A study of frequency variations of spontaneous otoacoustic emissions from human ears

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...what god empowers the eye and the ear?

...IT is that which cannot be heard
But by which we hear...

Listen.
Listen down.
Down to that sound.
What is it?
A current of air?
Vibrating vocal cords?
Your own ear drums?
Something running in your head?
It's all of these.
This sound is you vibrating.
This sound is you.

Alan Watts, Om, Creative Meditations
(Celestial Arts, Berkeley, 1980)
This thesis is my original work and has not been submitted, in whole or in part, for a degree at this or any other university. Nor does it contain, to the best of my knowledge and belief, any material published or written by any other person, except as acknowledged in the text.

Signed: Andrew Bee

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Contents

Summary

Chapter 1: Background to and beginnings of this thesis 1

Chapter 2: Frequency variations of SOAEs:
an historical perspective 10

Chapter 3: Methods 15

Chapter 4: Results 20

Chapter 5: An explanatory hypothesis 35

Chapter 6: A critical evaluation 43

Afterword 55

A personal note 56

References 57

Appendix 64
Summary

The majority of human ears are softly ringing. They are continuously emitting faint pure tones that can be detected with a sensitive microphone in the ear canal. Since Kemp (1979) first published a high resolution spectrum of this remarkable, although apparently normal, phenomenon (now called spontaneous otoacoustic emission, or SOAE), much research effort has gone into discovering the origin of these peculiar sounds. It seems clear that the sounds come from the cochlea and reflect the operation there of an active amplification system that endows the ear with its exquisite sensitivity and fine tuning.

This thesis was a study of variations in the frequencies of spontaneous otoacoustic emissions, both on an hourly scale to discern if circadian rhythms existed, and on a daily scale in fertile women to examine possible menstrual-linked variations. Notably, regular variations in frequency were discovered. The amplitude of SOAEs varied widely, but no systematic variation could be detected.

Regular circadian variations in frequency were found, typically showing a rise in frequency of 0.6–1% while asleep and a similar fall while awake. Consistent monthly variations, in step with the menstrual cycle, were also uncovered. The monthly cycle typically saw frequencies rise and fall by 0.4–0.6%, reaching a minimum near the onset of menstruation, and rising to a peak close to ovulation.

An examination of the literature revealed that certain cardiovascular parameters, particularly arterial blood pressure, follow — over both daily and menstrual cycles — a broadly similar time course to SOAE frequency. Further experiments produced data supporting a relationship between blood pressure and SOAE frequency, and it is therefore concluded that much of the circadian-linked, menstrual-linked, and background variation in SOAE frequency may arise from cardiovascular changes.

A likely causal mechanism, involving cerebrospinal fluid pressure, is put forward. It is speculated that the frequency-shifting effect of blood pressure is similar to that produced by the application of static pressure to the ear canal. In the latter, pressure is brought to bear on perilymph and SOAEs shift in frequency. In the former, blood pressure influences cerebrospinal fluid pressure (Cushing’s phenomenon), and this is conducted, via the cochlear aqueduct, to the cochlea. The outcome is the same: a change in perilymphatic pressure which changes the frequency of SOAEs.

Supporting this proposition, lying supine with head lowest raised emission frequencies. In addition, it is known that breathing and pulse are both detectable in cerebrospinal fluid pressure recordings, and the majority of seven subjects showed SOAE sidebands at 0.2–0.3 Hz and at approximately 1 Hz.