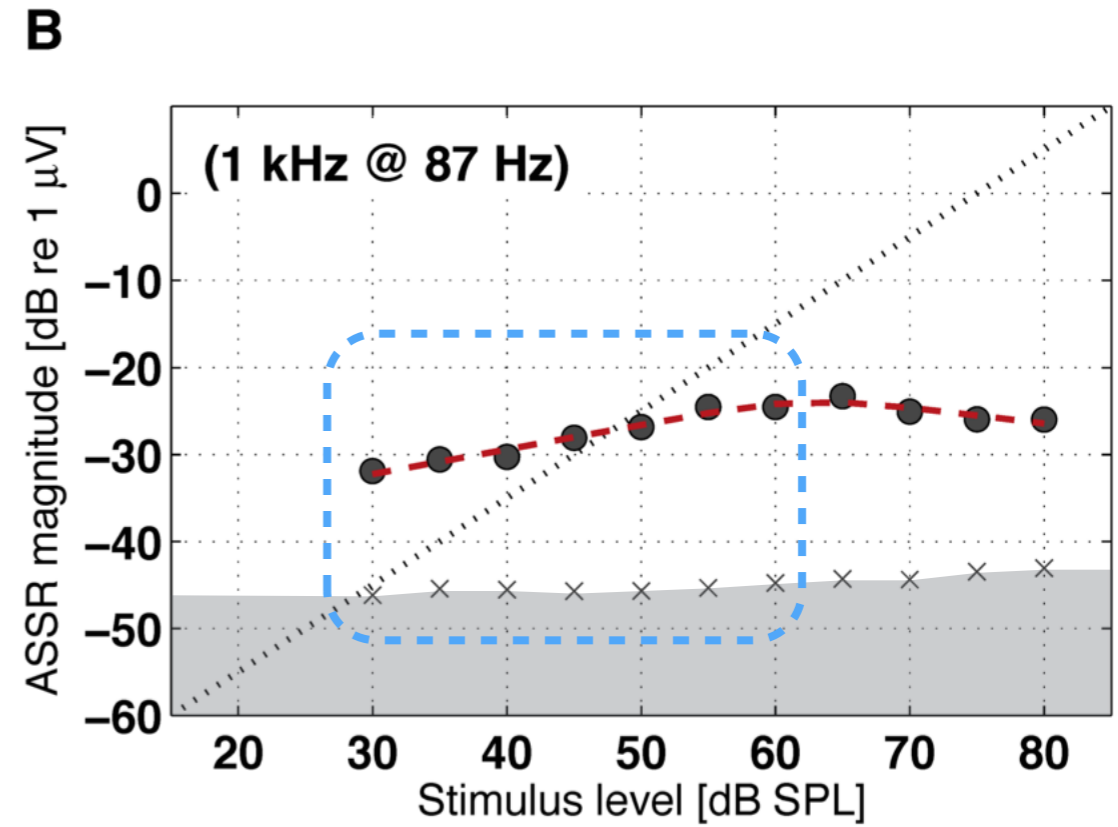
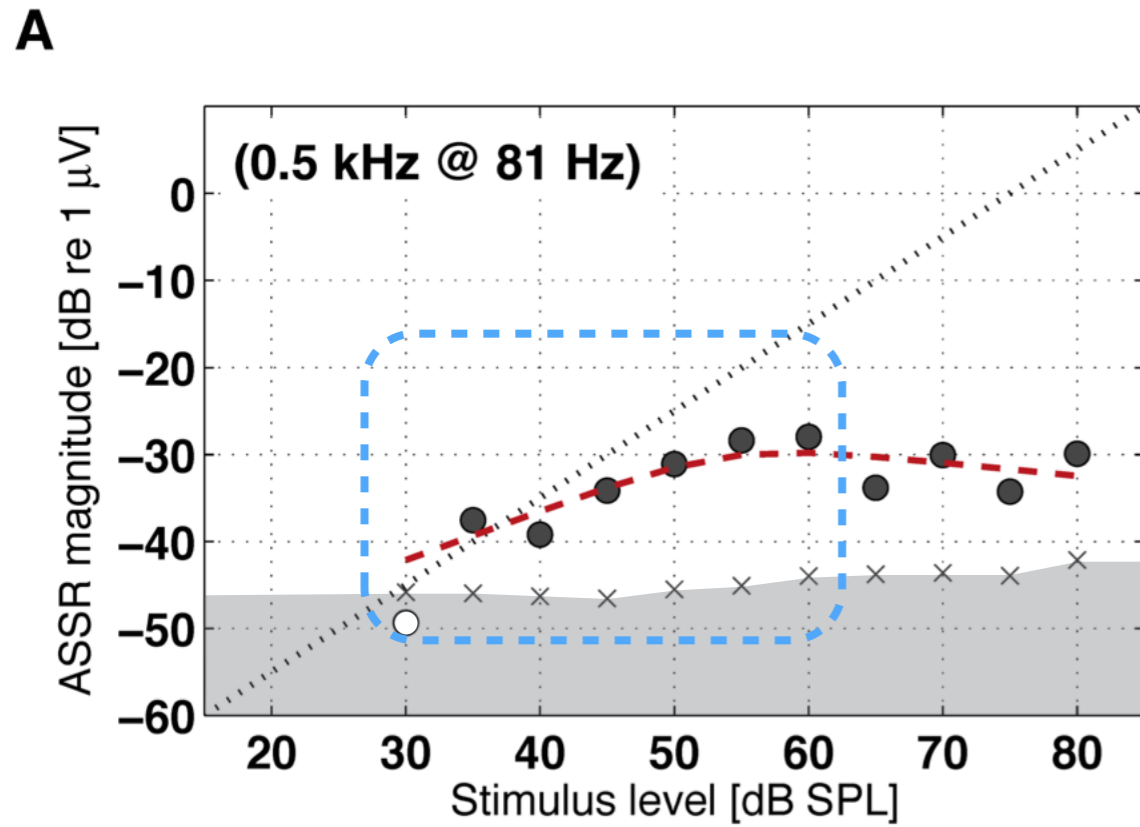


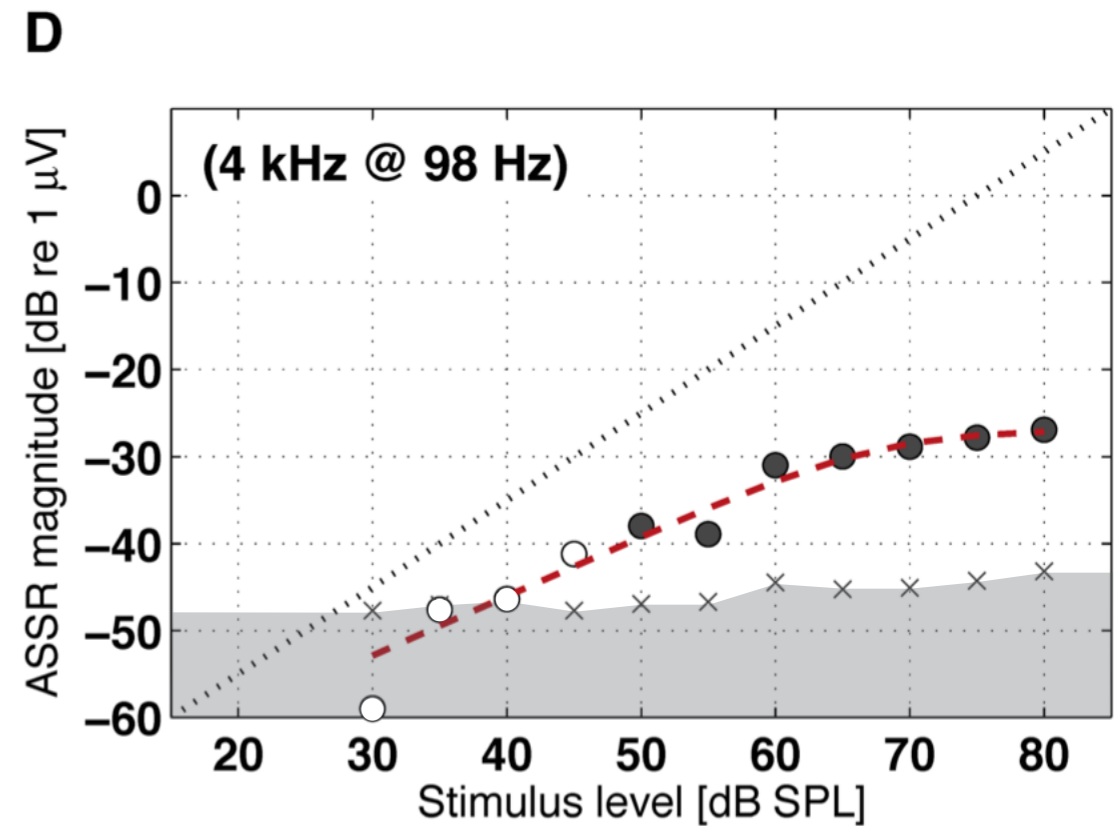
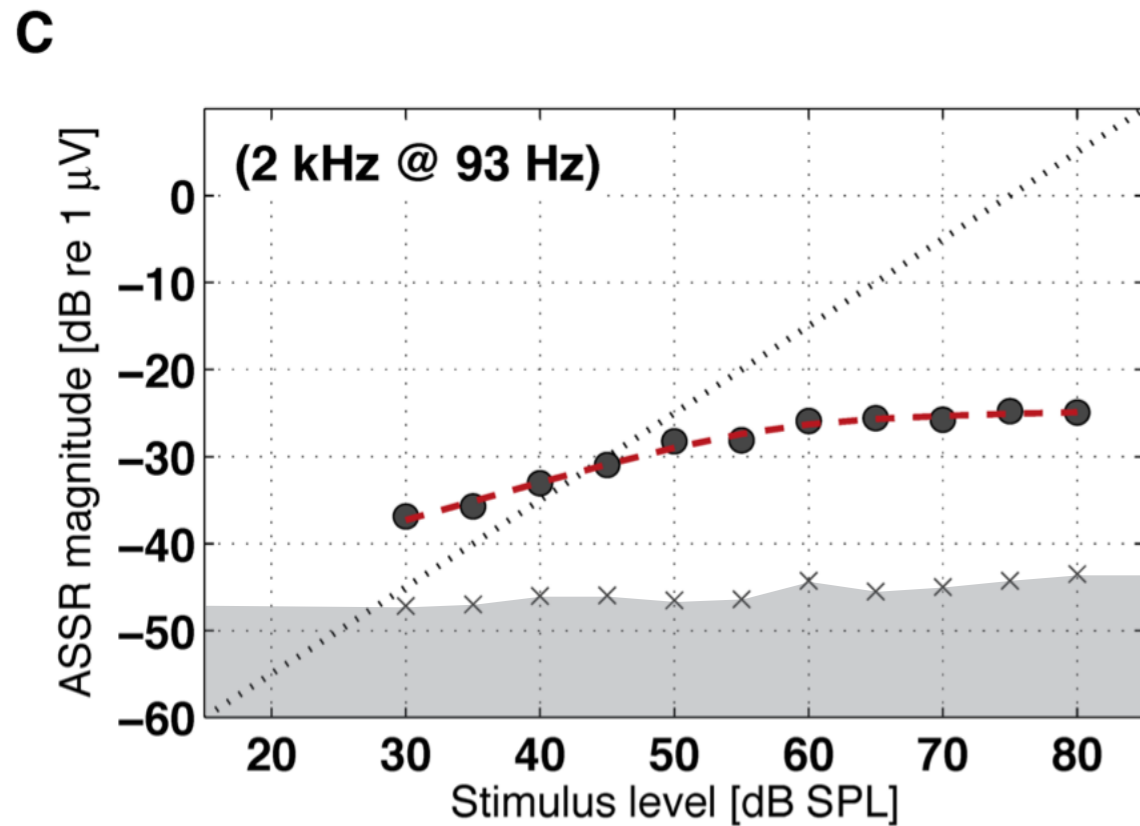
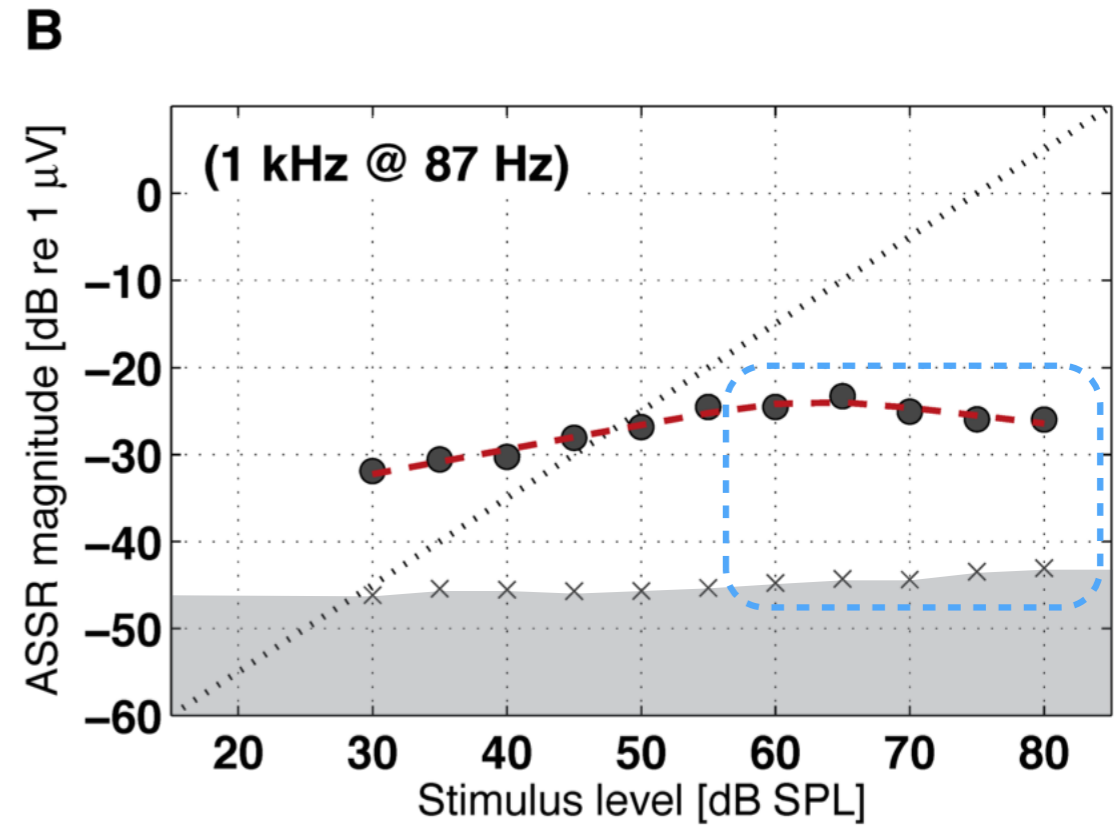
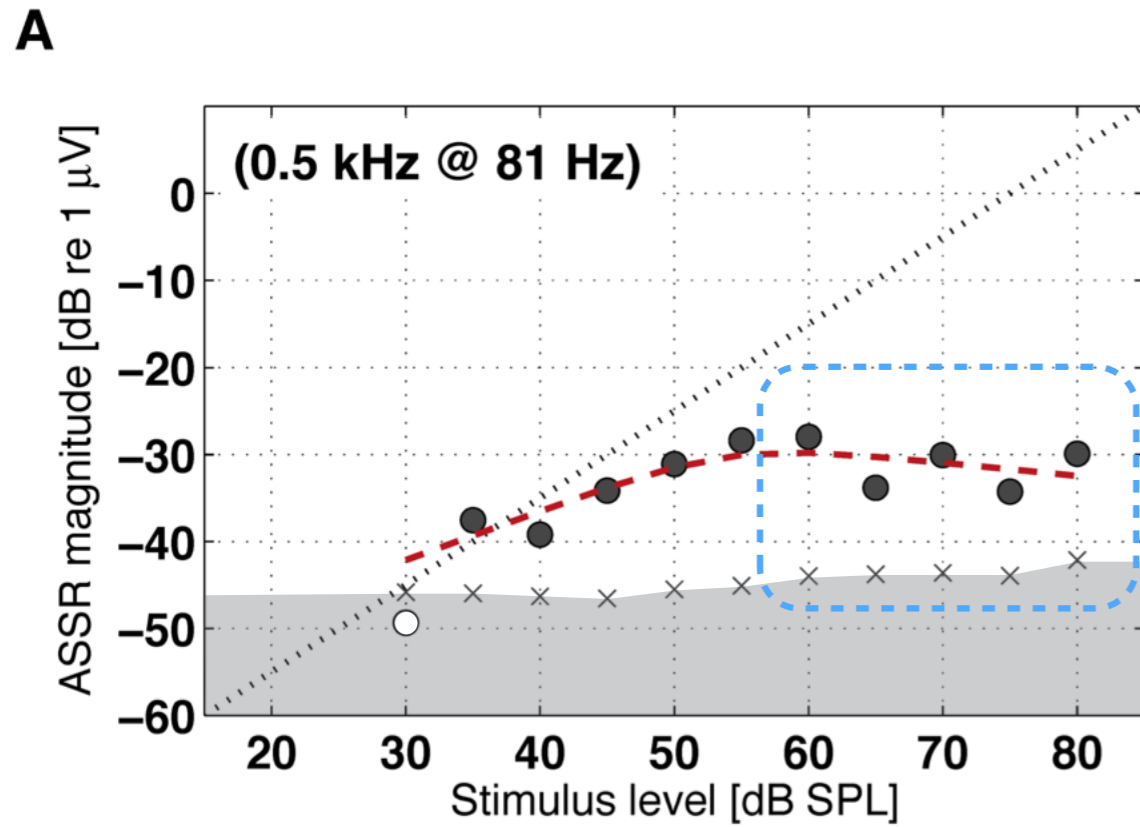
NH

D



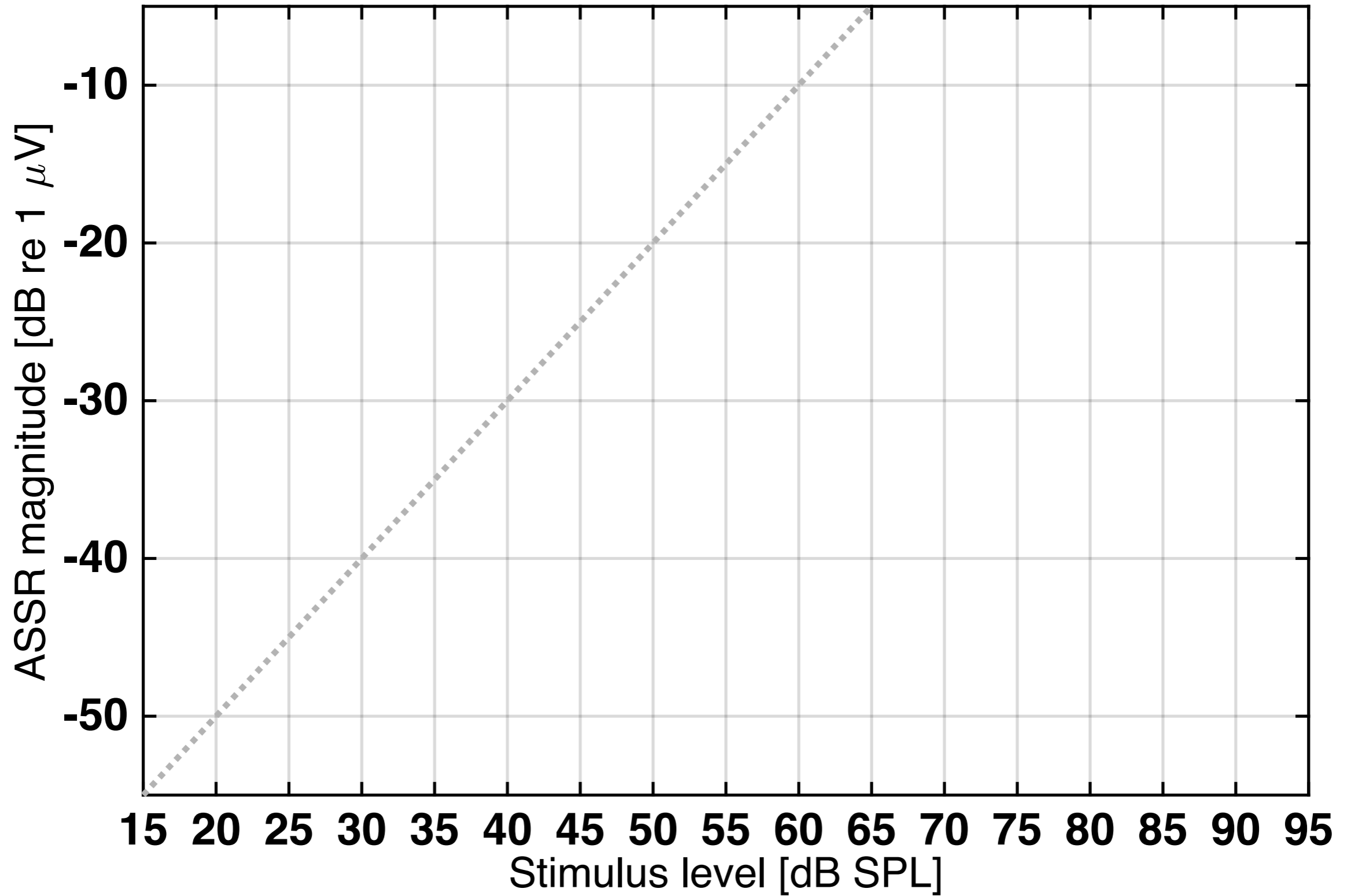
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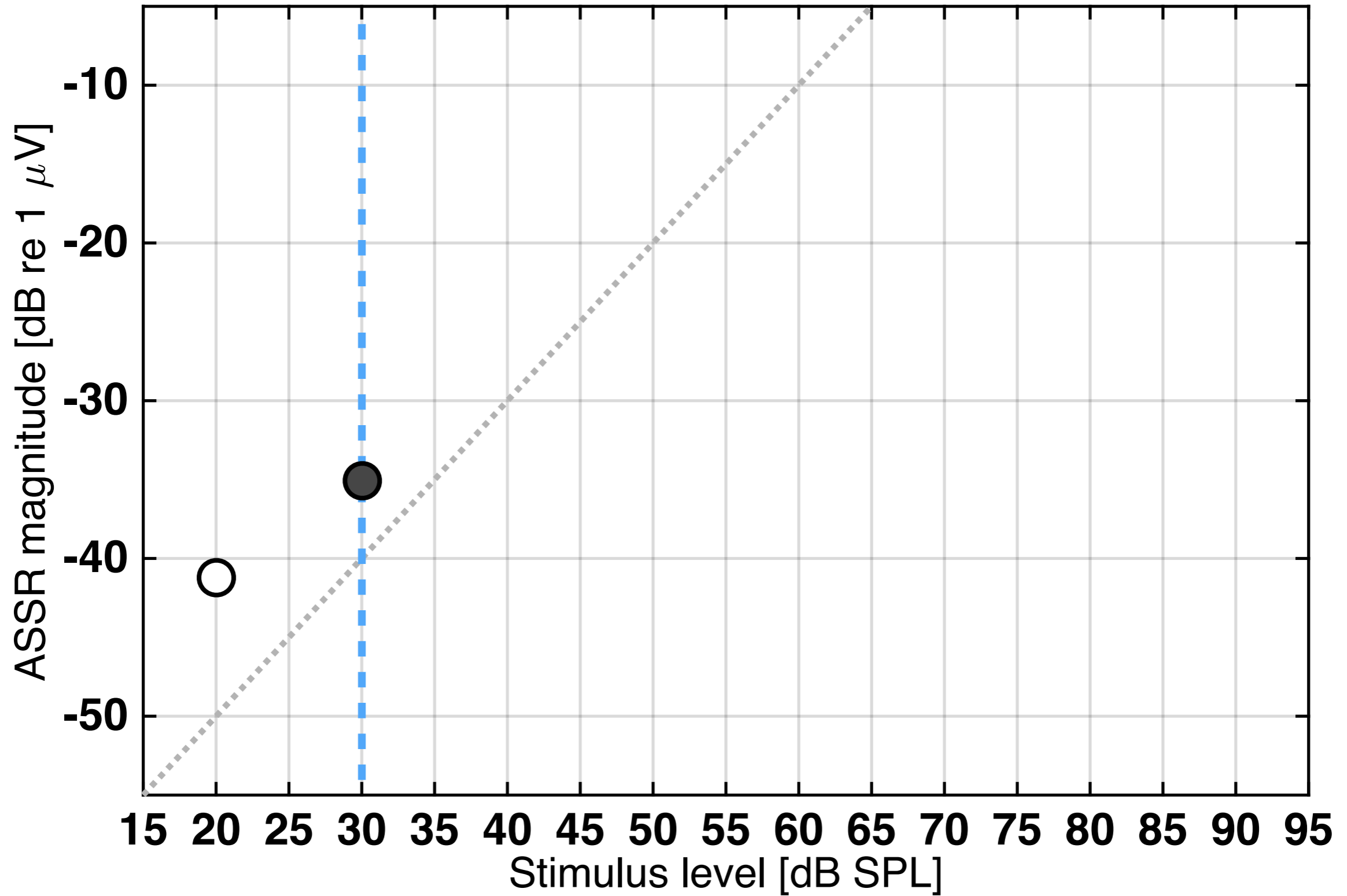


