The document below was presented as poster in the INSAR 2023 conference

SensPD's biomarker approach

SensPD has found a way to address the challenge of establishing a correlation between a measurable biomarker and a subjectively-defined condition like autism. Instead of using autism as the reference variable, we have chosen to use sensory perception. By measuring sensory perception in a precise and straightforward manner, our approach offers an innovative solution that accurately captures the link between the biomarker and the correlated variable.

Inviting research collaboration

Autism condition may arise from a variety of factors, including genetics, brain function, and chemical imbalances. The unique response patterns measured by SensPD reflect the manifestation of these underlying issues.

We are seeking collaboration with researchers who can identify biomarkers linked to these issues, so that we can match them with the response patterns detected by SensPD.

Aberrant Otoacoustic Emissions, a Marker of Sensory Processing Impairment, As a Possible Novel Biomarker of ASD

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Would you believe that the sound you hear when you cover your ears can be an early and objective detector of autism?

Autism spectrum disorder (ASD) defines a group of heterogenous neurodevelopmental conditions that are commonly associated with Sensory processing (SP) impairment.

Otoacoustic emissions (OAEs) are weak acoustic signals emitted from the outer hair cells in the cochlea, spontaneously and in response to sensory stimulation. Multiple non-ASD related studies linked OAE patterns with speech recognition, brain connectivity and sensory processing (visual, auditory, olfactory, gustatory, and tactile).

Aberrant OAE profiles in ASD were found to be associated with decreased connectivity and impaired SP. The detailed OAE measurements offered here allow for classification of ASD types.

Understanding how the autistic brain works is not only important for autism. Prof. Uta Frith:

"Understanding the autistic brain is understanding the human brain"

