

# Hormonal Fingerprint and Sound Perception:

A segmentation model to understand and predict individuals' hearing patterns based on OtoAcoustic Emissions, sensitivity to loudness, and prenatal exposure to hormones

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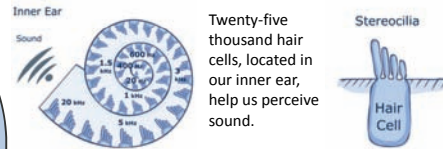
## Introduction

Research confirms the impact of hormones on human physical and personality traits. Can this *Hormonal Fingerprint* also explain the different sensory representations of a same sound stimulus? Is there a link between hormones and sensitivity to loudness? Is the listening experience related to hormones? The answer to these critical questions would help to identify, understand, and predict human perception and behavior.

**Business and Medical Applications** include:

- *Segmenting* individuals into groups based on their perception,
- Designing the *right sensory mix* for each group,
- Adapting *noise prevention* plans for each group,
- Identifying and reaching individuals more exposed to hearing diseases like *tinnitus* and *hyperacusis*.

## About Sound Perception



Twenty-five thousand hair cells, located in our inner ear, help us perceive sound.

Each of their stereocilia captures, amplifies a certain frequency, and transmits the information to the brain. During this process, the inner ear generates its own sound: OtoAcoustic Emissions (OAEs).



## 1 OAEs and Sensitivity to Loudness

Among the 16 Caucasian men considered, some subjects perceived a same sound of 6 kHz—equivalent to a crying baby—4 times louder than others. A segmentation based on OtoAcoustic Emissions at 6 kHz and sensitivity to loudness is proposed.

### Super Amplifiers

At 6 kHz, subjects S13 to S16 presented a high SNR (Signal to Noise Ratio) in the range [25, 39] dB. They reported being disrupted by high-pitched sounds (mosquito, baby, klaxon). They were identified as *Super Amplifiers*.

### Medium Amplifiers

At 6 kHz, subjects S1 to S8 presented a SNR in the range [15, 24] dB. 6 of them reported sensitivity to high-pitched or bass sounds. They were identified as *Medium Amplifiers*.

OtoAcoustic Emissions and Sounds Perceived as Disruptive for 16 Caucasian men in their thirties

Subjects	0.7 kHz	1 kHz	1.4 kHz	2 kHz	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	Disruptive sounds
S1	-1.0	8.0	5.0	26.0	19.0	16.0	11.0	21.0	-1.0	Baby
S2	1.0	7.0	3.0	17.0	20.0	19.0	8.0	12.0	10.0	
S3	2.0	4.0	6.0	23.0	21.0	17.0	10.0	18.0	4.0	Plates
S4	5.0	14.0	15.0	26.0	24.0	23.0	-2.0	10.0	12.0	High-pitched sound
S5	0.0	8.0	6.0	16.0	23.0	21.0	4.0	-1.0	6.0	High-pitched sound
S6	-1.0	3.0	9.0	4.0	10.0	15.0	9.0	16.0	10.0	Train
S7	7.0	1.0	2.0	24.0	16.0	22.0	12.0	22.0	11.0	Too loud bass
S8	9.0	17.0	19.0	31.0	23.0	24.0	2.0	20.0	17.0	
S9	6.0	-2.0	9.0	12.0	13.0	14.0	-1.0	0.0	11.0	
S10	9.0	8.0	10.0	11.0	9.0	3.0	4.0	3.0	7.0	
S11	4.0	9.0	13.0	12.0	8.0	2.0	3.0	2.0	6.0	
S12	-1.0	6.0	15.0	14.0	14.0	6.0	-1.0	3.0	6.0	
S13	0.0	8.0	14.0	28.0	21.0	25.0	33.0	38.0	6.0	Mosquito
S14	0.0	11.0	16.0	23.0	28.0	39.0	20.0	17.0	11.0	Baby
S15	11.0	6.0	10.0	17.0	16.0	32.0	18.0	16.0	21.0	High-pitched sound
S16	6.0	12.0	11.0	17.0	15.0	30.0	16.0	21.0	21.0	Klaxon

OAE measurements performed with an Otaloud clinical device by DervalResearch in September 2009.  
Screening Protocol: PE for [0.7, 1.4] kHz, OP for [2, 12] kHz.