Intermediate summary

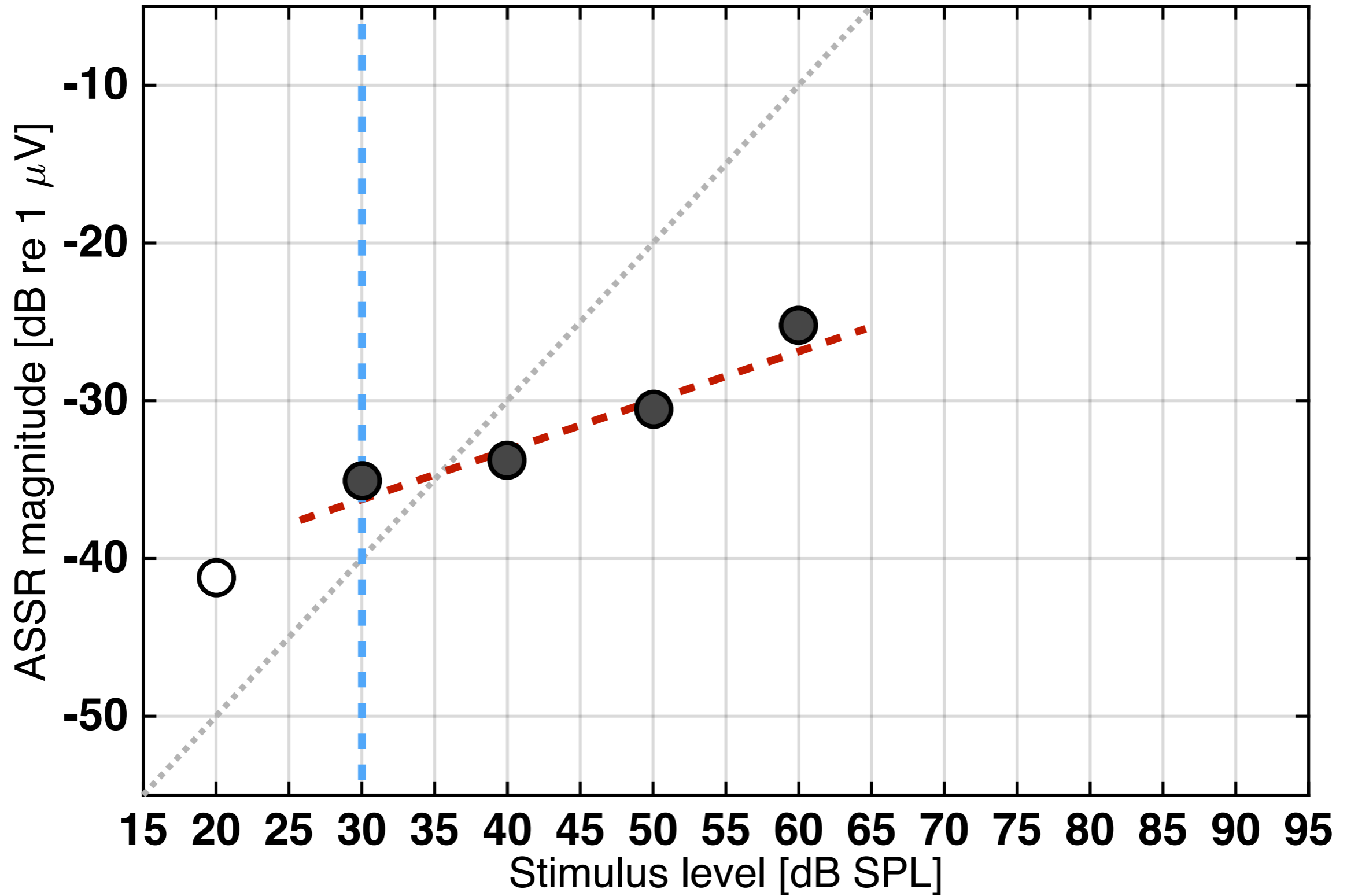
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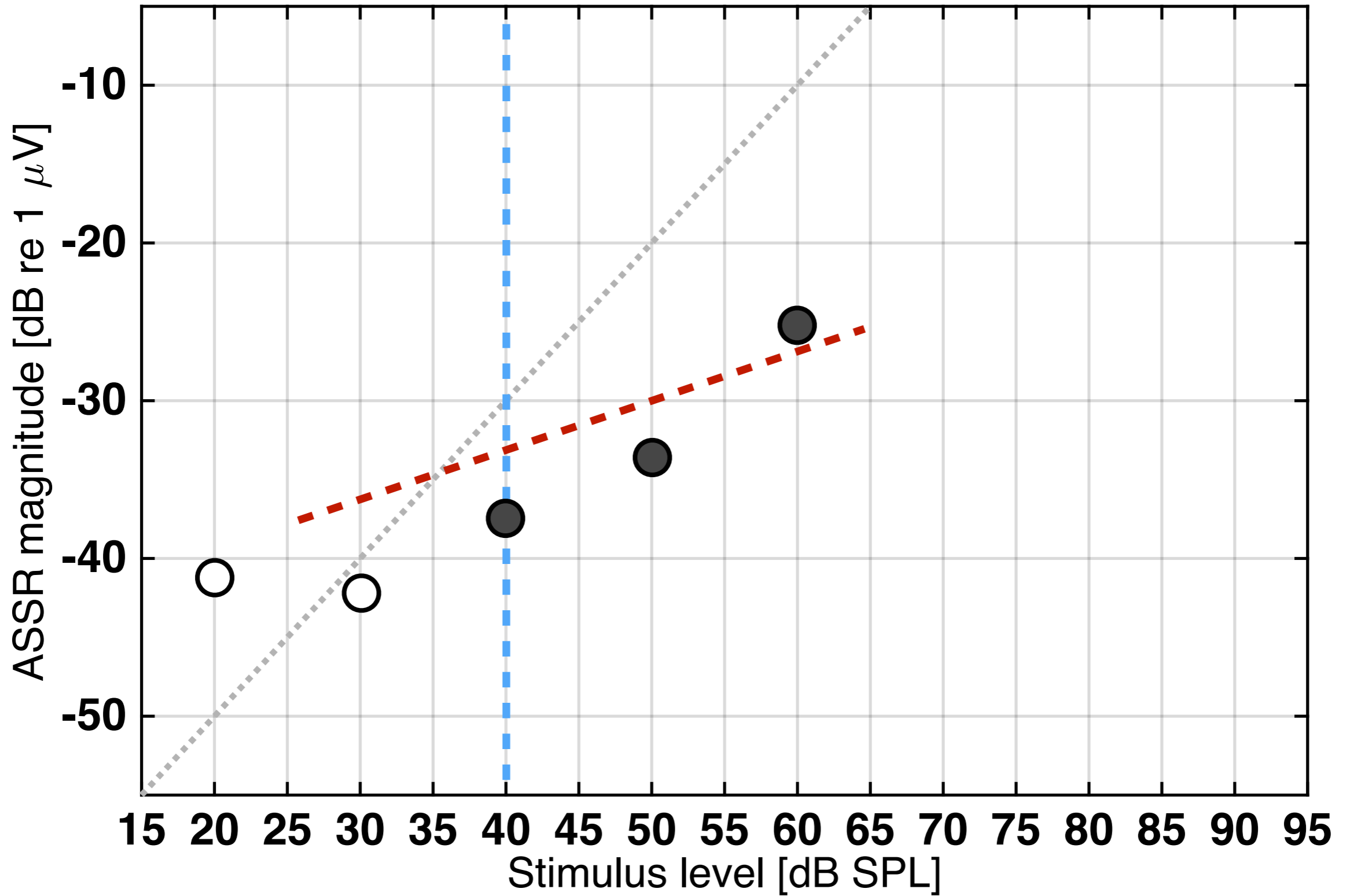
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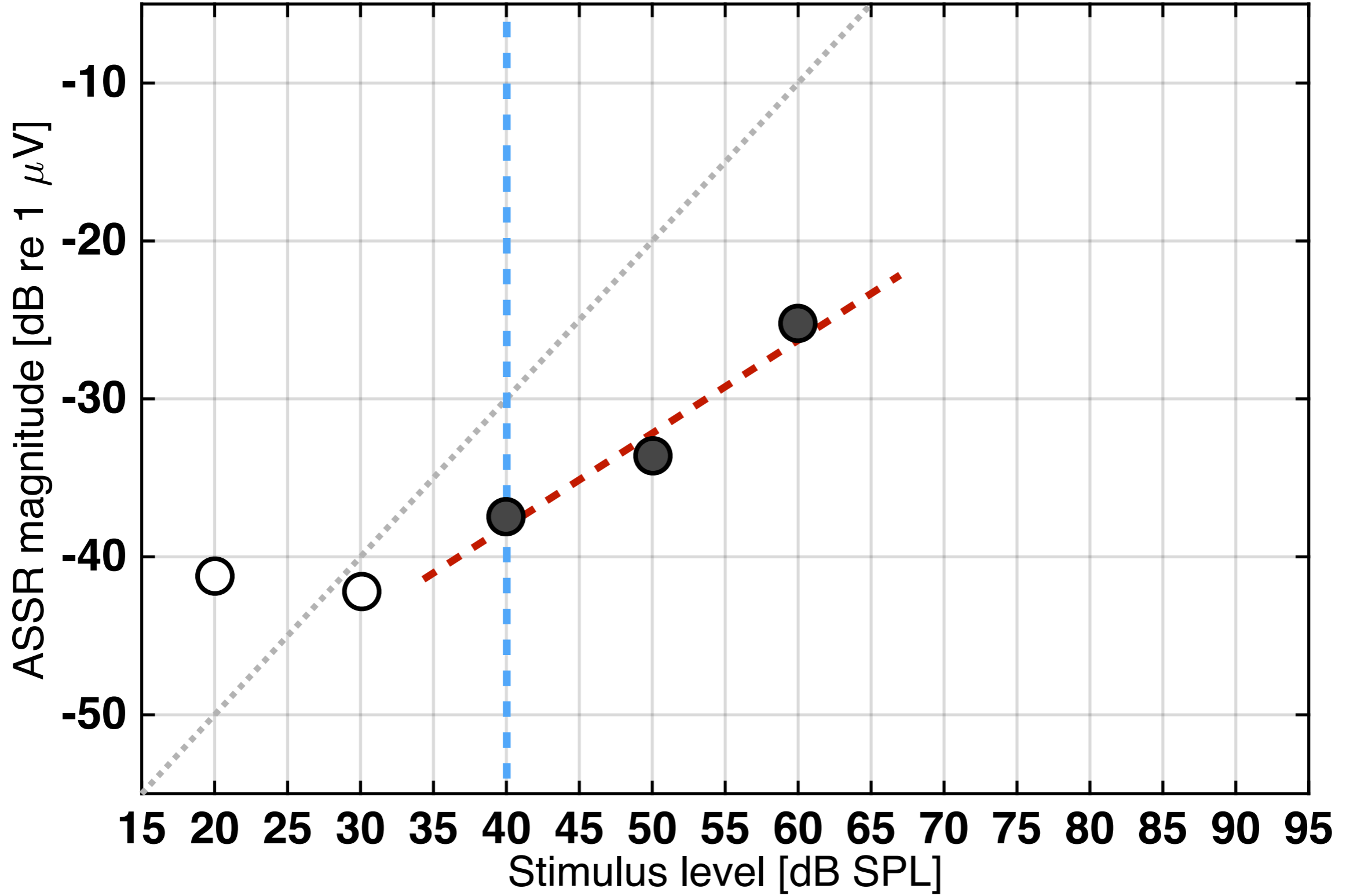
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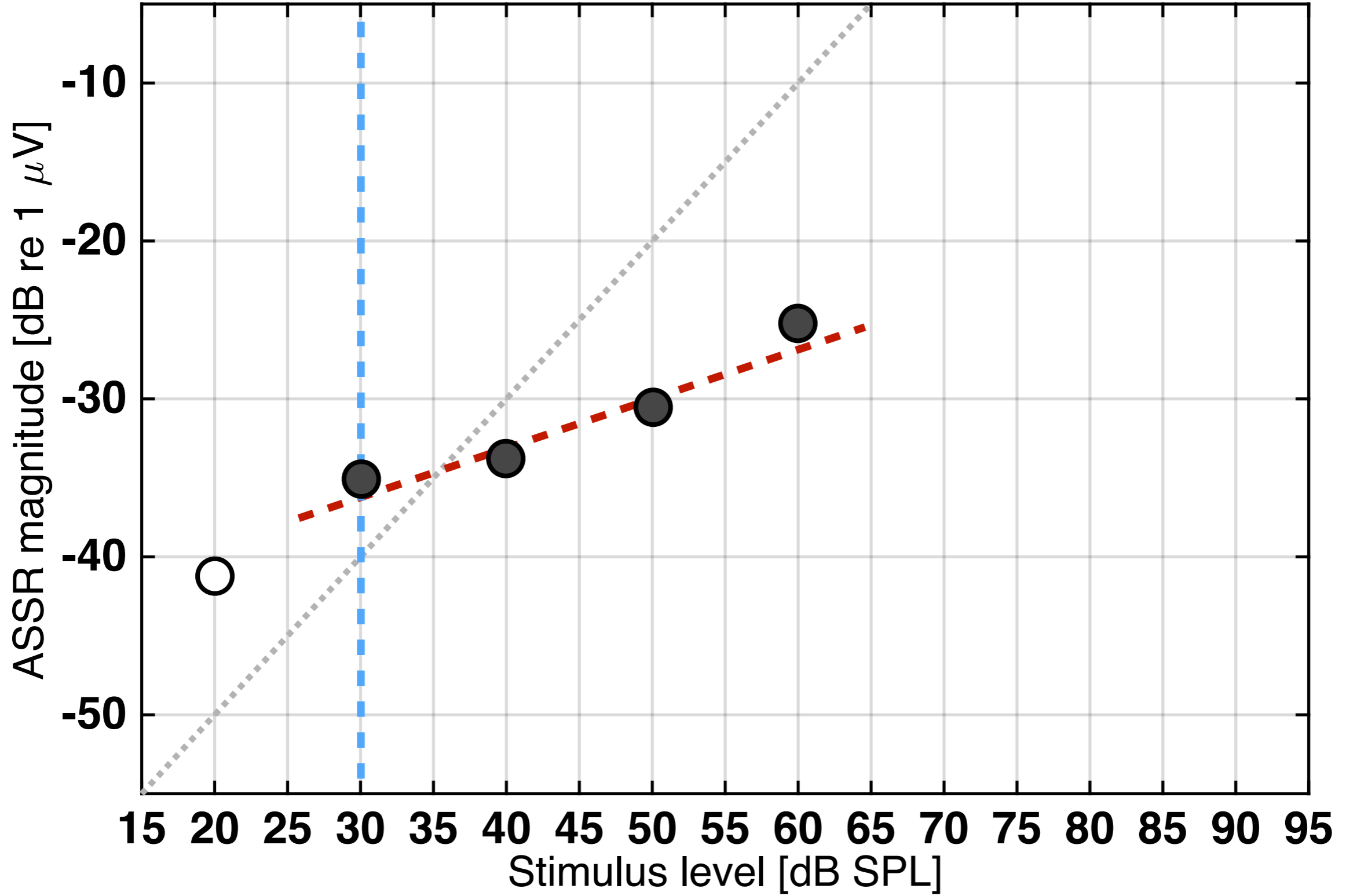
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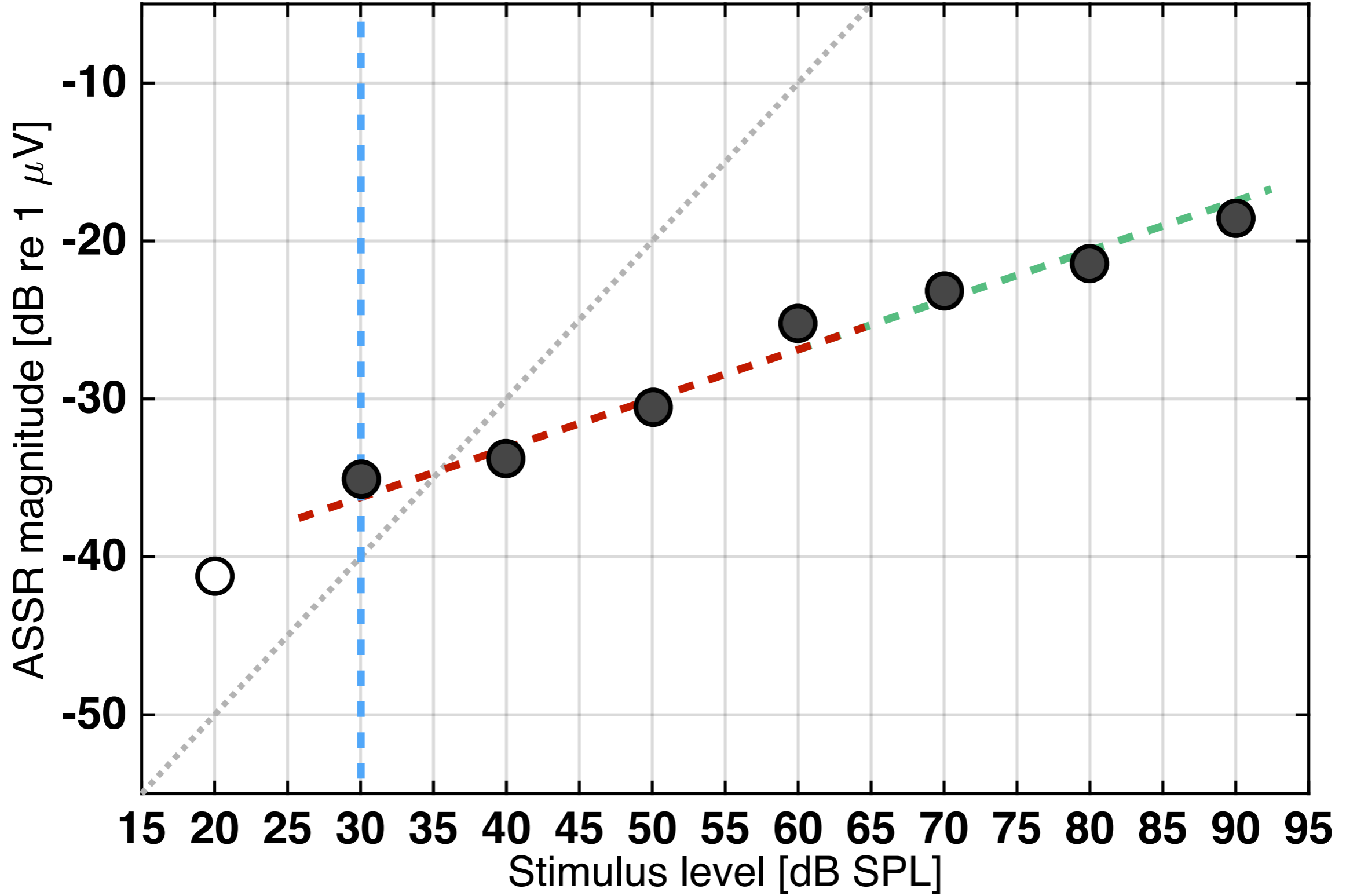
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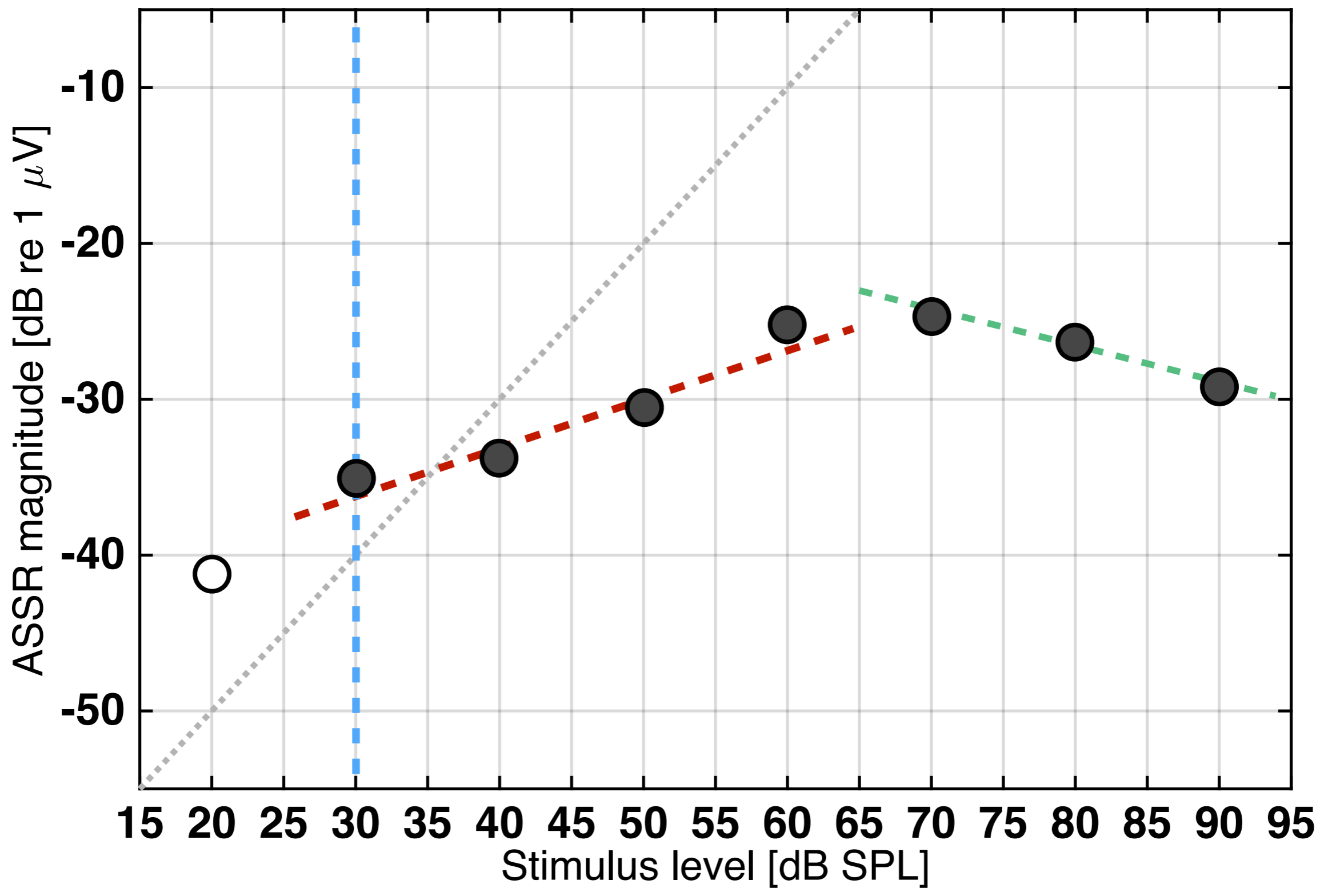
Intermediate summary