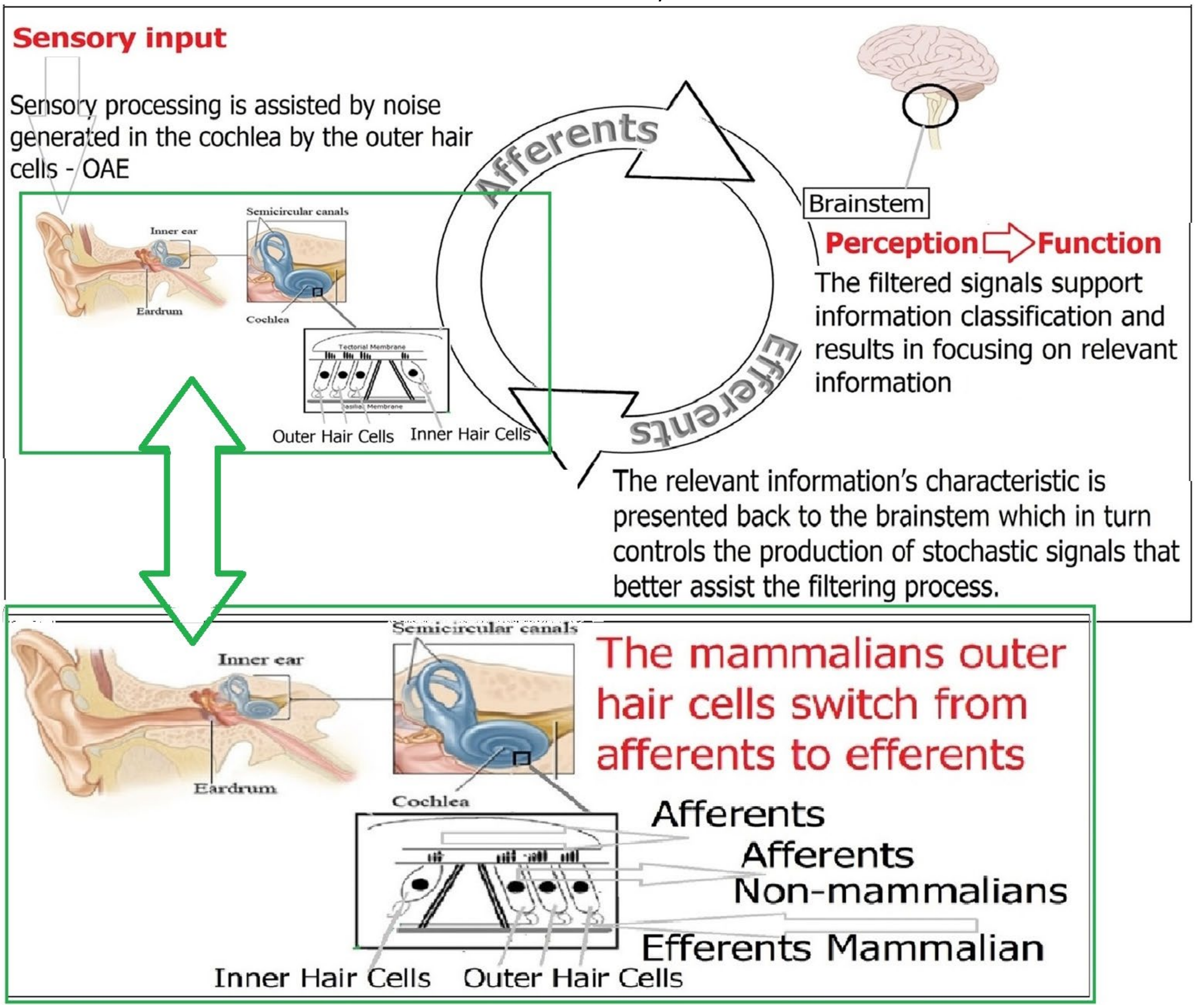
Measurement model overview

Definition Sensory Perception (SP) – the process by which all our sensory organs process the input stimuli for further cognitive processing. SP allows us to experience and understand the world around us by signals filtering and by detecting changes in the environment.

Definition Stochastic Resonance (SR) – is a phenomenon that occurs when the addition of random noise to a weak, coherent signal can enhance the detectability of that signal. The stochastic signals help increase the sound to noise ratio of a weak signal and make it easier to observe. For SR to occur, the weak signal must have a well-defined frequency or periodic pattern.

Definition Otoacoustic Emissions (OAEs) – are stochastic signals generated by the Outer Hair Cells of the inner ear both spontaneously and in response to a vocal stimulation. OAEs enable Stochastic Resonance transformations. In mammalians OAEs production can be selectively suppressed by the brainstem's efferents.

Definition Perception to Function – The way we perceive the world through our senses affects our behavior. The cognitive processing may be impeded by Sensory overload and the inability to separate relevant from irrelevant information. An optimal operation of sensory perception supports selective processing of sensory input and filtering of irrelevant sensory signals.



Auditory feedback processing loop

1) Input stimulus + OHC's stochastic signals for SR processing
2) Afferents move the mix to the brainstem
3) Brainstem processed input to the brain and to the efferents
4) Brainstem's filter instructions move through the efferents to the OHCs
5) Loop back to (1)