### Non Amplifiers

At 6 kHz, subjects S9 to S12 presented a low SNR in the range [2,14]. They reported no particular sensitivity to loudness. They were identified as *Non Amplifiers*.

## Methodology

This research was conducted between June 2008 and September 2009 on **650 individuals from over 25 countries**, with different genders, ethnicities, ages, vocations, hobbies, and preferences.

**Measurements** performed included:

- *Hormonal Fingerprint*: Length of the index and ring fingers of the right hand, with the help of a digital Vernier Calliper
- *Perception of Sound*: OAE (OtoAcoustic Emissions) of the right ear, with a clinical OAE reader from Interacoustics.
- *Most/Least Favorite Sounds*: frequencies, with a real-time spectrum and noise analyzer.

The poster focuses on a segment of 16 Caucasian men in their thirties.

## About Hormonal Fingerprint

Sports and musical abilities, as well as other traits—including the ratio between the length of the index and ring fingers of the right hand—are set before a fetus enters its 14<sup>th</sup> week. A **shorter index** indicates a greater influence of **testosterone**; a **shorter ring finger** a greater influence of **estrogene** (Manning 2002).



## 2 Hormones and OtoAcoustic Emissions

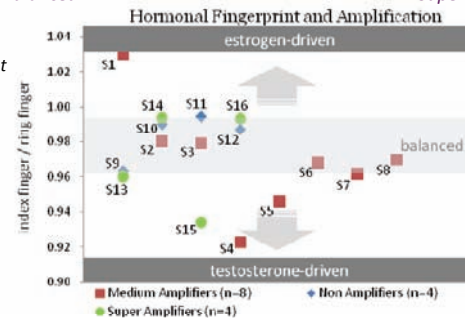
The average *Hormonal Fingerprint* among the 16 Caucasian men considered was 0.97 (length of the index finger divided by the length of the ring finger), with a minimum of 0.92 and a maximum of 1.03. Men with the same amplification profile presented a similar *Hormonal Fingerprint*.

### Non Amplifiers are Balanced

*Non Amplifiers* were balanced, with a *Hormonal Fingerprint* in the range [0.97, 0.99].

### Super Amplifiers are Extreme

*Super Amplifiers* were with a *Hormonal Fingerprint* in the range [0.92, 0.96], or estrogen-driven with a *Hormonal Fingerprint* in the range [0.99, 1.03].



## Conclusion

This research **confirms the impact of hormones on human perception of sound, and OtoAcoustic Emissions**:

- Individuals of the same age and gender can amplify a same sound up to 4 times louder.
- Sensitivity to loudness is linked to OtoAcoustic Emissions.
- *Non Amplifiers* present a balanced *Hormonal Fingerprint*, whereas *Super Amplifiers* present a testosterone- or an estrogen-driven *Hormonal Fingerprint*.
- Acting as a predictor, the *Hormonal Fingerprint* overrides gender, and age in explaining the different sensory representations of a same sound stimulus.

Further research:

- *Super Amplifiers* seemed to have a weaker **immune system** (presence of allergies, hyperacusis) whereas *Non Amplifiers* were fitter and involved in contact activities (team sports, team work).
- A link between OAEs and the **frequency of the favorite music** was identified.
- **Other hormones** might influence traits and perception.

## Aknowledgments

This research has been conducted in collaboration with Interacoustics. Special thanks to Rie Sobyte, Hans van den Heuvel, Marja Salaspuro, and to all our subjects.

Poster and more information available at [www.derval-research.com](http://www.derval-research.com)