Intermediate summary



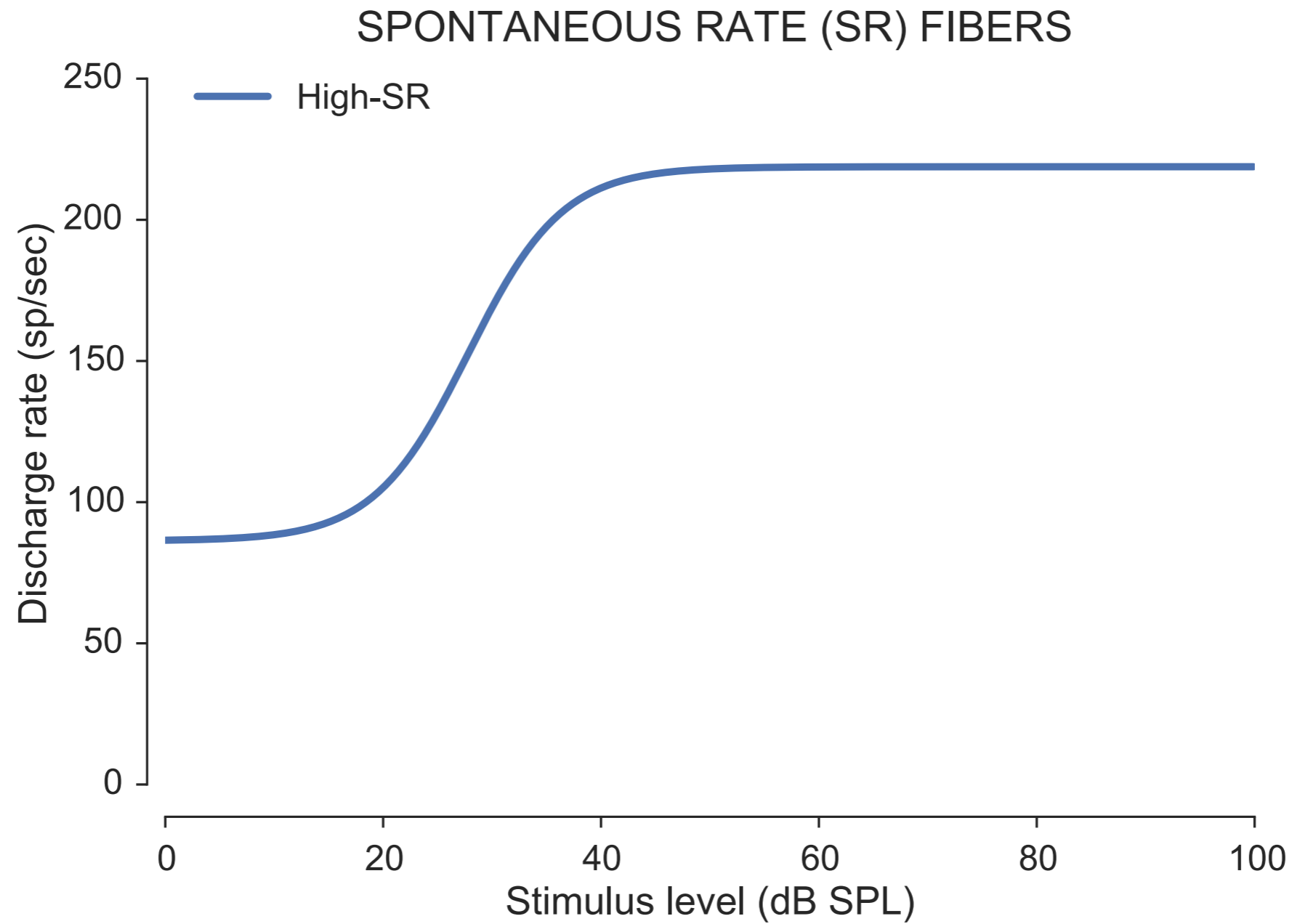
Intermediate summary



Contribution of SR fibers to deafferentation

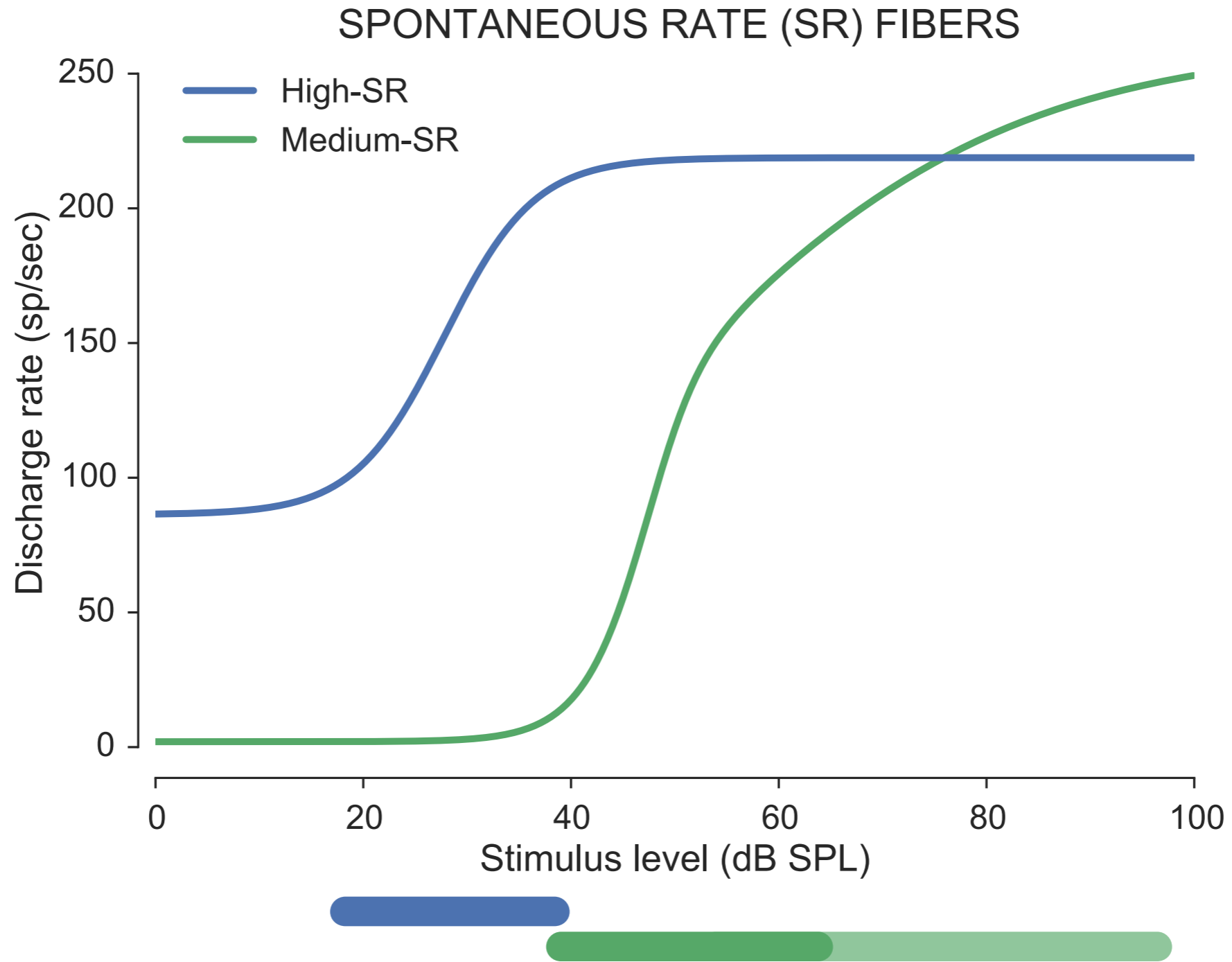
Lieberman (1978)

Yates (1990)



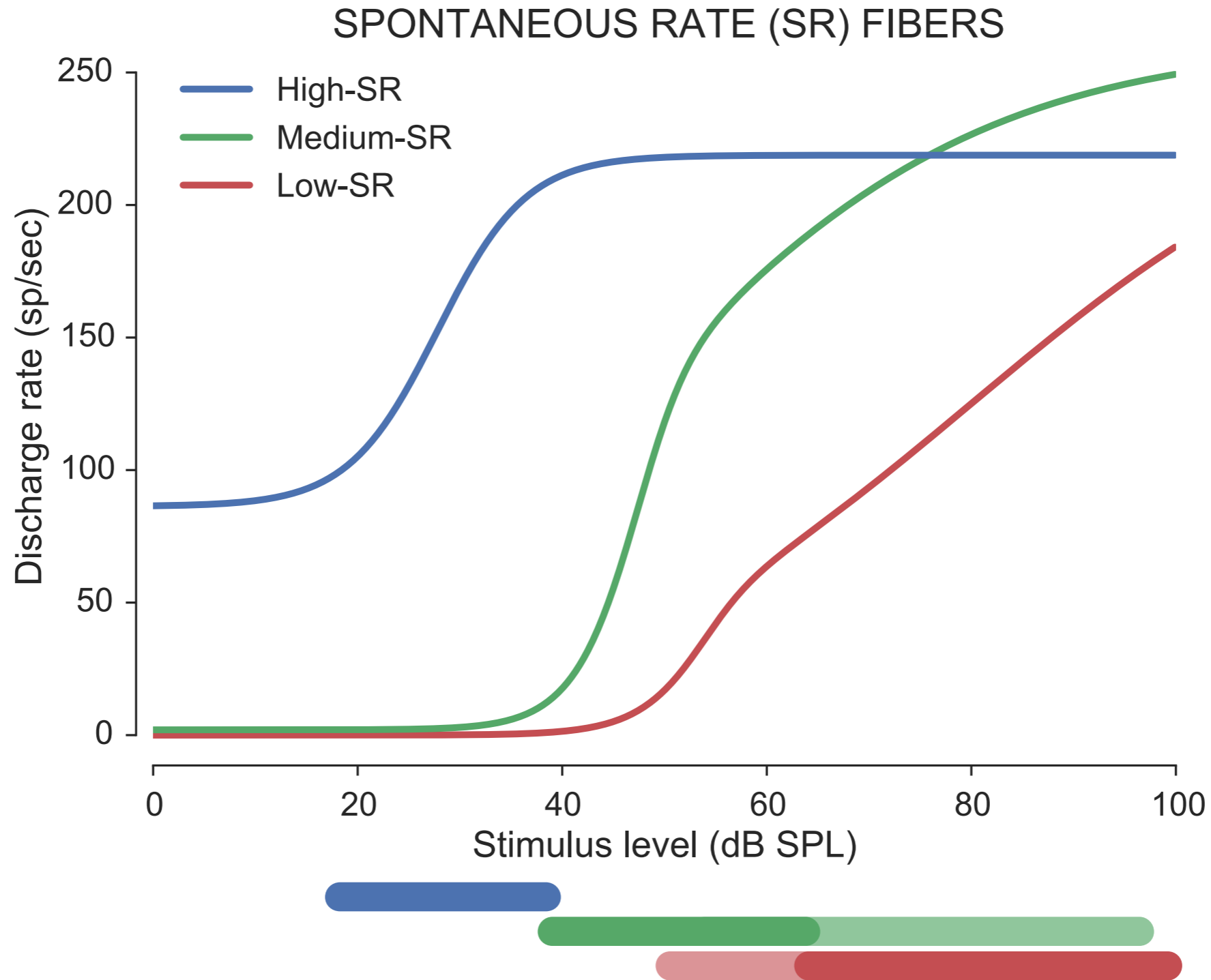
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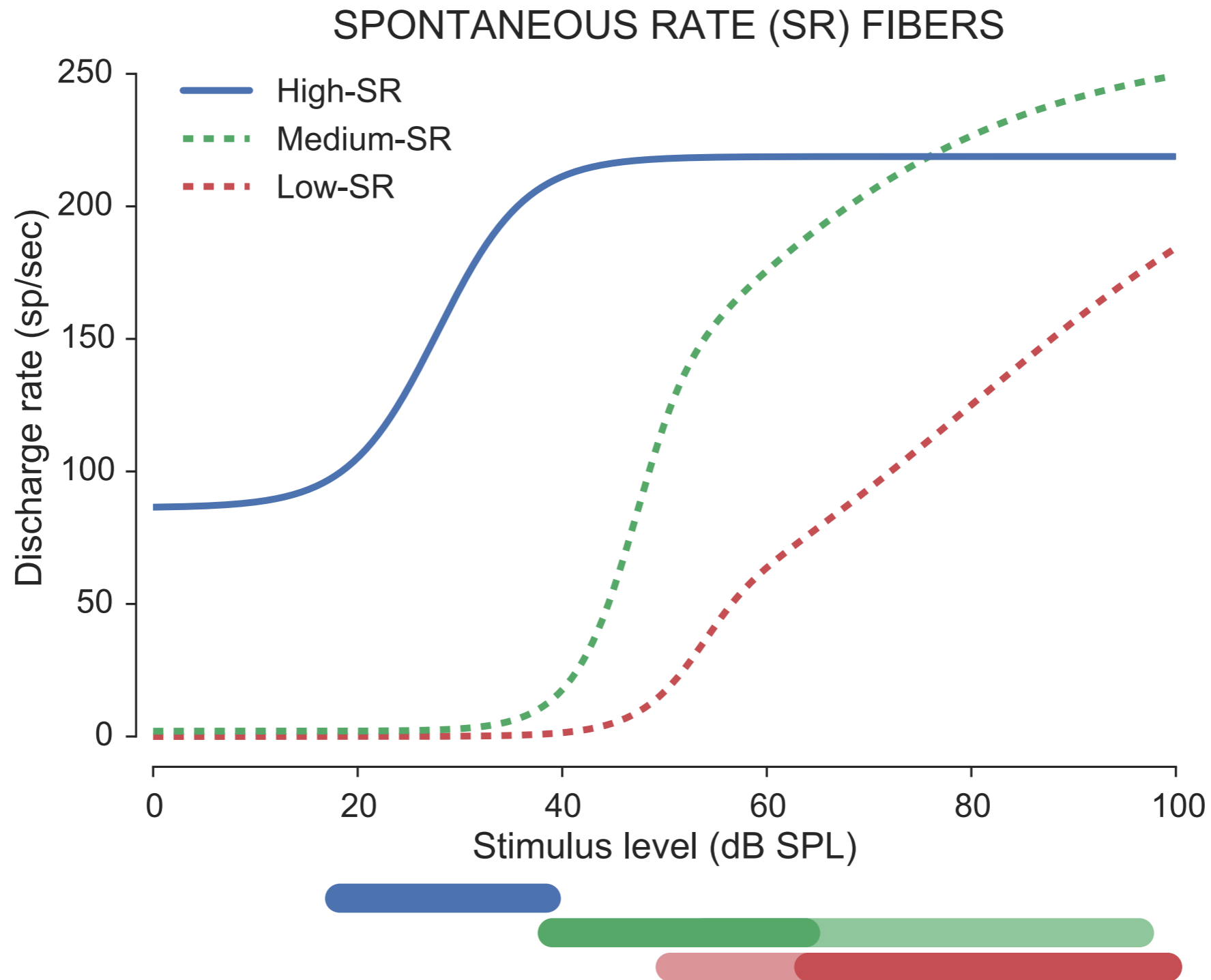
Lieberman (1978)

Yates (1990)