Note: Mammalian feedback control of OAE production

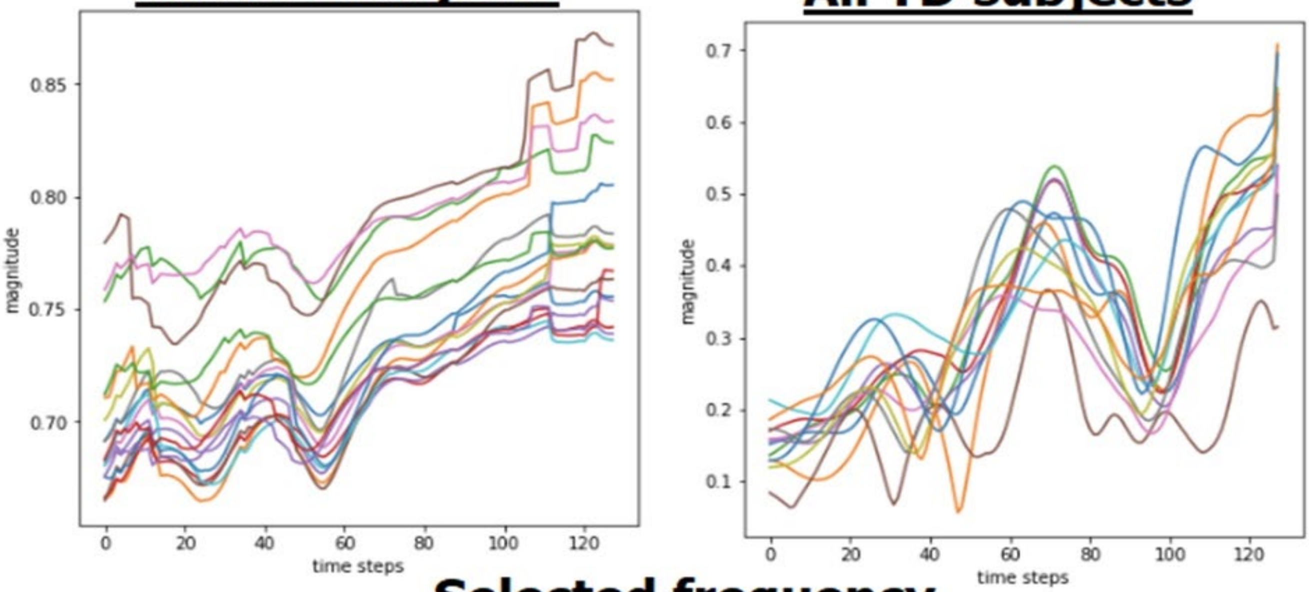
Outer hair cells in the vertebrate auditory system generate stochastic acoustic signals known as Oto-Acoustic Emissions (OAE). These stochastic signals, using stochastic resonance transformations enable selective processing and better response to weak periodic signals at natural, nonzero noise intensities.

The mammalian auditory system is unique because during the fetal development (22 gestational weeks in humans) the innervation of the outer hair cells switches direction from afferents to efferents. Brainstem has control over the production of OAE by selectively suppressing outer hair cells thus generating optimal filters for input vocal signals.

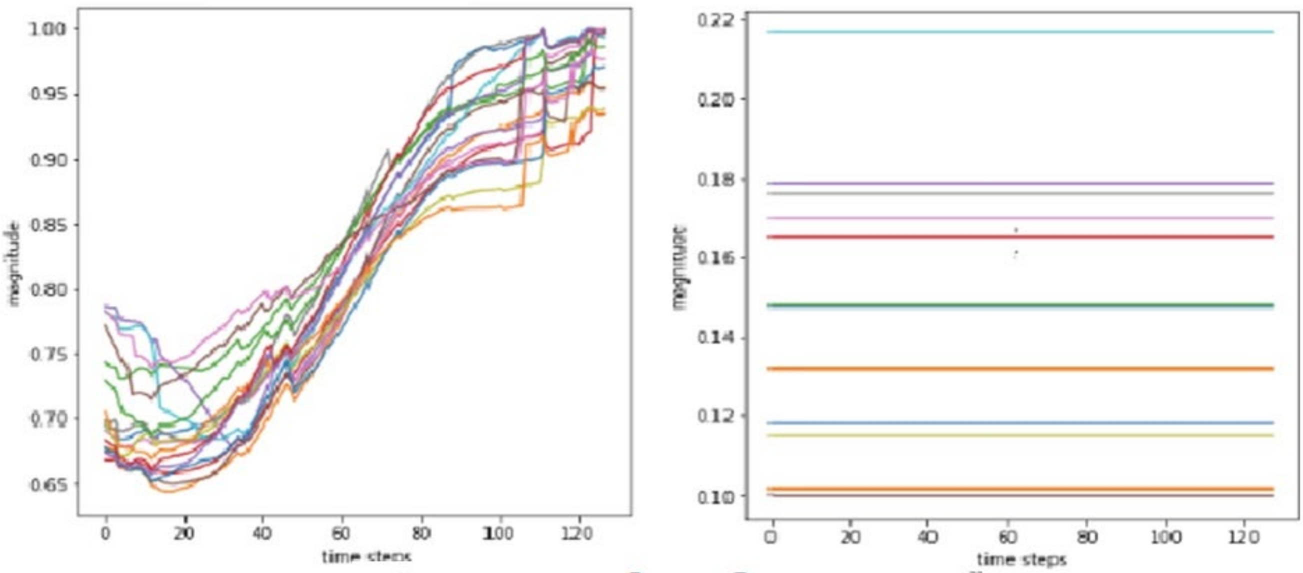
Method – Stochastic Resonance dictates using a vowel /eh/ as a stimulus. STFT was applied to generate a 3D matrix of time (X) vs. Frequency (Y) vs. Volume (Z).
The response was recorded using a standard OAE device within 750Hz to 7500Hz frequency band.

Suppression Analysis – Discipline II, predicts that key frequencies of the response, will show different suppression patterns. As expected, the volume of some frequencies, all from the TD subjects' response, is very low.

All ASD subjects **All TD subjects**



Selected frequency



Suppression frequency

- X axis – time from 0 to 120 milliseconds and the same y axis – Volume in millivolts.
- Each graph represents a single sample frequency recorded from all subjects.
- The TD subjects' volume (Y axis) range is much lower.

<u>Structure Analysis</u> – Non-suppressed frequencies were mapped and classified in accordance with the locations of their peeks and dips. We found that TDs and ASDs do not share the same response types. The variations in the ASD types are much greater than in TD types which allows us to draw one typical TD sample response as opposed to several response samples for ASDs.

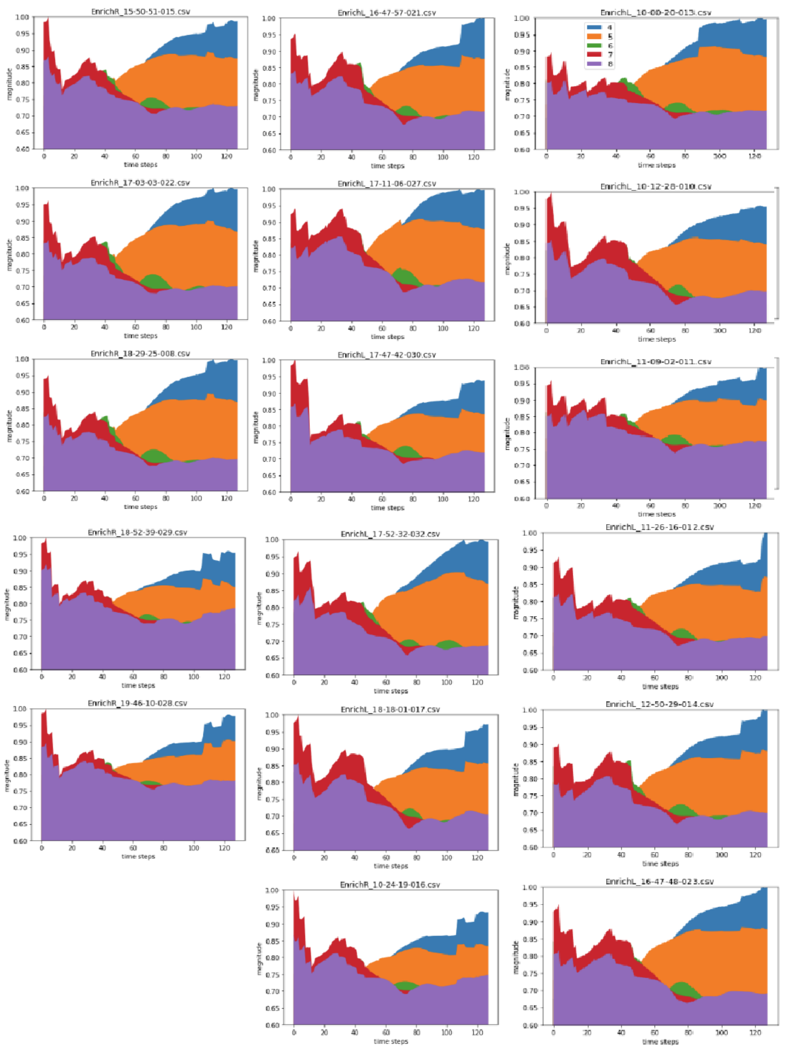
ASD structure types

Structure Type	# Total	# Left Ear	# Right Ear	# out of 17 subjects