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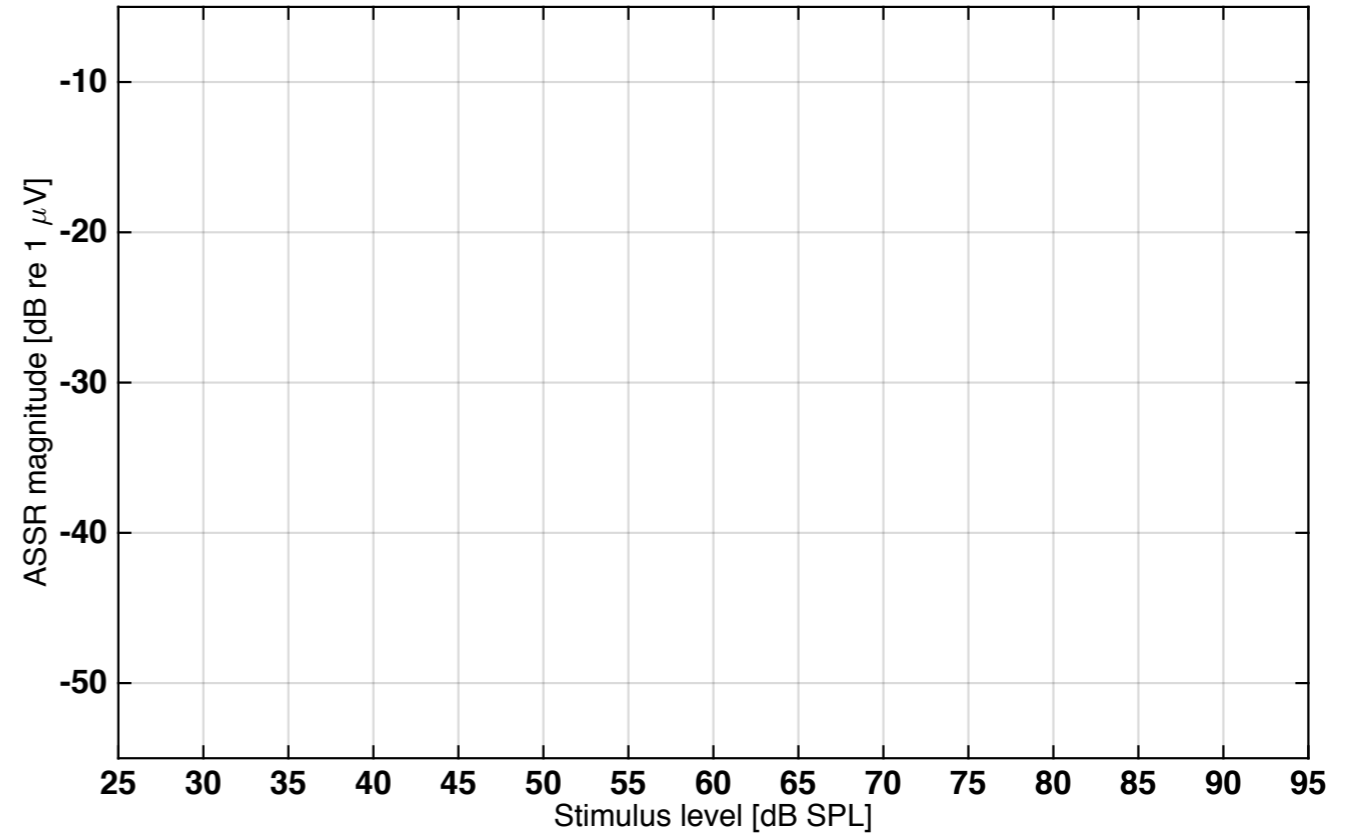
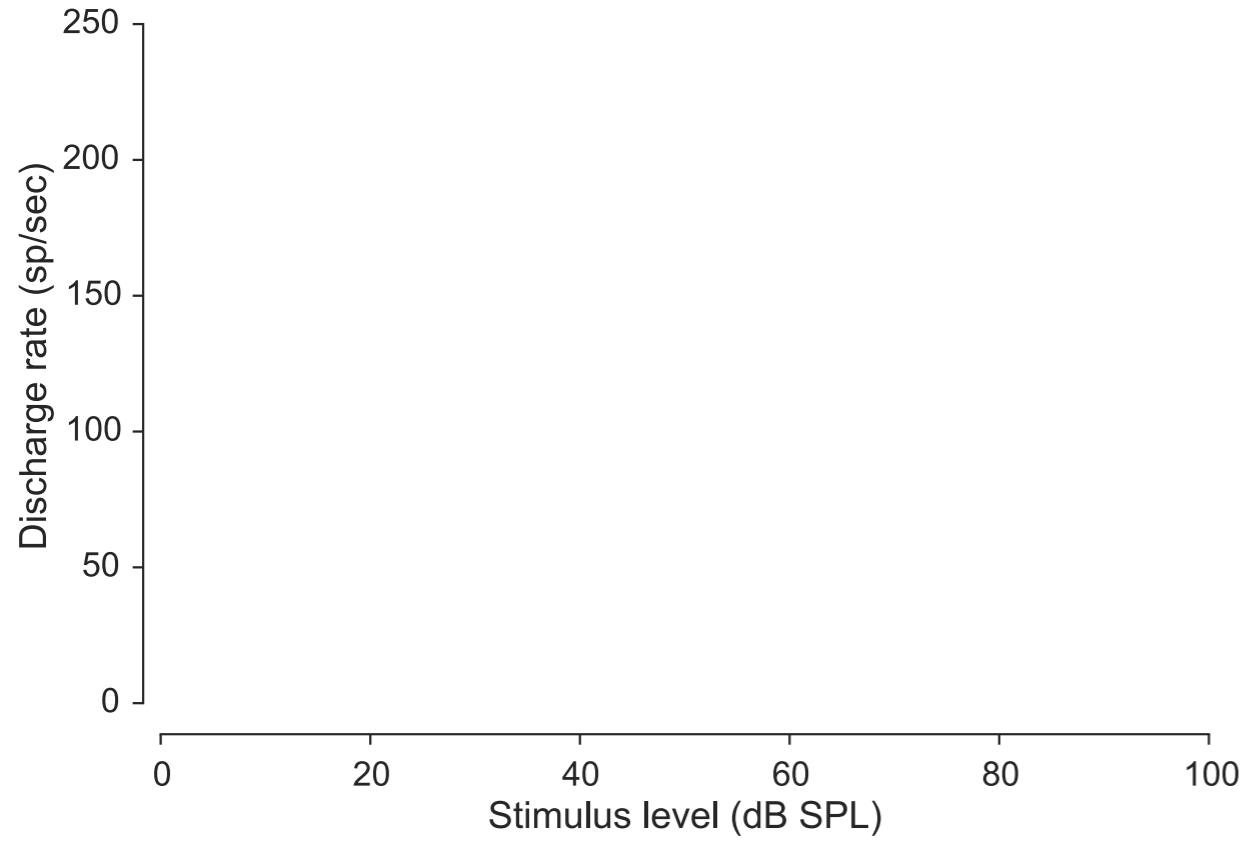
Yates (1990)



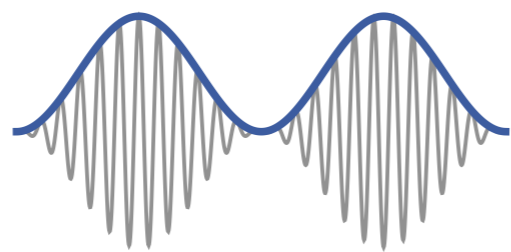
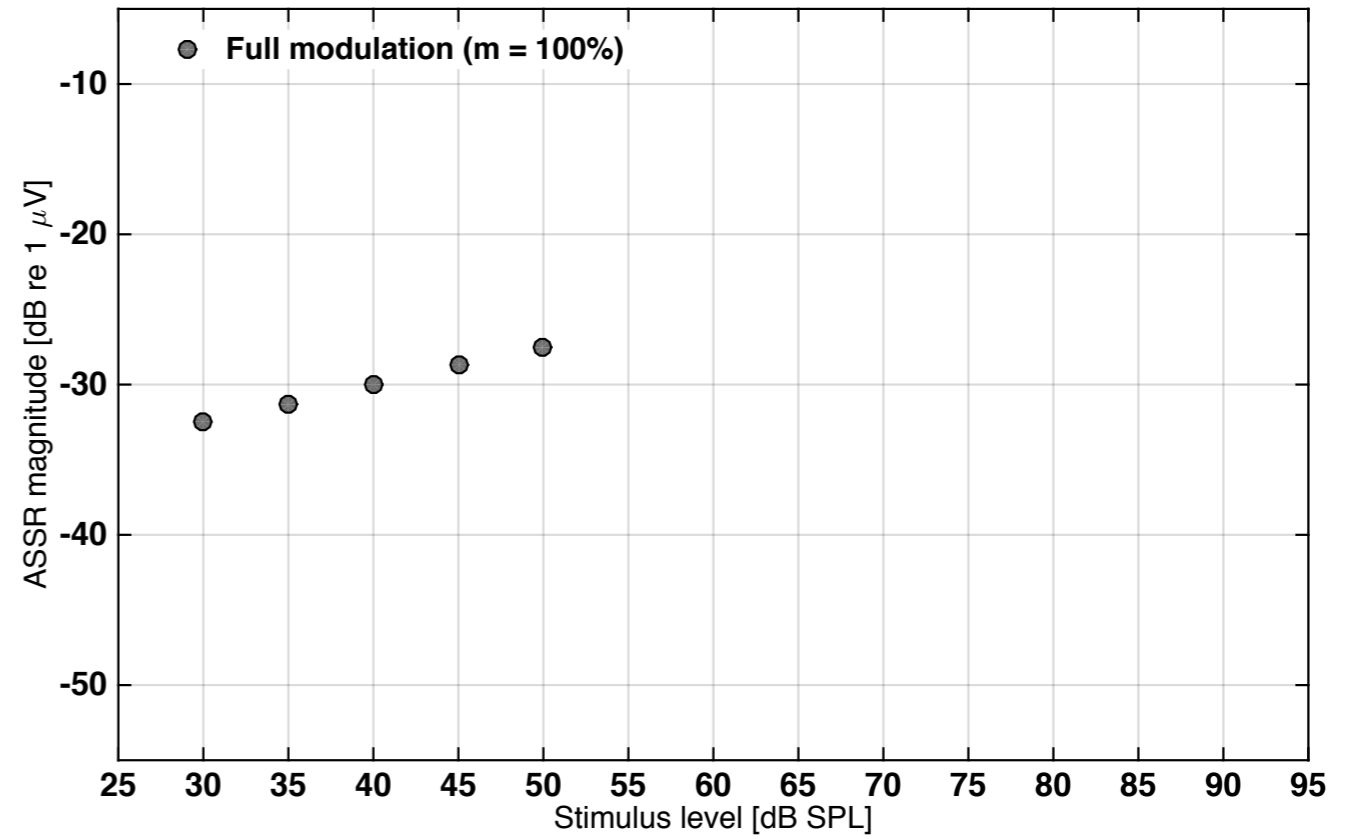
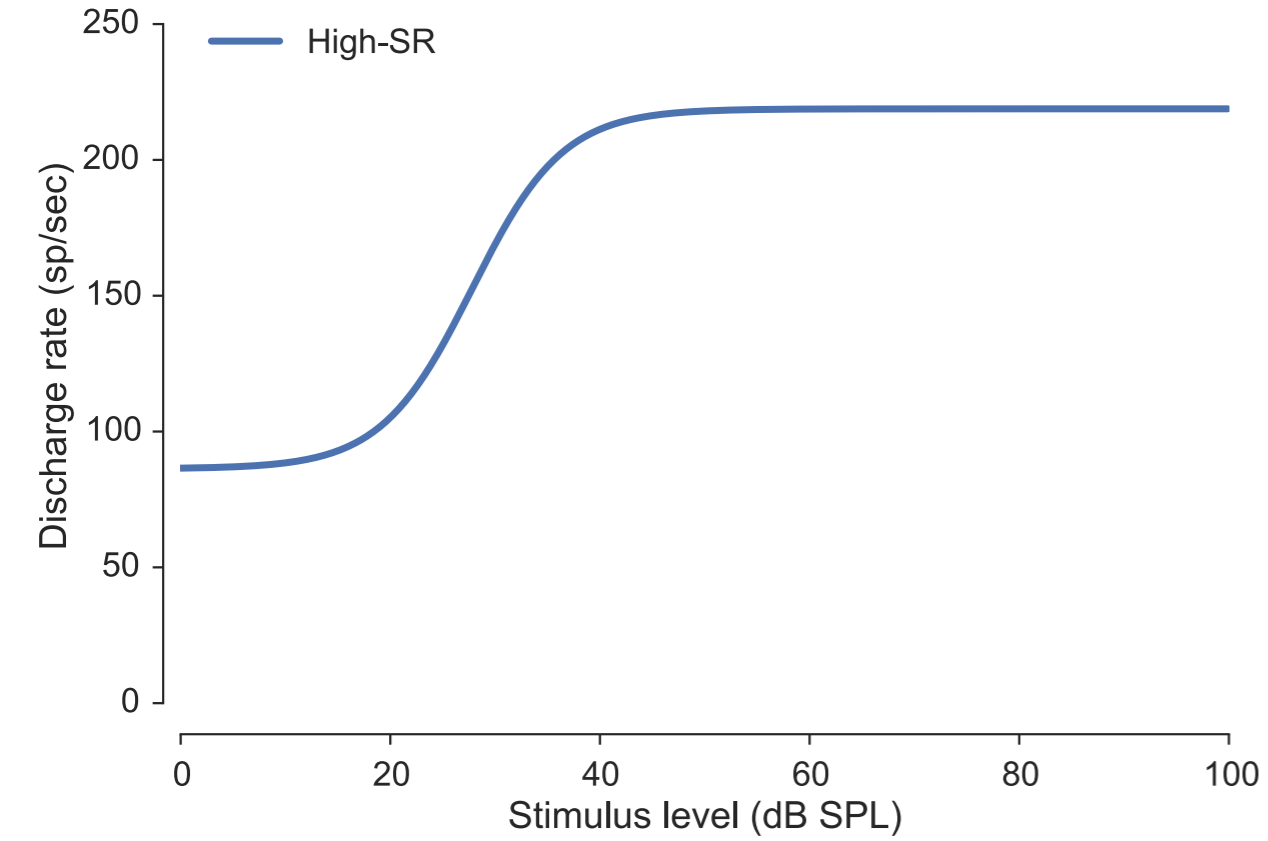
- Furman *et al.* (2013) showed that ANF “**deafferentation**” due to noise over-exposure is more **selective** to **medium-** and **low-SR fibers**

Potential explanation

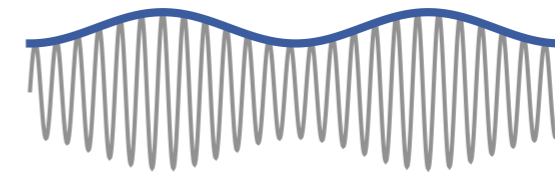
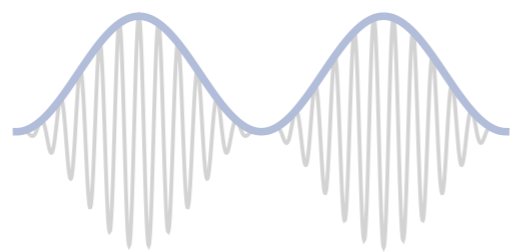
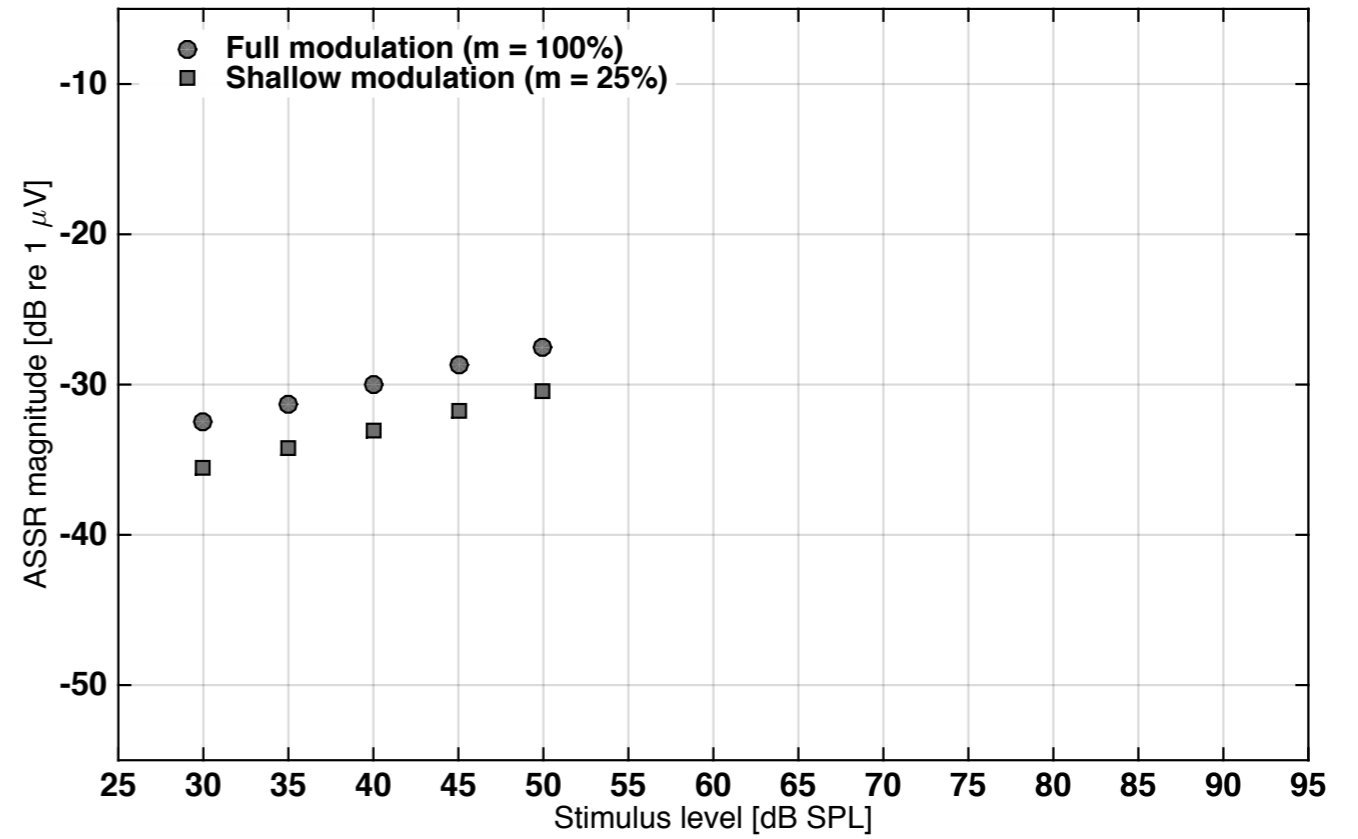
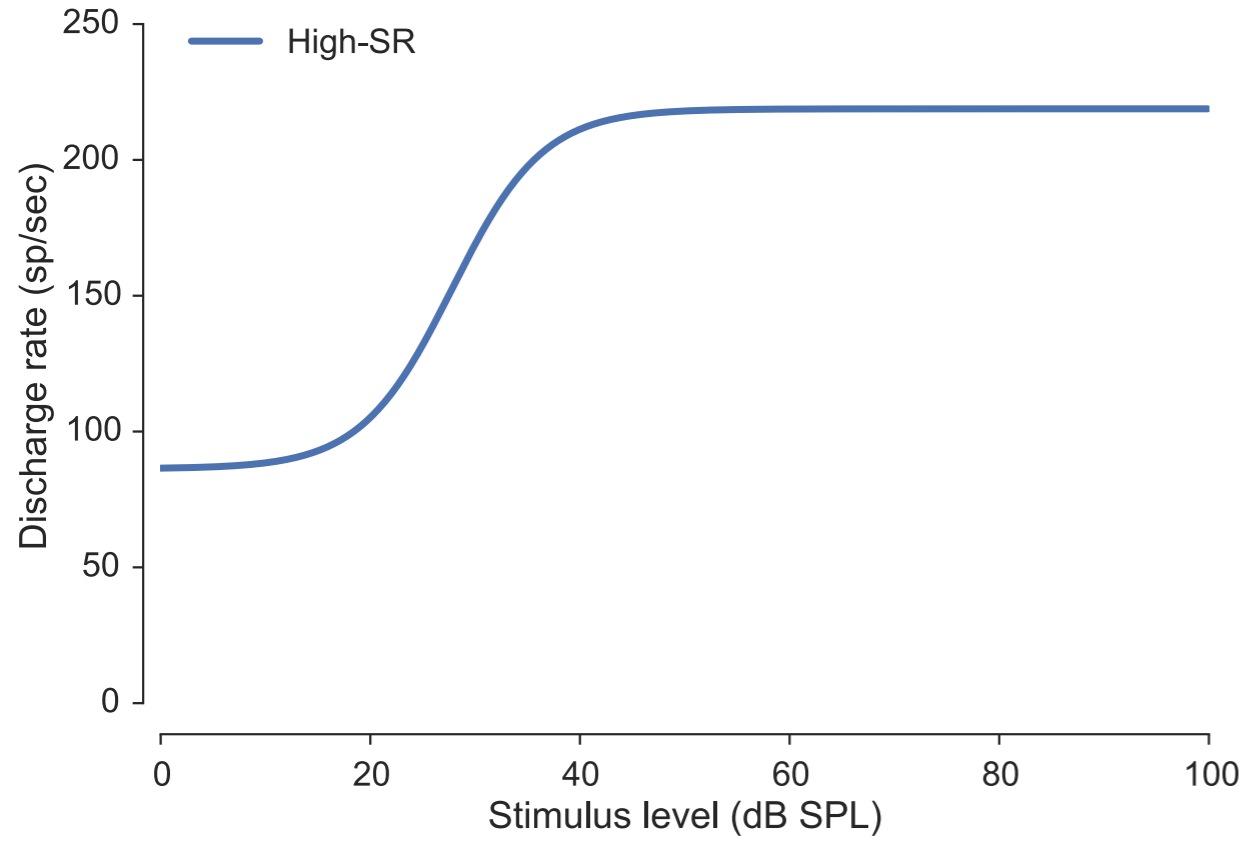
Potential explanation



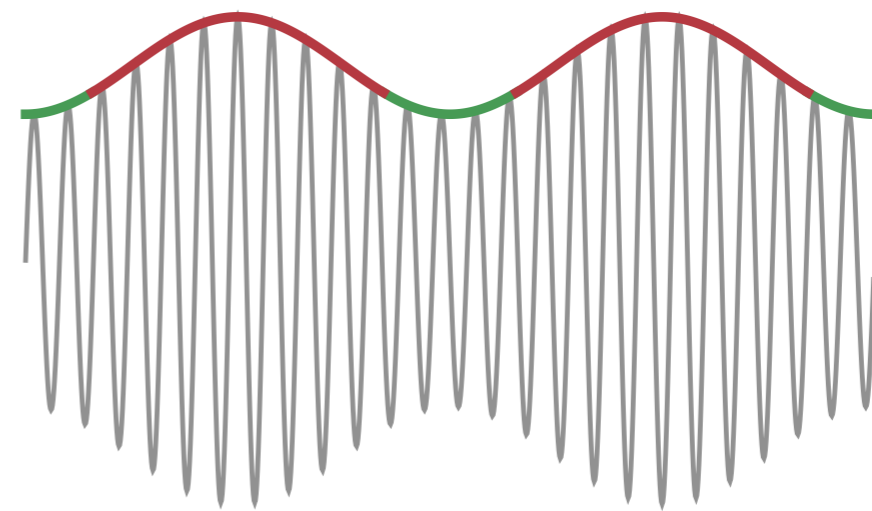
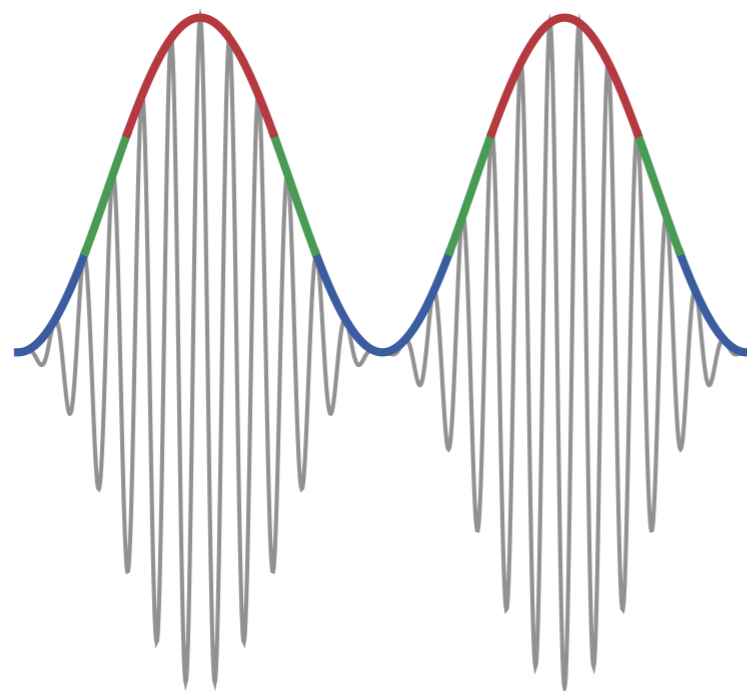
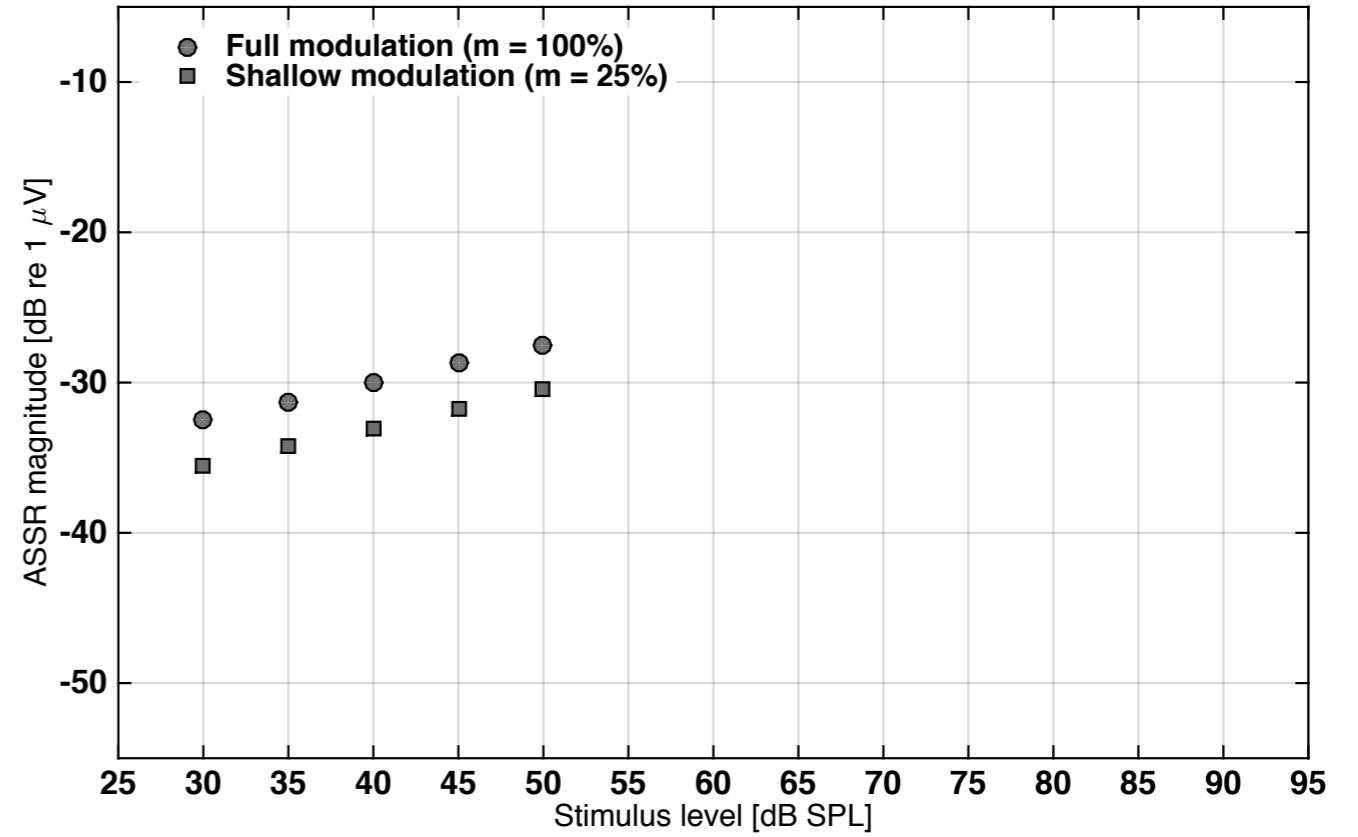
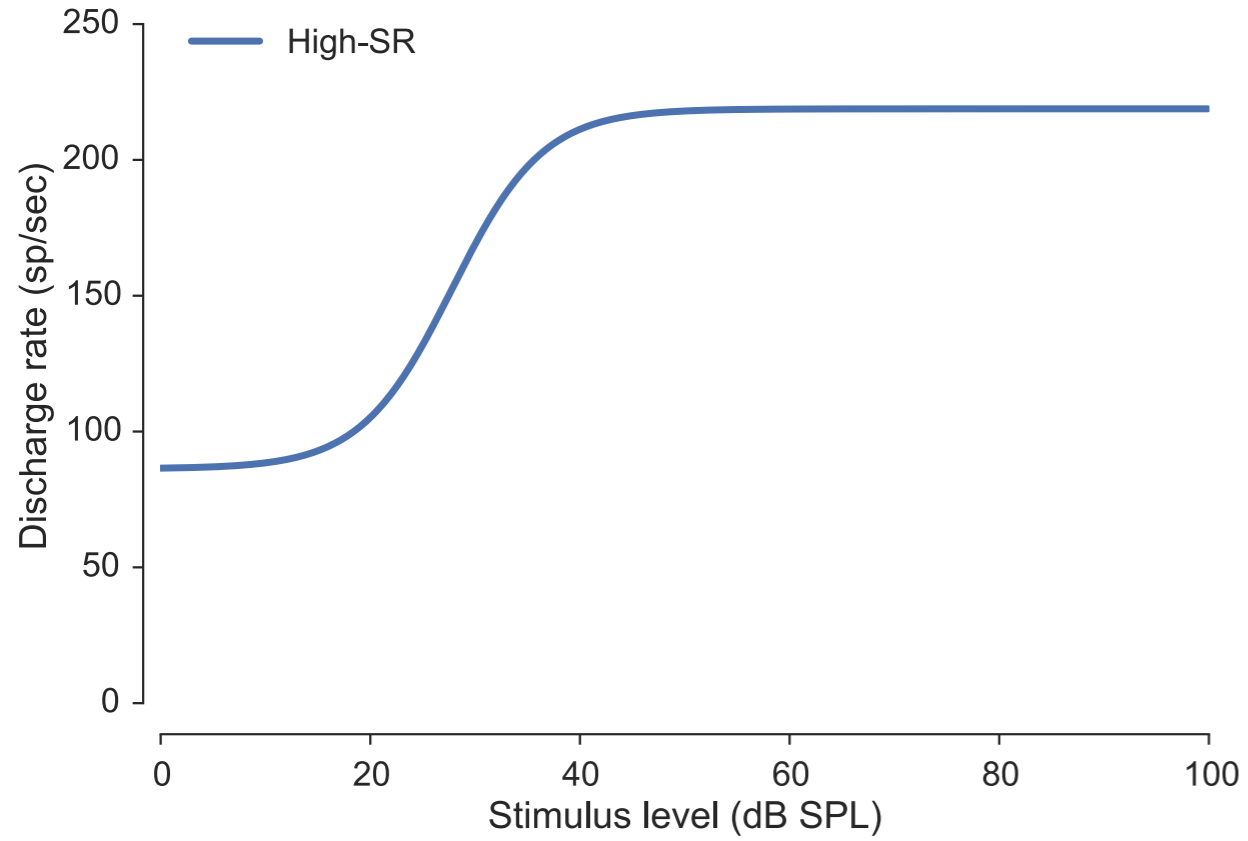
Potential explanation



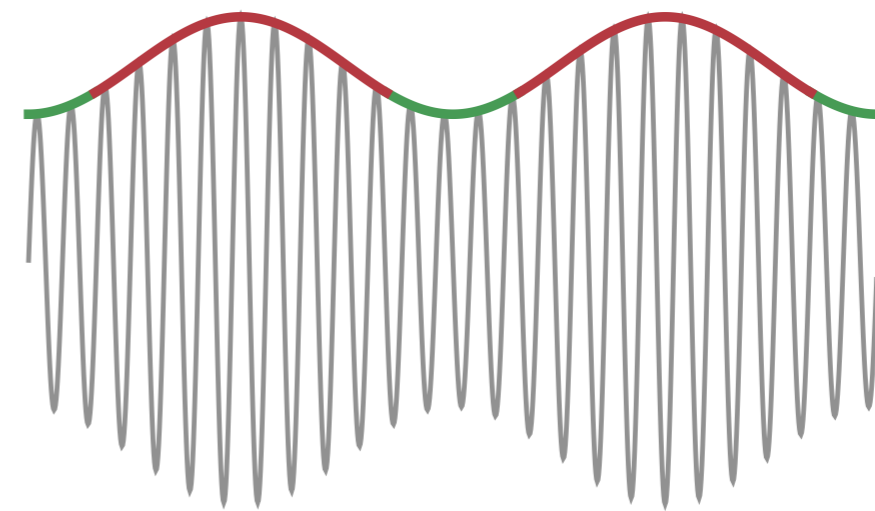
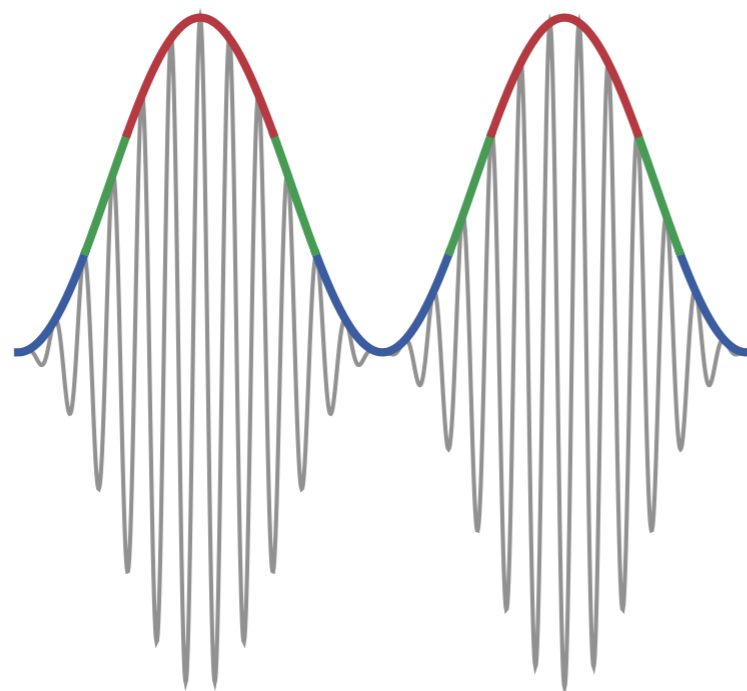
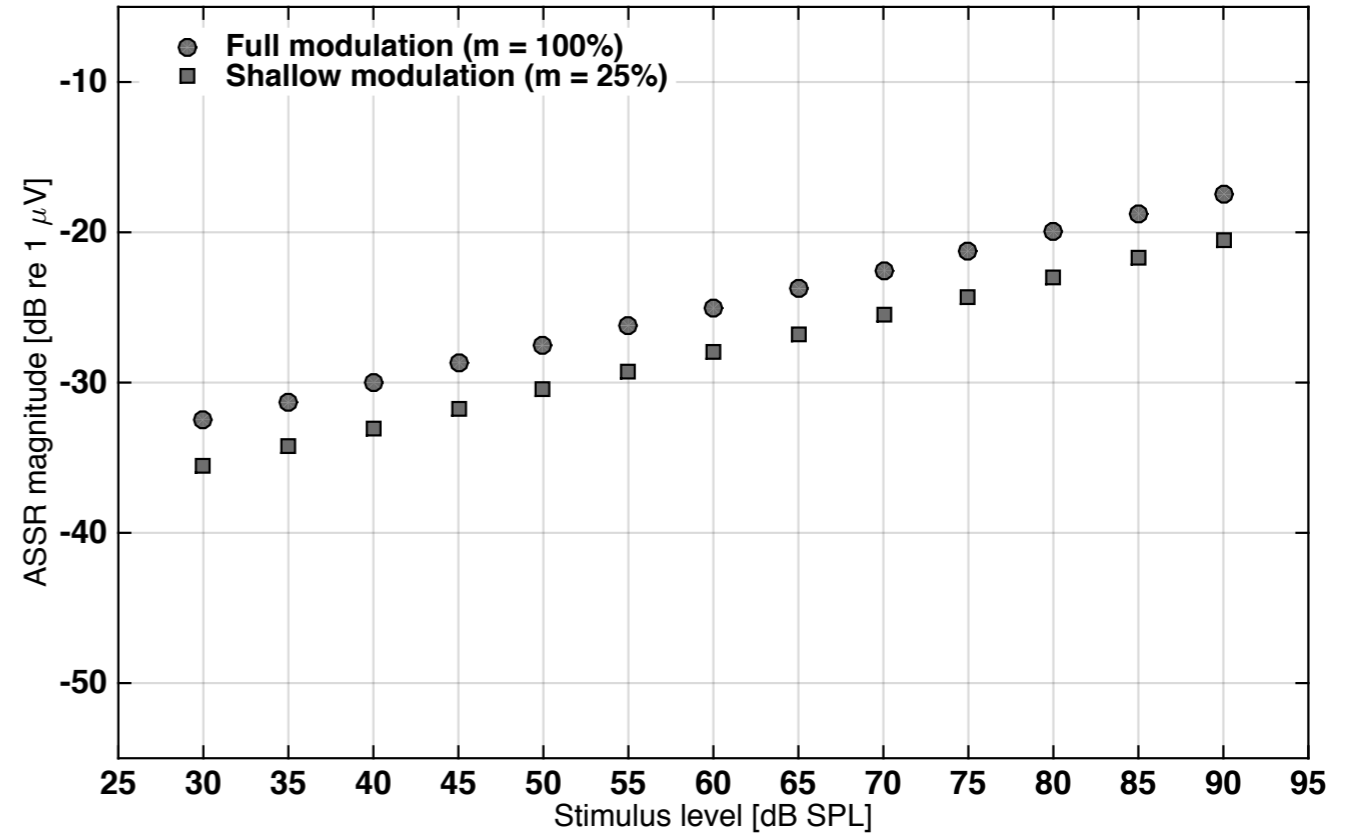
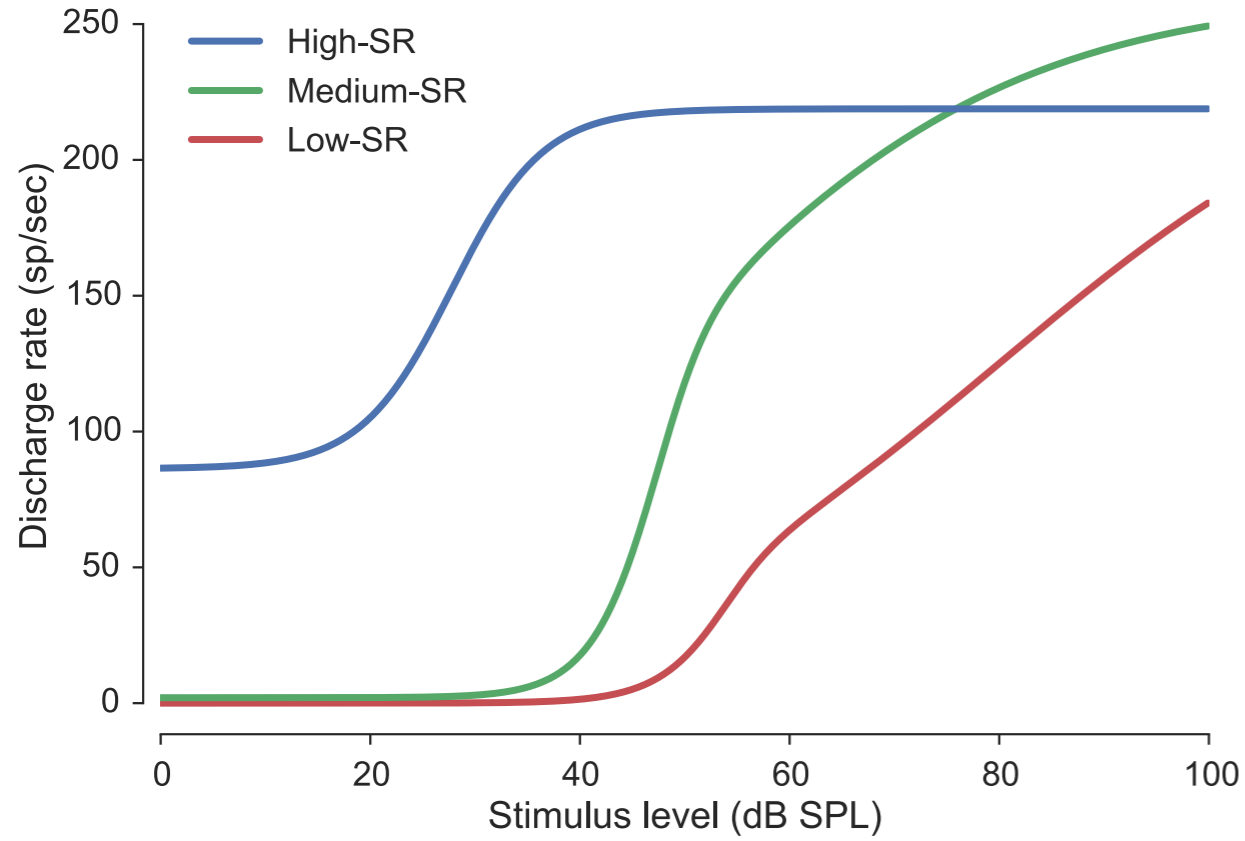
Potential explanation