1 (most common)	189	107	82	17 out of 17
2	26	13	13	7 out of 17
3	35	6	29	7 out of 17
Other Types	8	4	4	4 out of 17
Total	**258**	**130**	**128**	**27 Subjects**

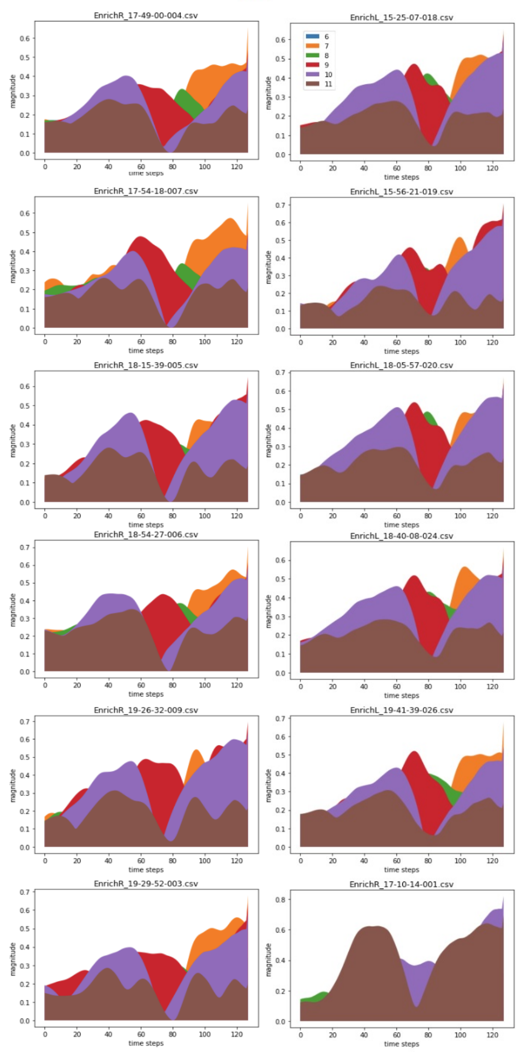
TD structure types

Structure Type	# Total	# Left Ear	# Right Ear	# out of 17 subjects
1	20	19	1	6 out of 12
2 (most common)	114	39	75	12 out of 12
Other Types	28	23	5	7 out of 12
Total	**162**	**81**	**81**	**12 Subjects**

<u>ASD</u>



<u>TD</u>



- X axis – time from 0 to 120 milliseconds and the same y axis – Volume in millivolts.
- Each graph represents a single subject. Each color represents a single frequency response of the subject. The frequencies' color scheme is the same for all graphs.

<u>Conclusions</u> – Selected frequencies analysis of viewable formants, reveals different response profiles between TD and ASD. A distinction between TD and ASD subjects is possible as well as classification of various ASD types.

These results support the feasibility of OAE measurements as a biomarker and possibly stratifying biomarker for ASD