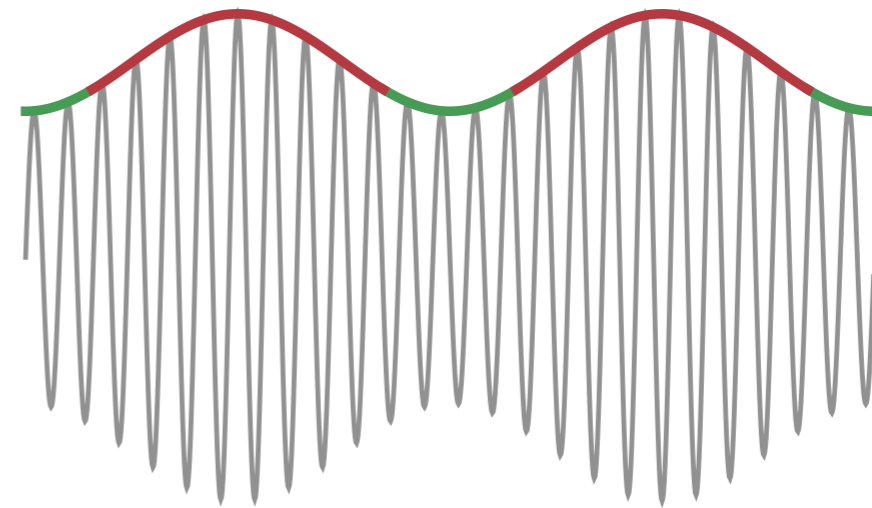
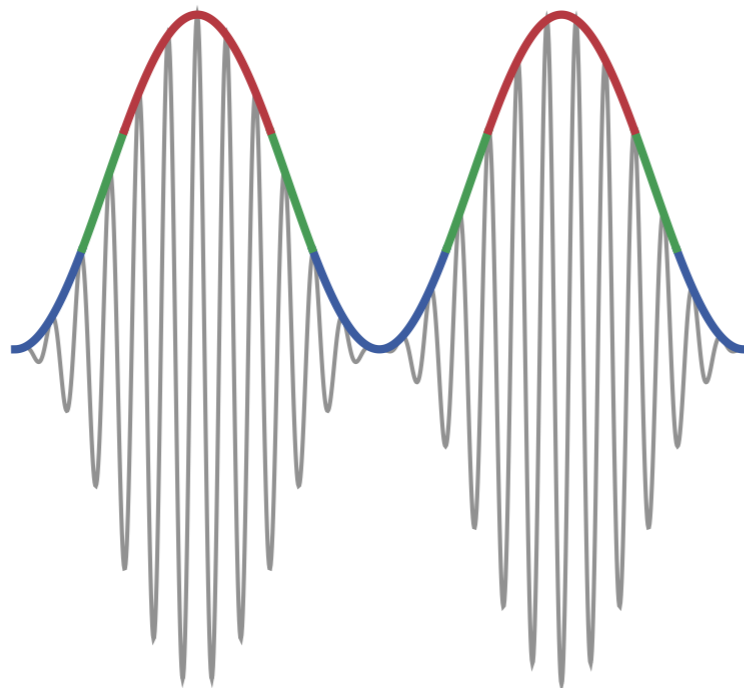
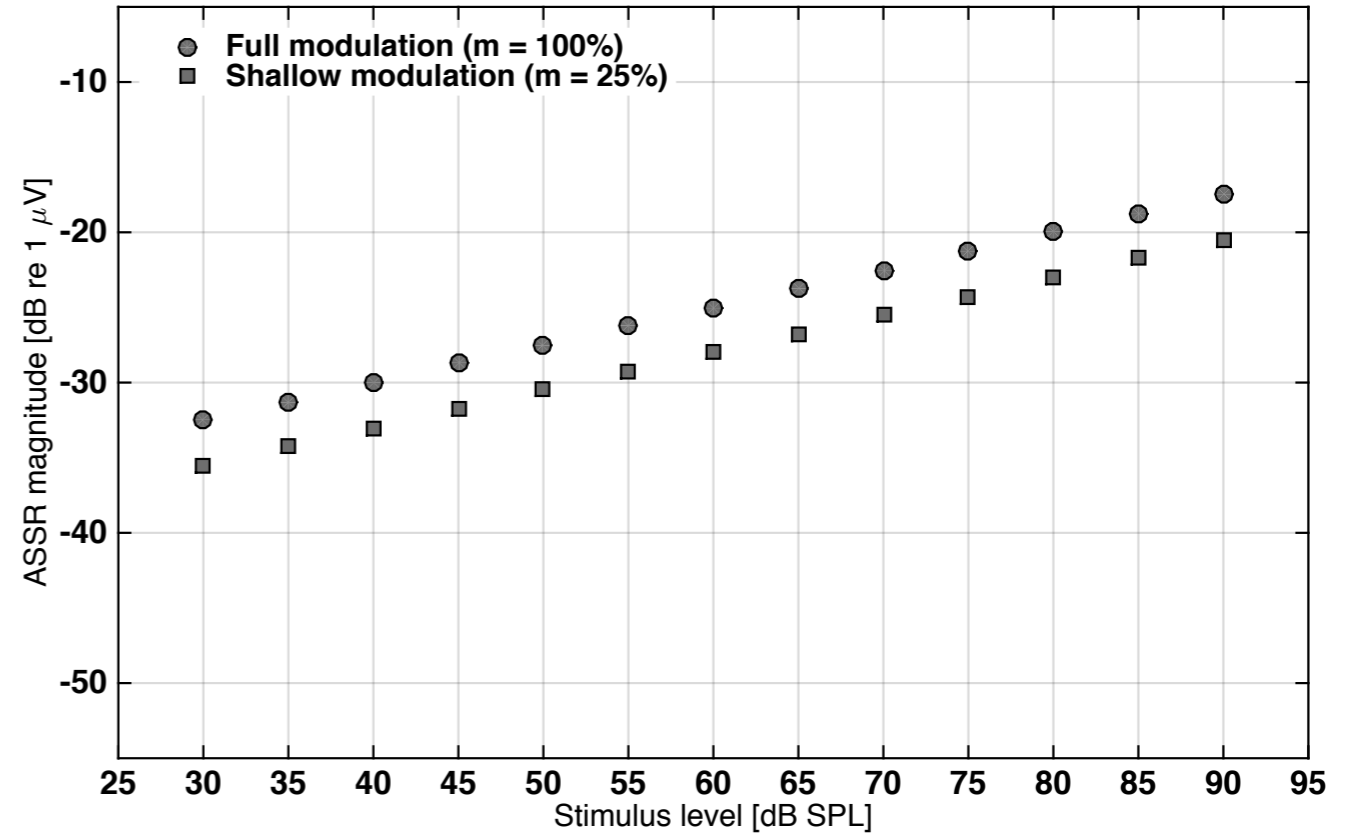
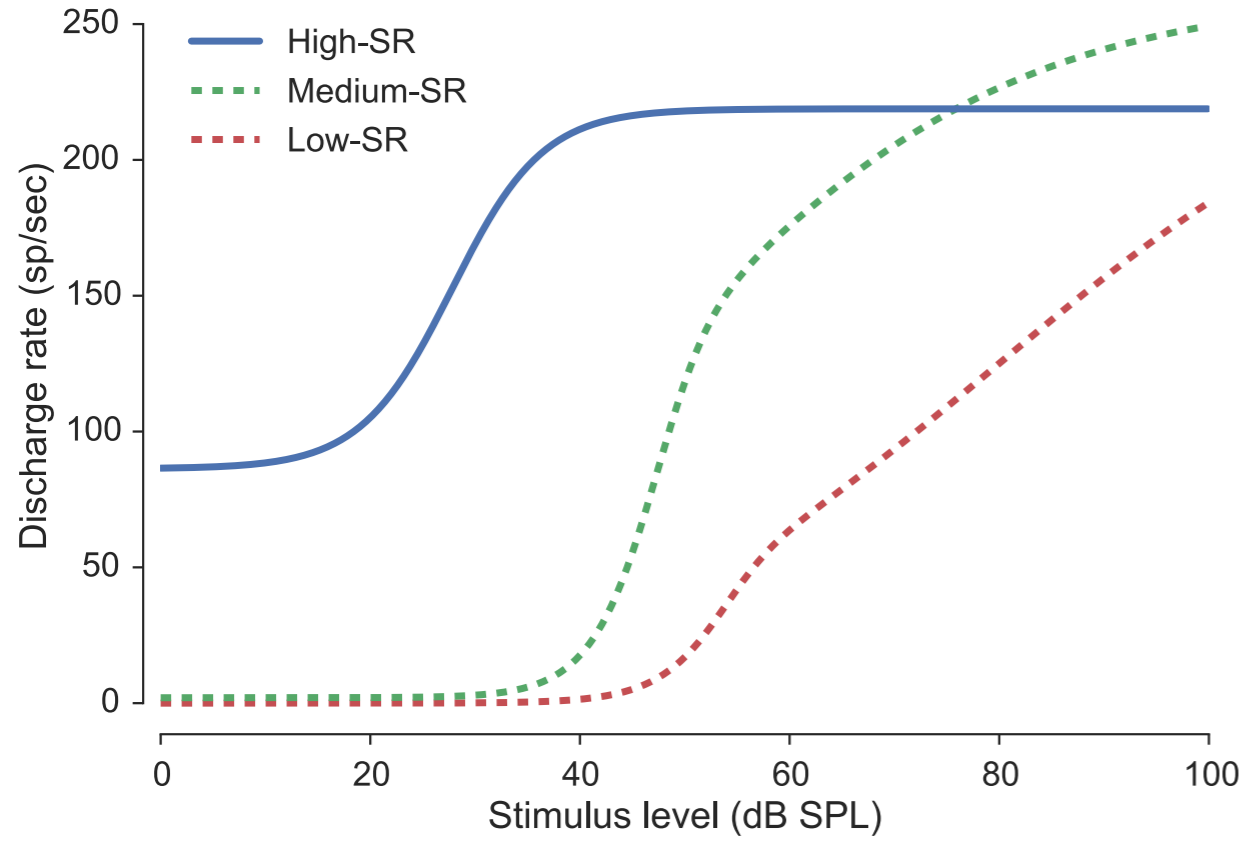
Potential explanation



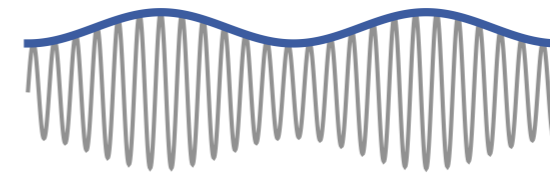
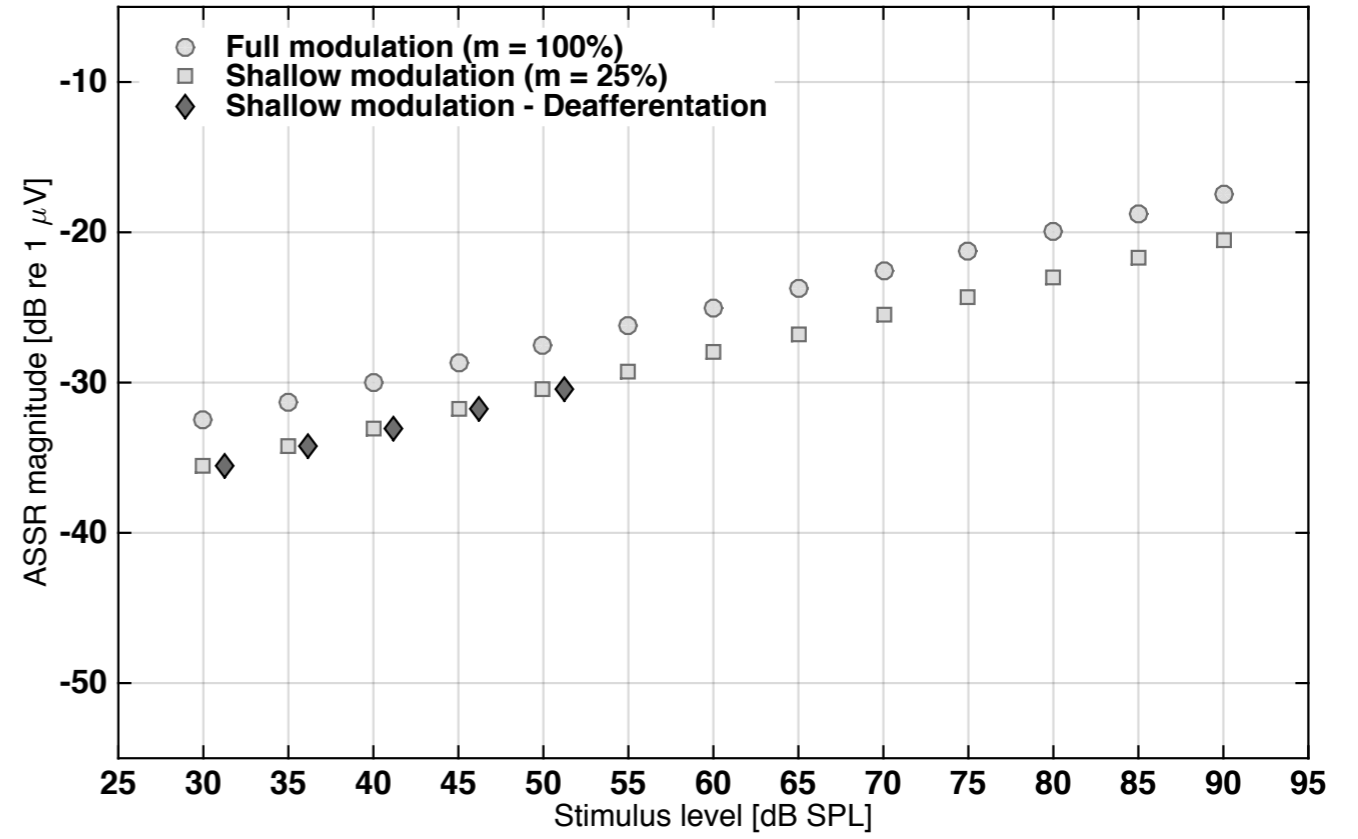
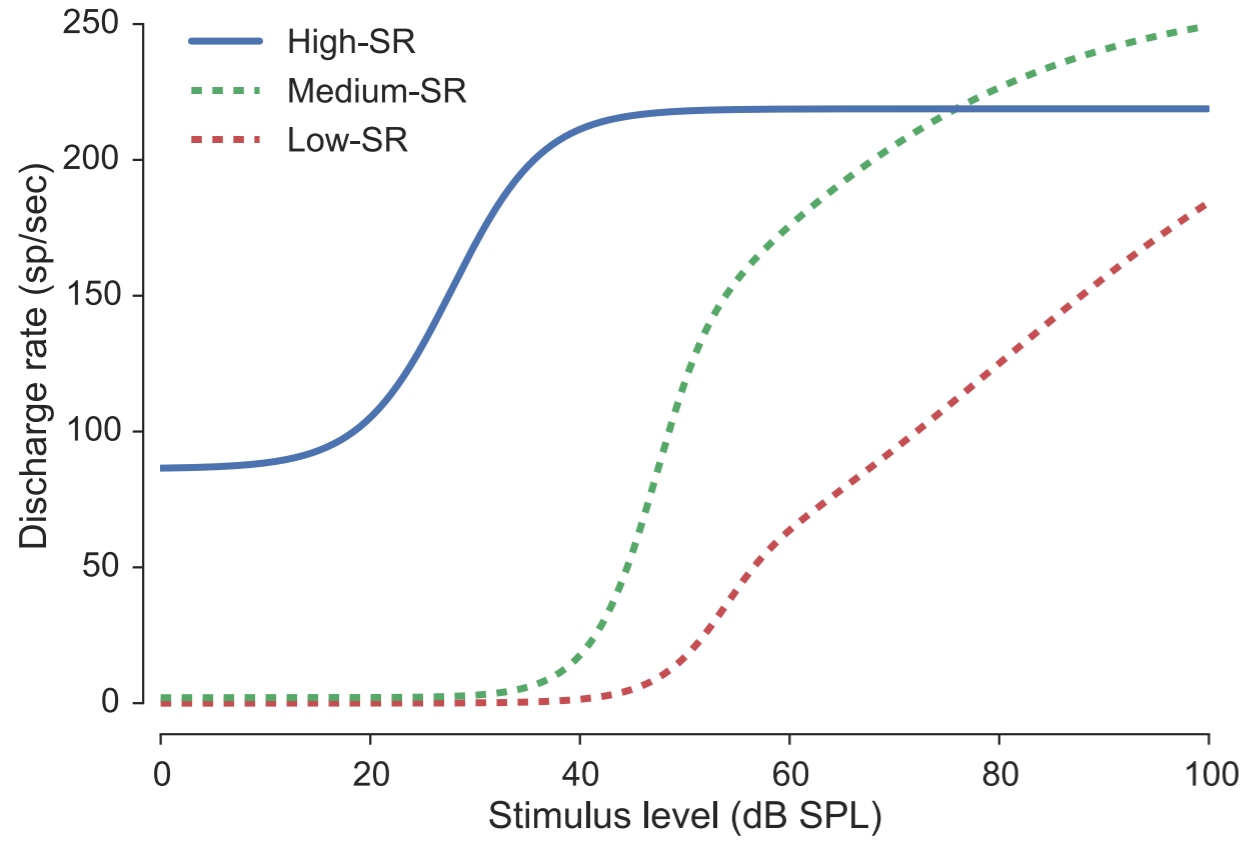
Potential explanation



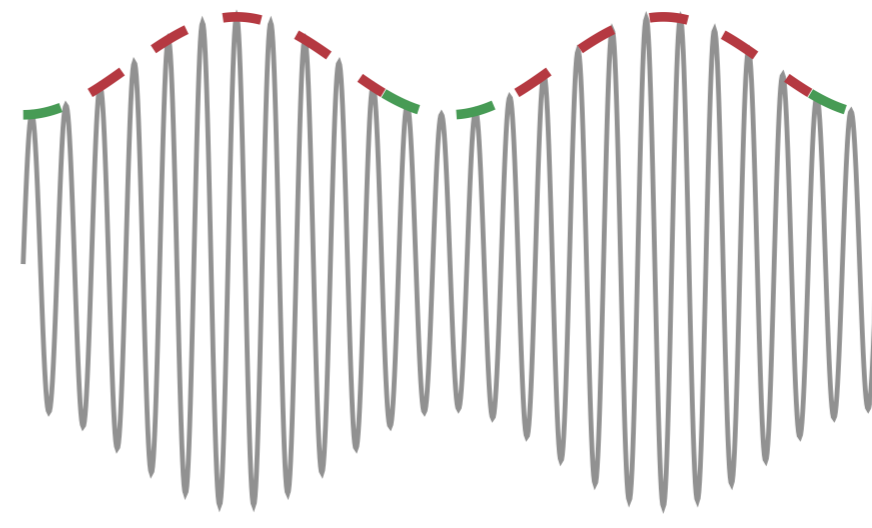
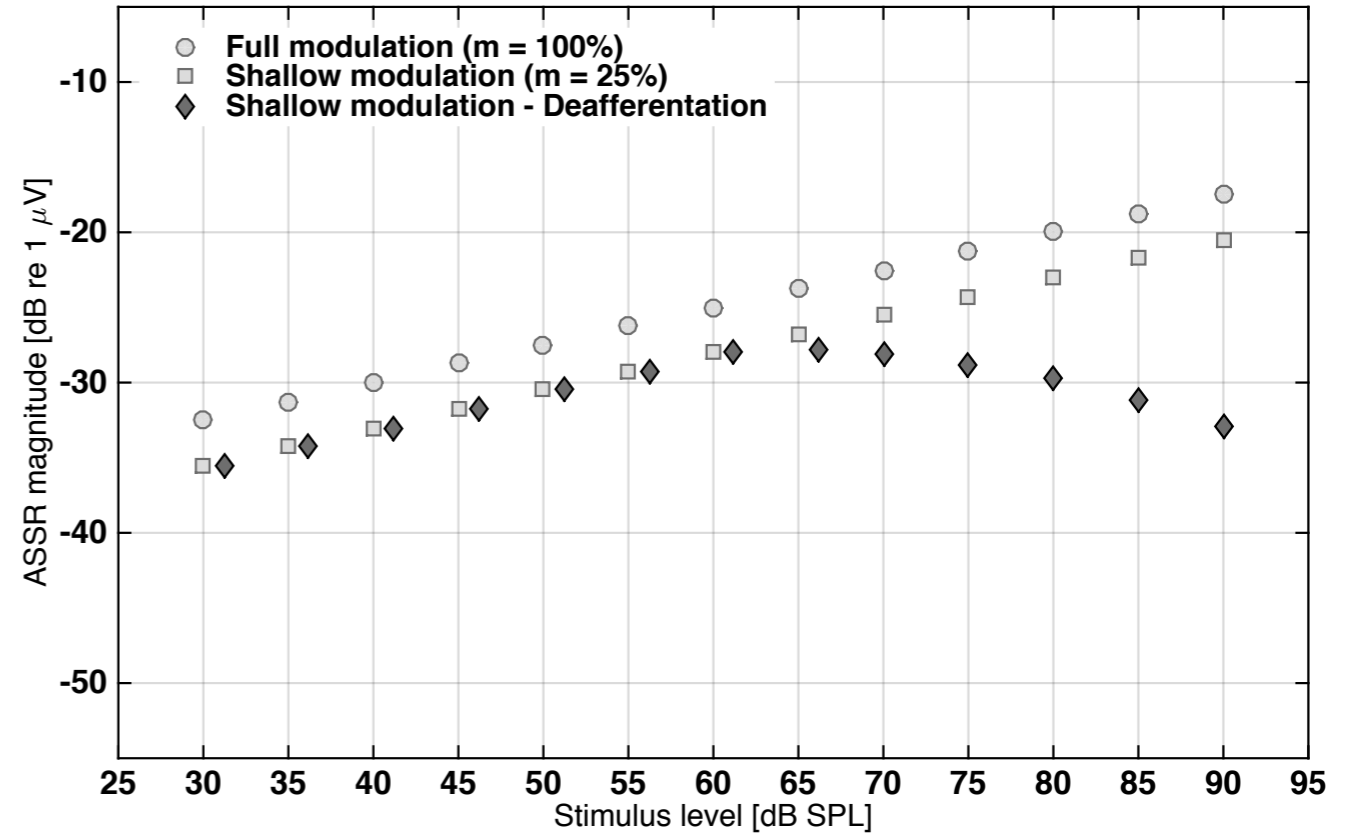
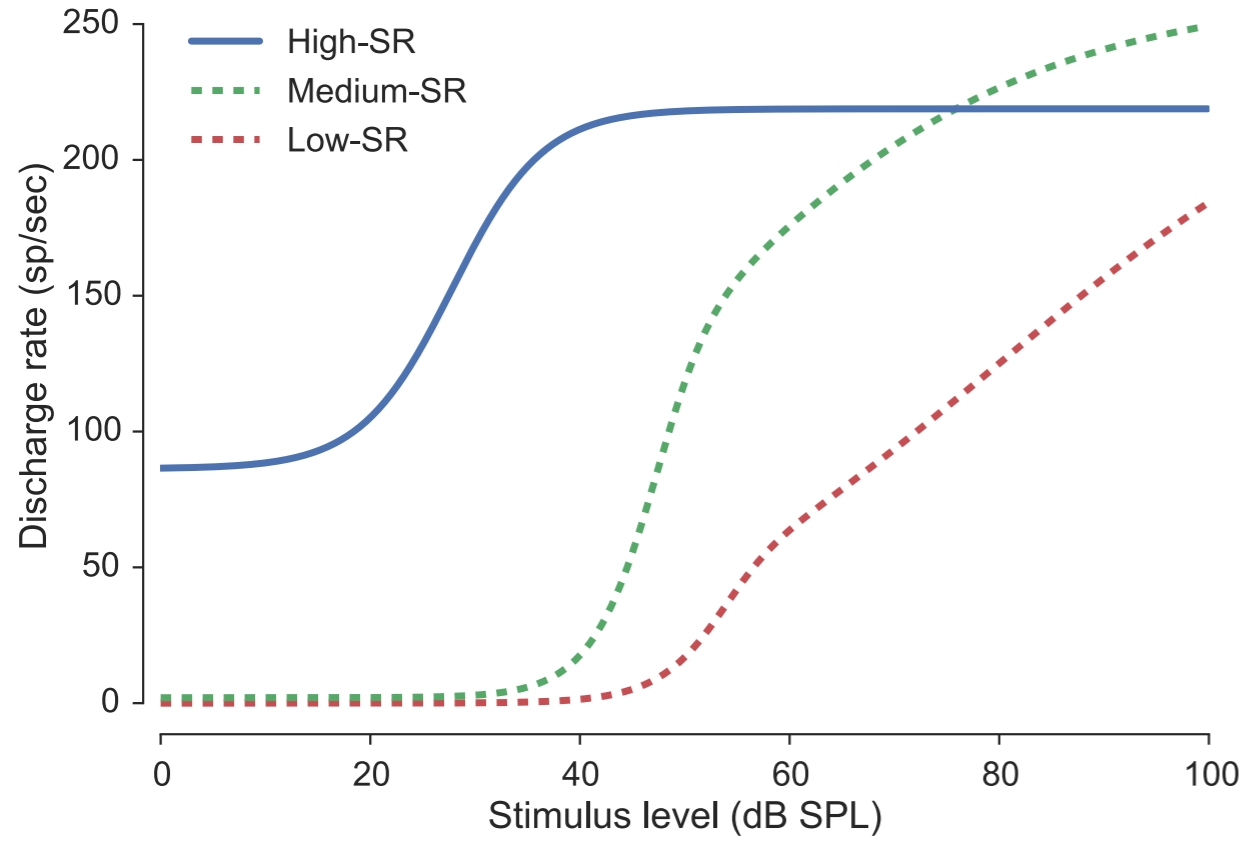
Potential explanation



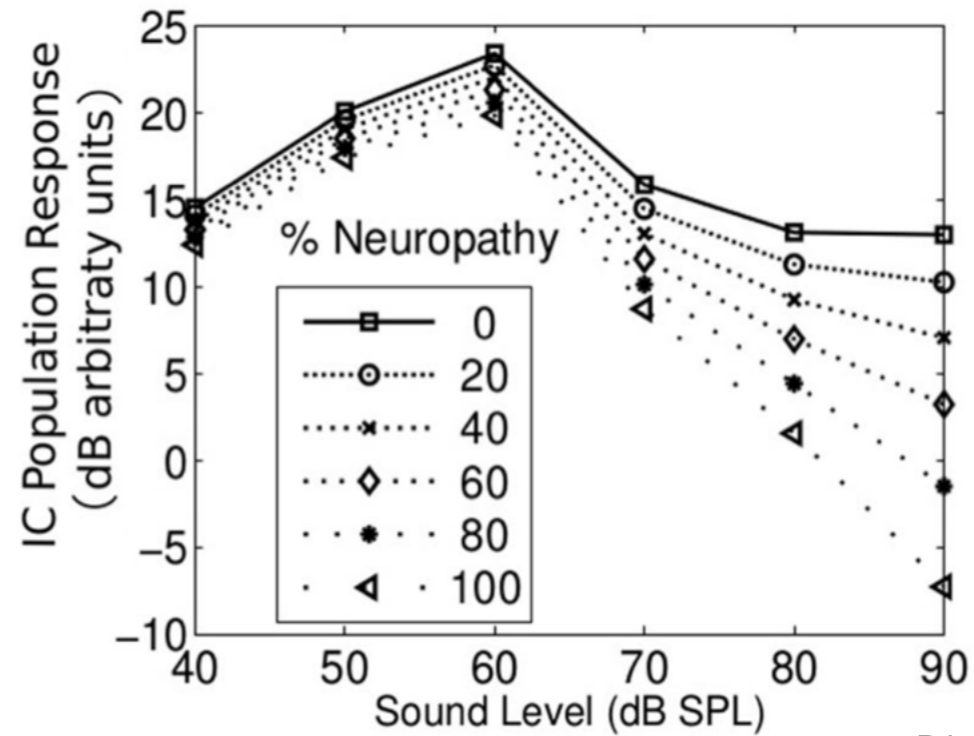
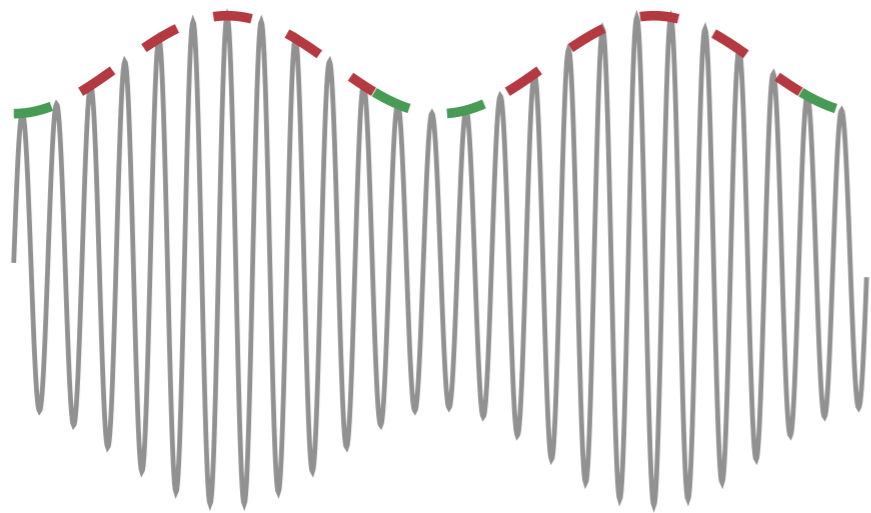
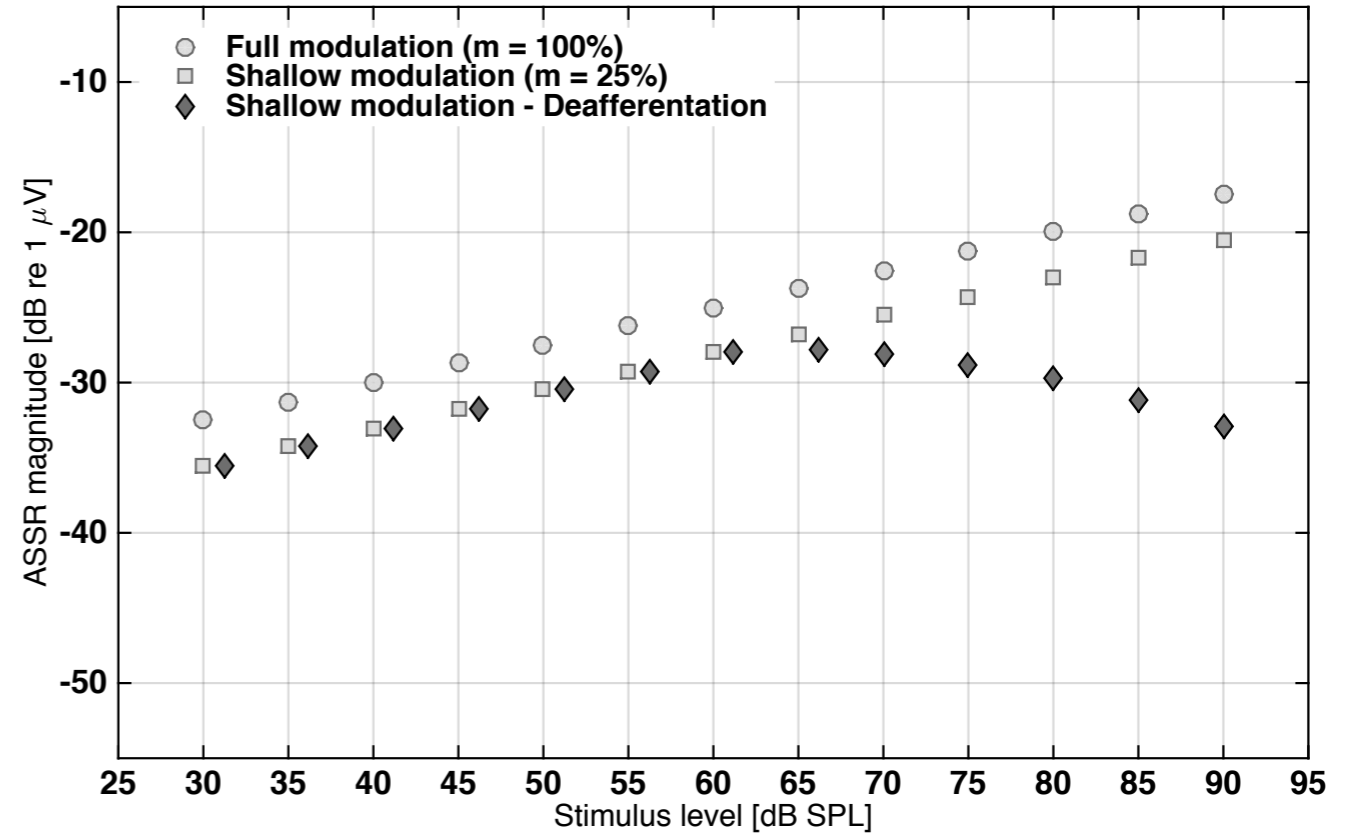
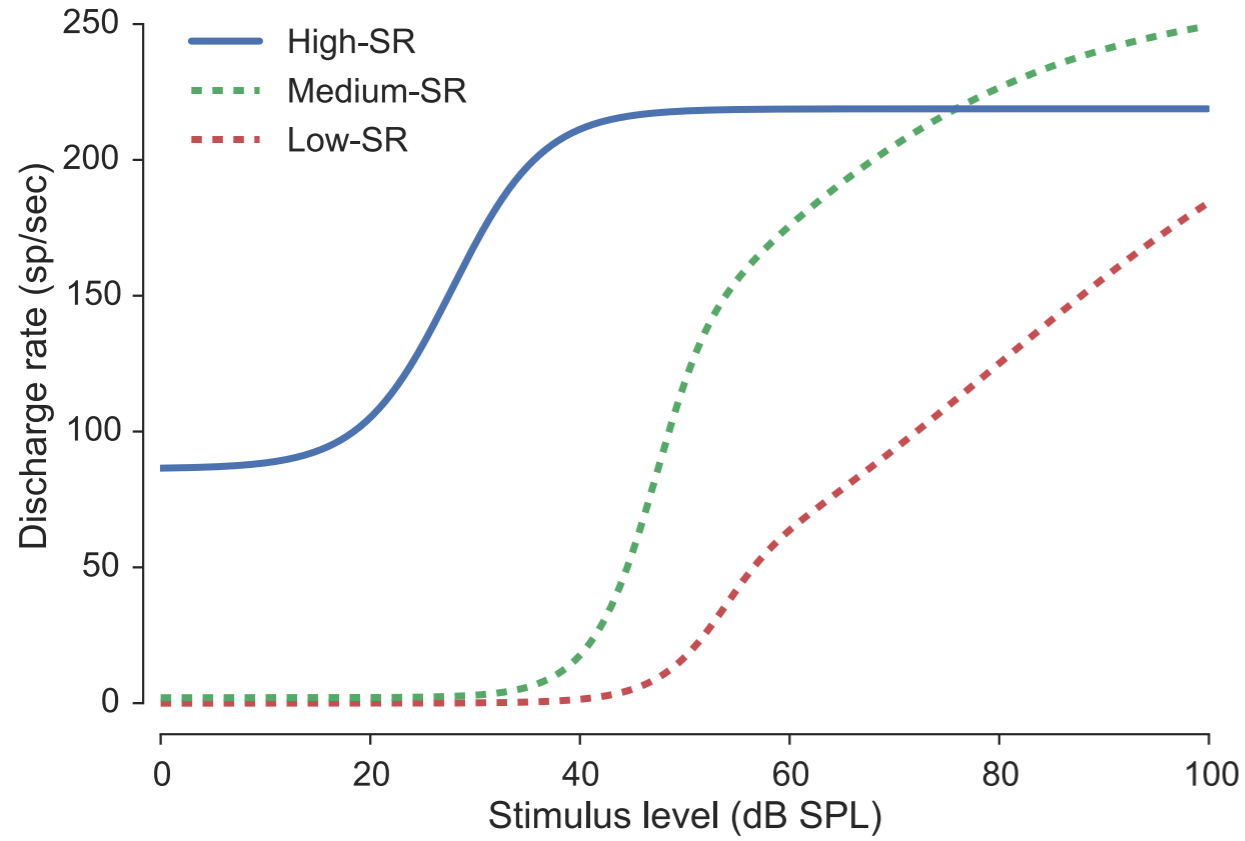
Potential explanation



Potential explanation

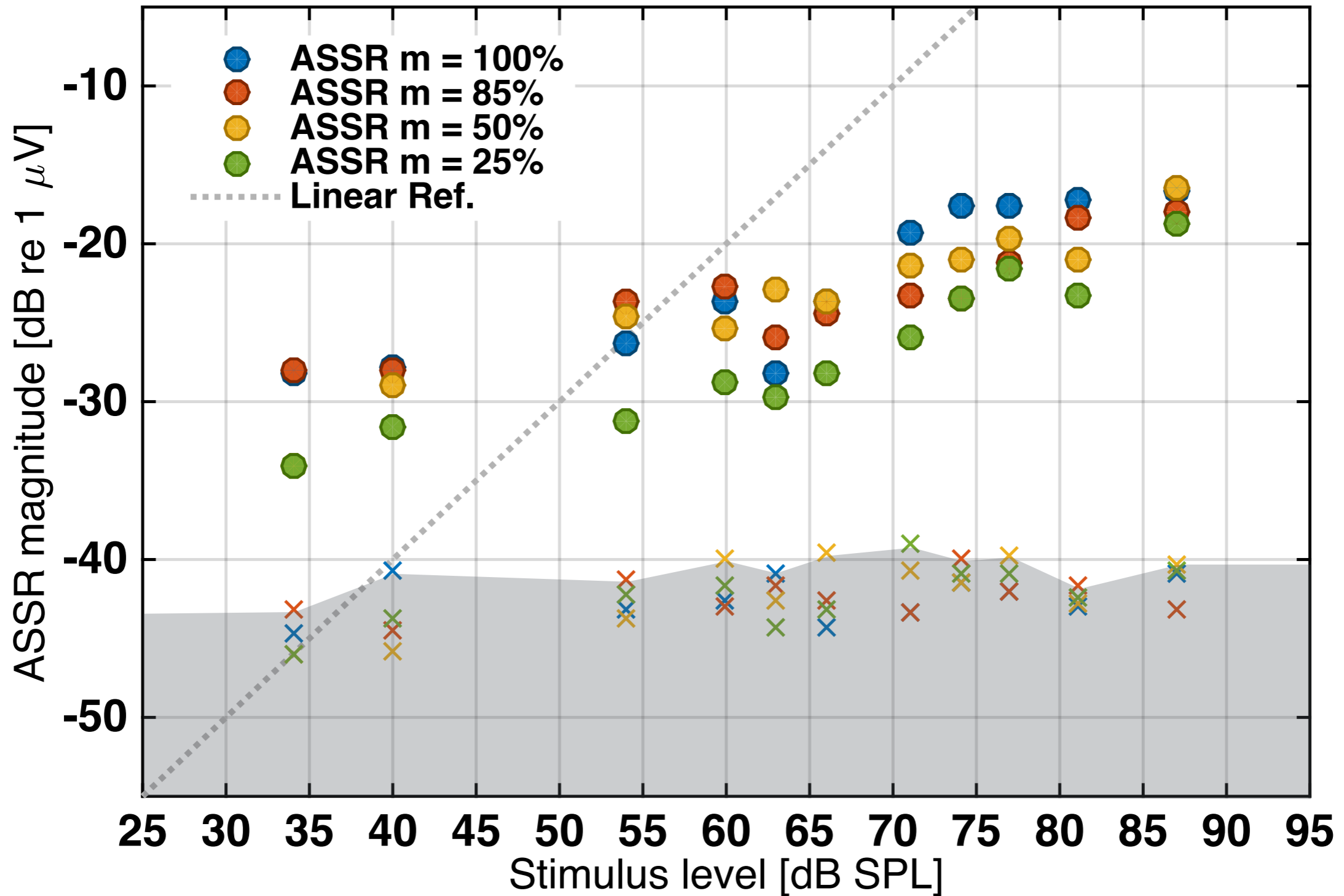


Potential explanation

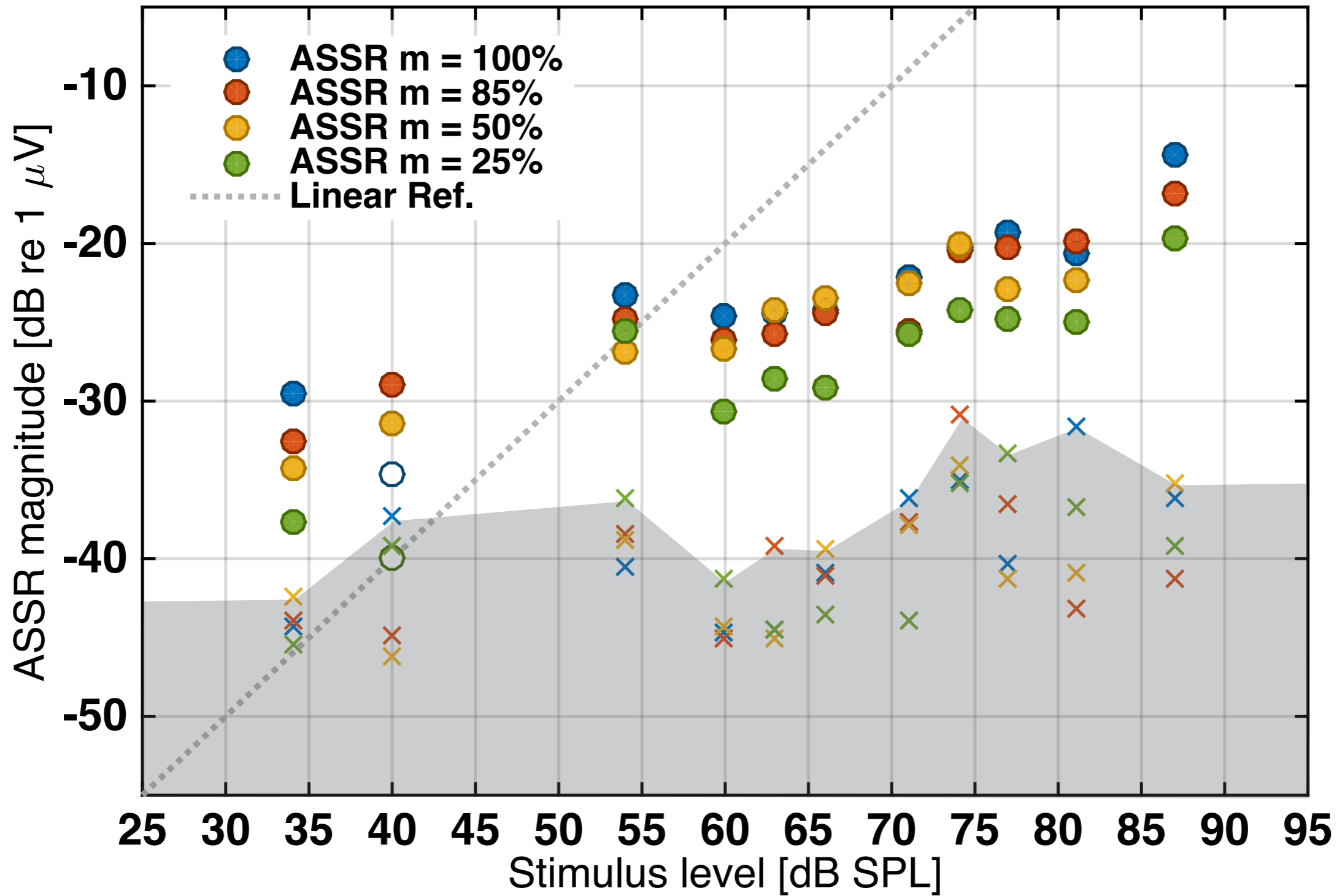


Pilot results: Individual NH subjects

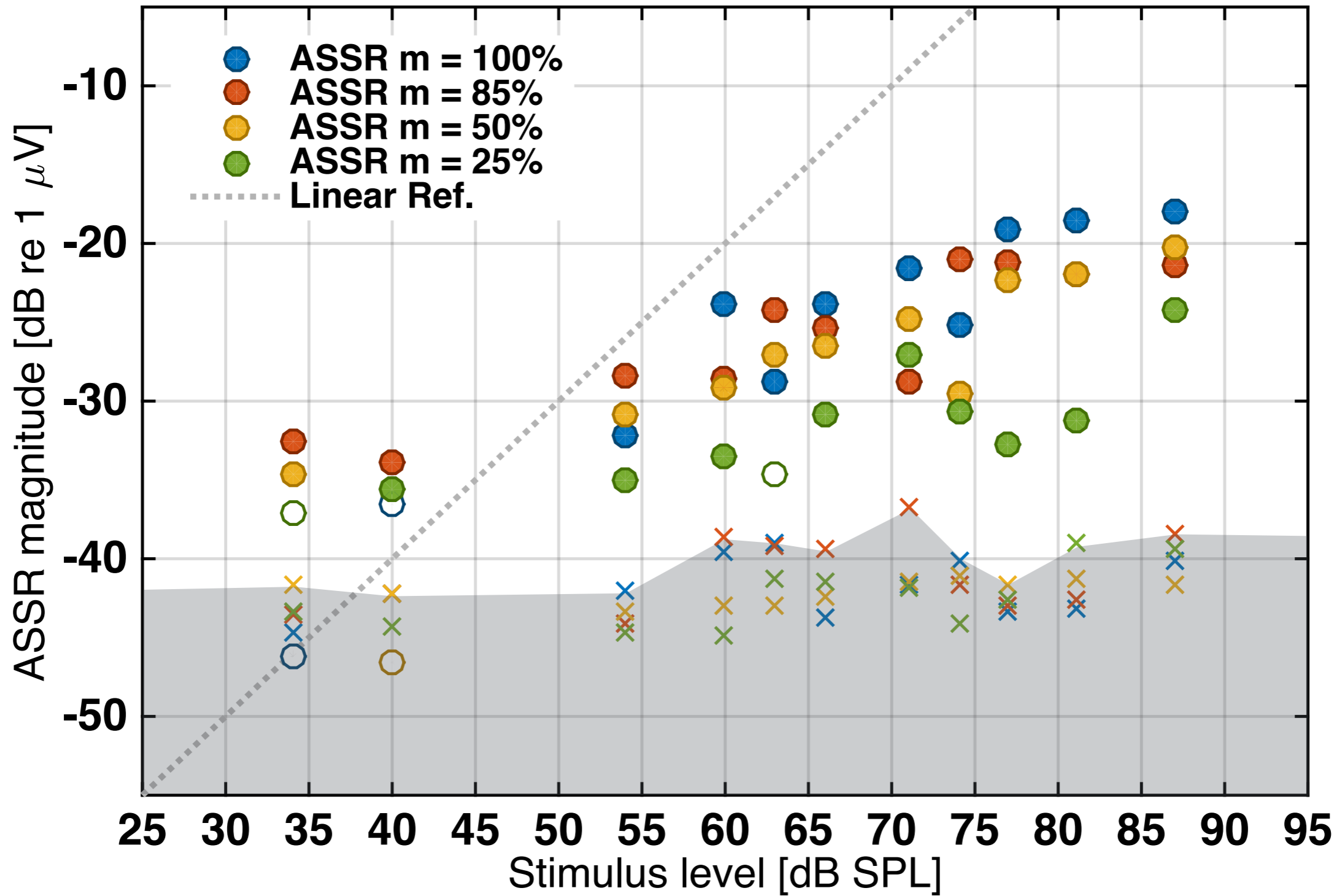
Subject: APG



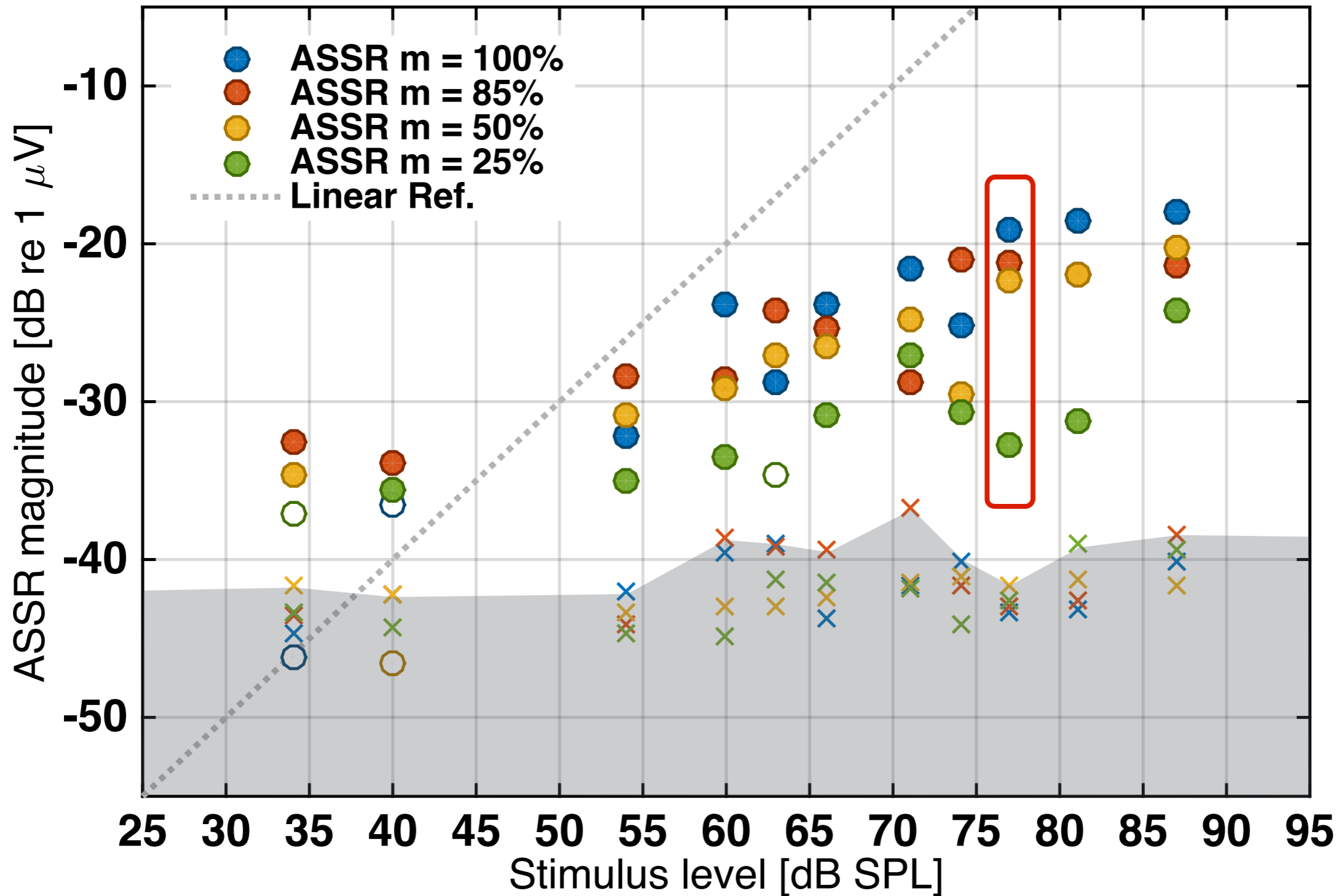
Subject: KGS



Subject: IGC

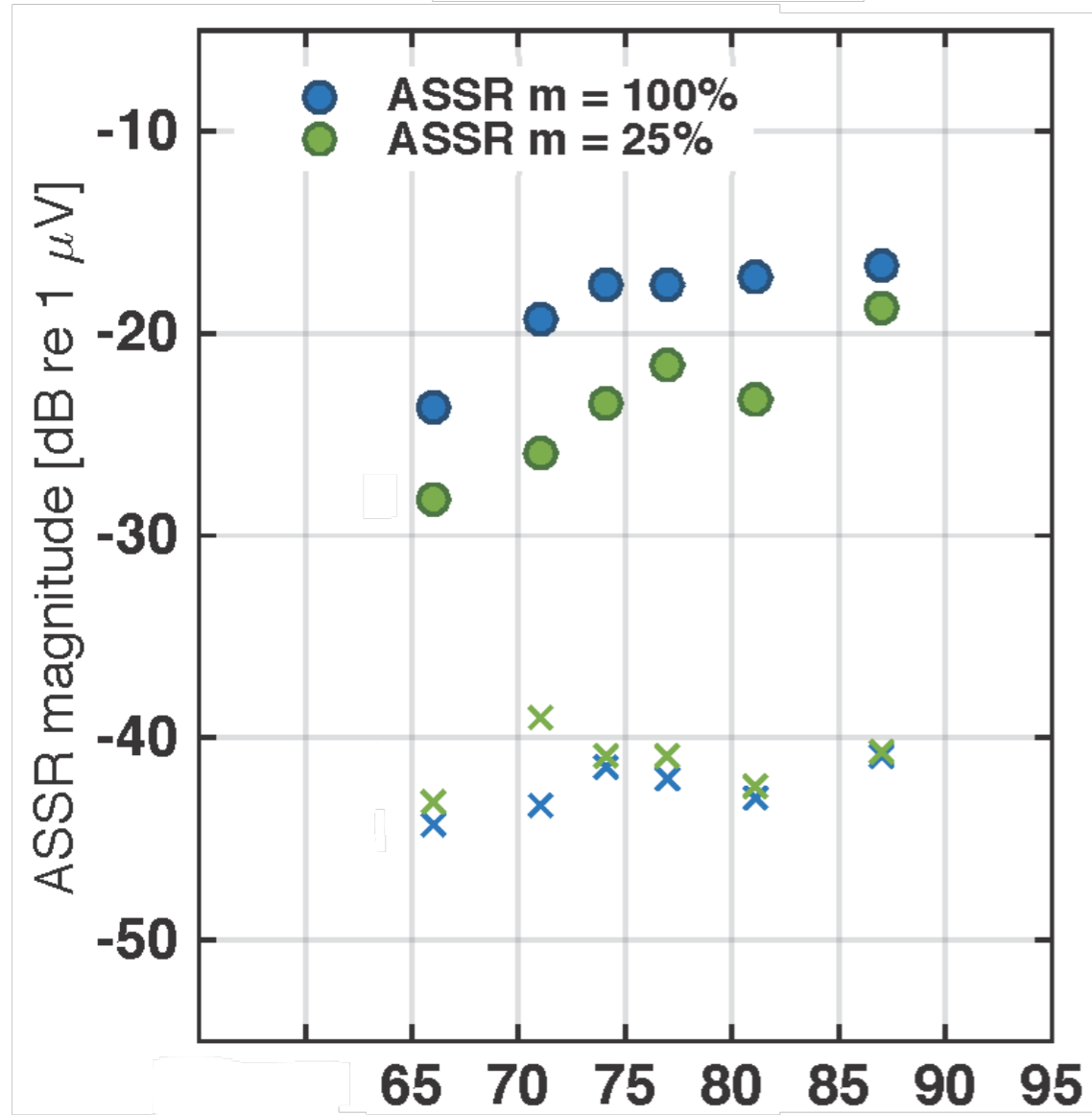


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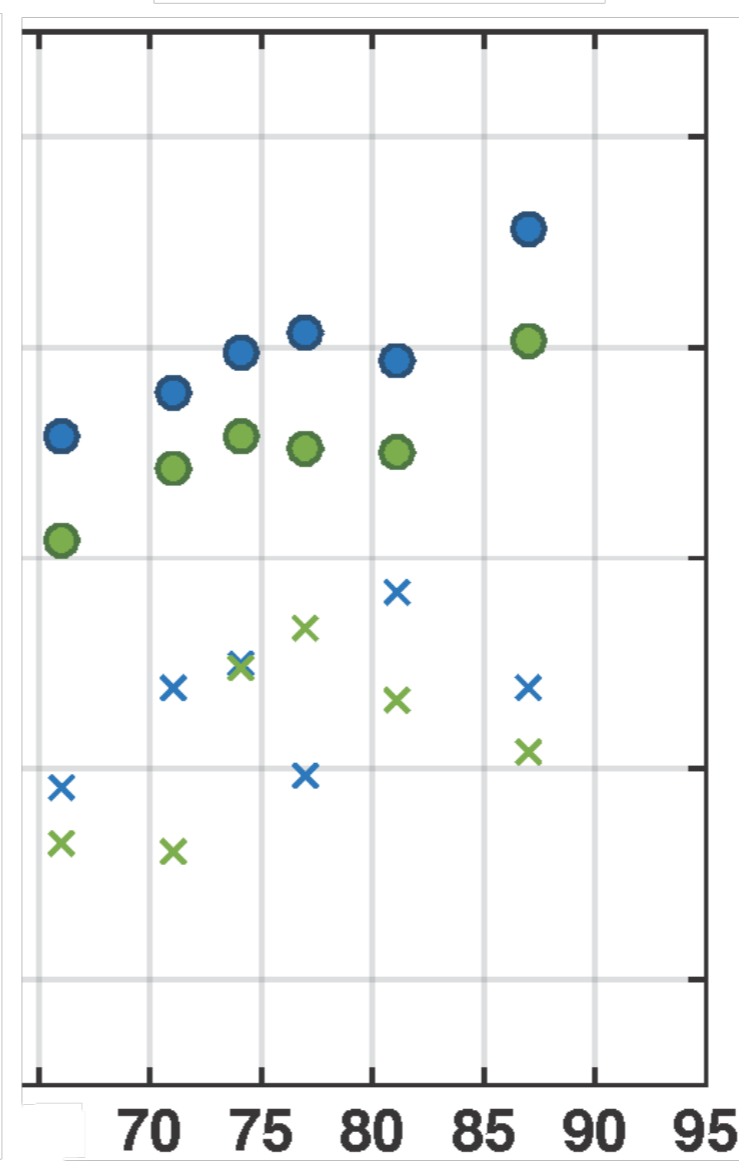


Pilot results: Individual NH subjects

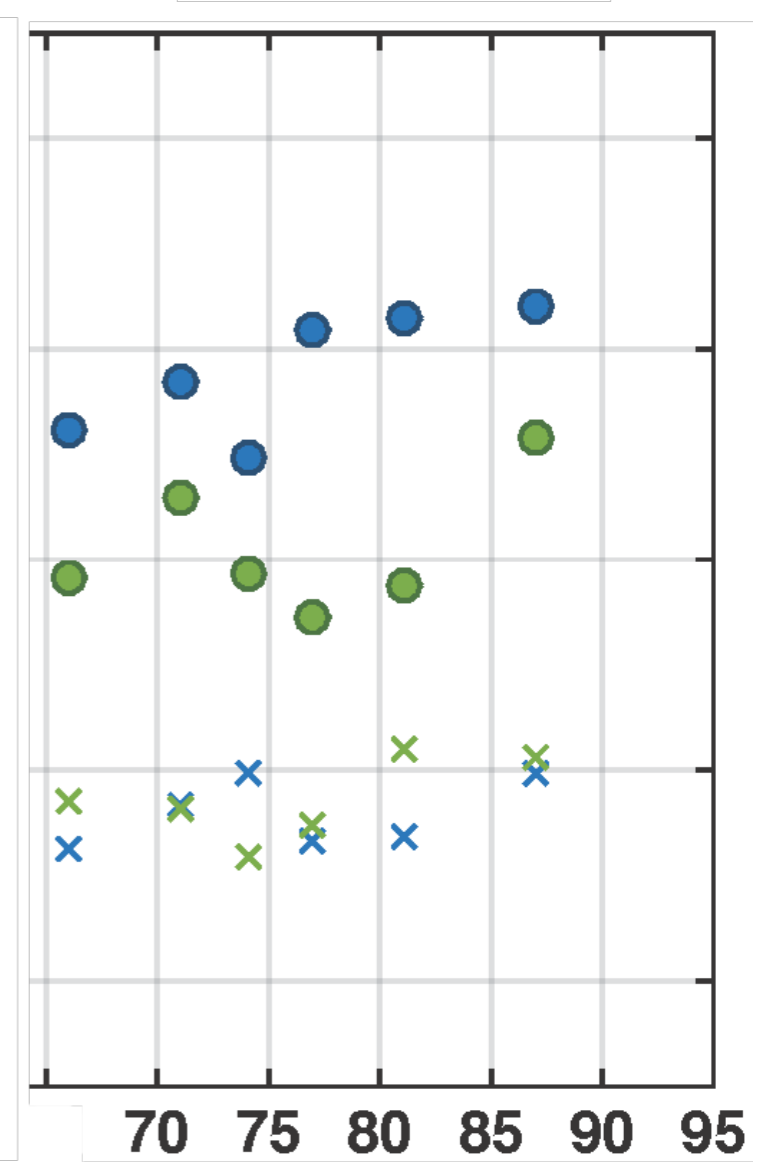
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Subject: KGS



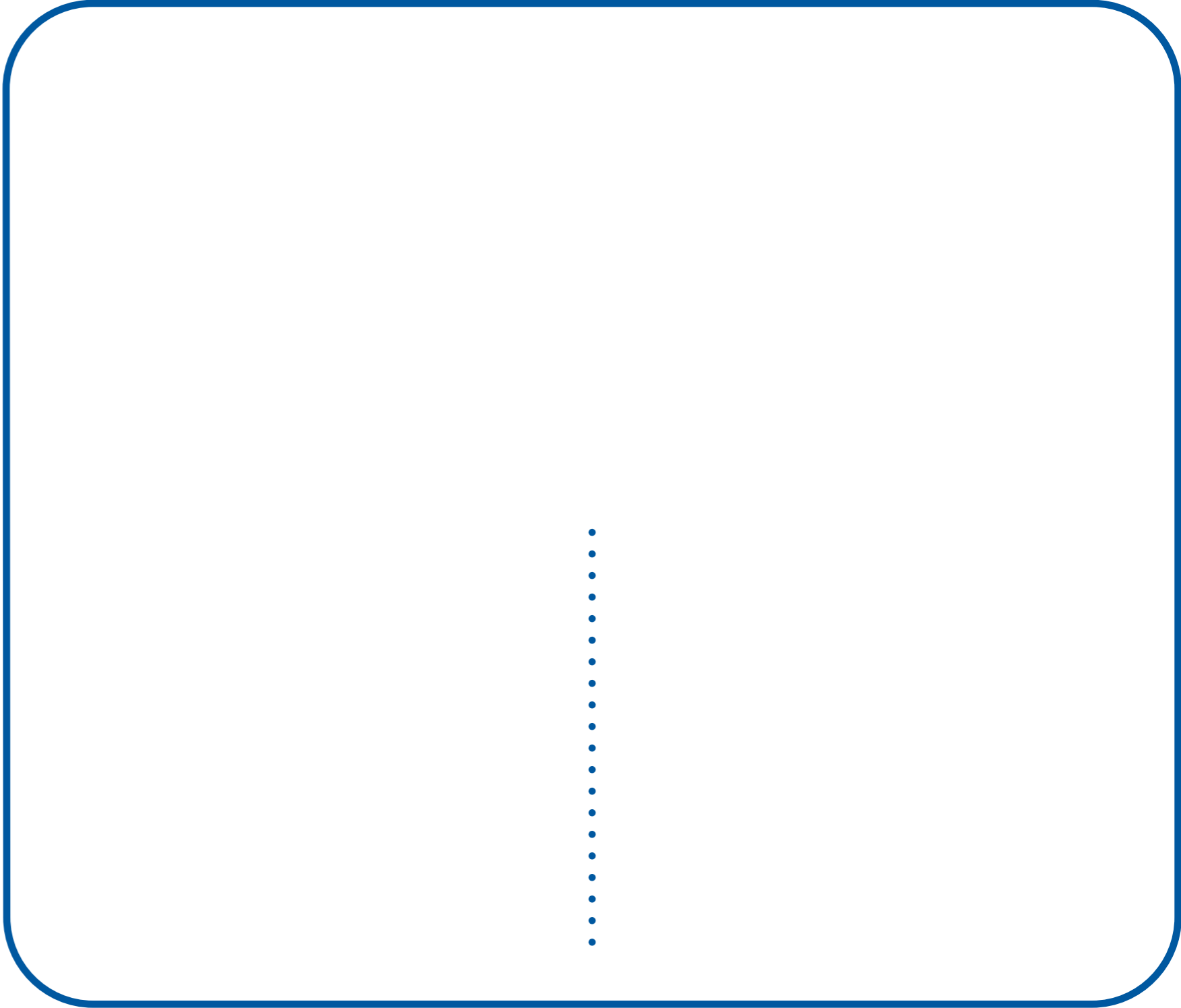
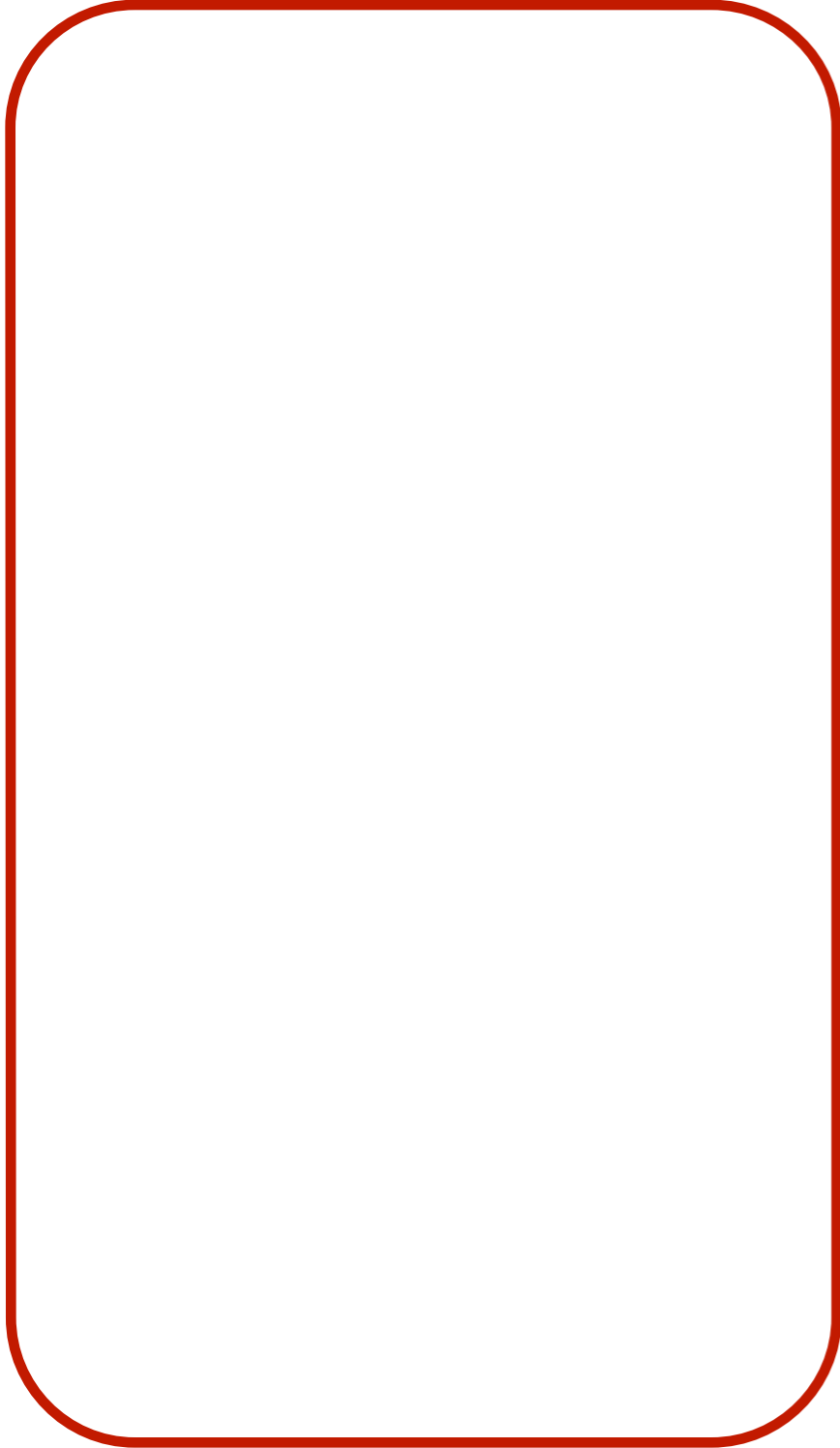
Subject: IGC



Stimulus level [dB SPL]

Next steps

Next steps



Low exposure NH



Next steps

Low exposure NH



High exposure NH



High exposure mild HI

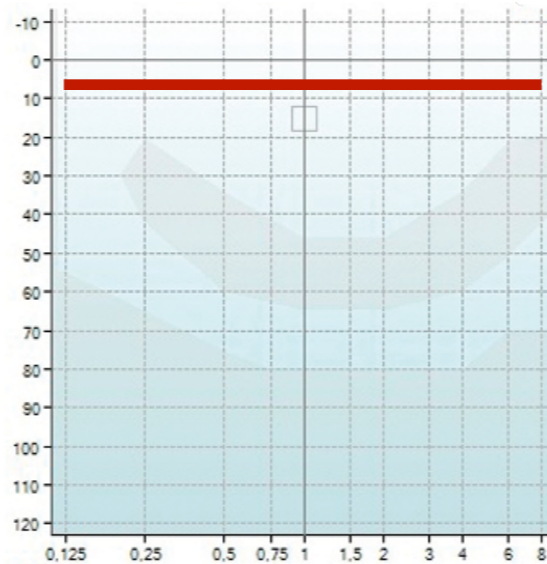


Next steps

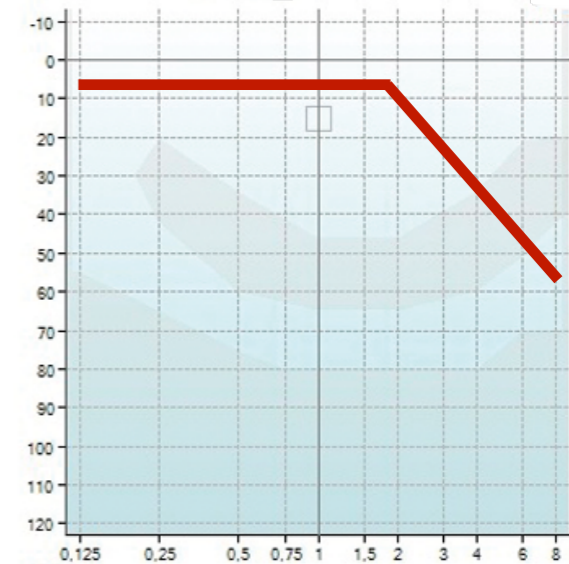
Low exposure NH



High exposure NH



High exposure mild HI



- ASSR are already used in the clinics to **estimate thresholds** objectively
- **ASSR growth functions** are suggested to be used as a tool to **assess compression** (and loss of compression) at different frequencies simultaneously
- We hypothesize that ASSR growth functions at higher stimulation levels using shallow modulations **reflect the integrity of ANFs**

Thank you!

Mange tak!

Moltes gràcies!