MEASURING OTOACOUSTIC EMISSIONS IN
HETEROSEXUAL AND HOMOSEXUAL FEMALES: A COMPARITIVE STUDY

A Research Report
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ABSTRACT

This study compared the TEOAE and DPOAE strengths in 10 homosexual and 10 heterosexual young females. A previous study had demonstrated a difference in strengths based on a hypothesis of developmental differences. Results of the study did not show statistically significant differences between the two female groups for either TEOAE or DPOAE measures. Because of the small sample size, a graphic representation of the data was completed, and showed a definite trend for the emission strength to be weaker in the homosexual females. This trend was discussed in light of the developmental hypothesis.
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CHAPTER I
INTRODUCTION AND REVIEW OF LITERATURE

Otoacoustic emissions (OAEs) are weak sounds, which appear to be produced by activity of outer hair cells in a normal human cochlea (Gelfand, 1997). While four types of emissions have been identified, only click-evoked transient and distortion product emissions have found their way into routine clinical usage (Gelfand, 1997). OAEs are currently believed to reflect a biological amplifier within the cochlea responsible for the sharp frequency selectivity, high degree of sensitivity, and wide dynamic range of the normal auditory system (Norton & Stover, 1994). Otoacoustic emissions measure the ability of the cochlea, specifically movement of the outer hair cells and are not a measurement of any neural activity. The outer hair cells are set into motion when a click stimulus is presented, a response signal from the cochlea is then sent back through the middle ear and ear canal and is picked up by a microphone. The click response is usually detected 5 msec or more after the originating click (Gelfand, 1996). Distortion product otoacoustic emissions are found by presenting two different frequencies, one high and one low, to the ear at the same time, as shown in Figure 1. The probe is placed in the ear canal through which the stimulus tones f1, the low tone, and f2, the high tone, are presented and amplified. The sound waves produce a traveling wave in the cochlea and a third wave, produced by an interaction of the stimulus tones in the cochlea, are emitted back along the basilar membrane and middle ear system. This wave that is produced by the cochlea is called the distortion product. These waves are picked up and amplified by the microphone and then filtered and analyzed by a software program, the strongest readings are found around 1000-4000Hz (Gelfand, 1997). A reading is then given showing where the stimulus tones (f1 and f2) occurred and where the distortion product occurs when stimulus
Figure 1. Diagram of Distortion Product Otoacoustic Emission System.
Figure 2. Diagram of Transient Otoacoustic Emission System.
tones are subtracted out. The noise of the patient and environment is reflected in the noise floor, which is measured concurrently with the emissions.

Transient otoacoustic emissions are echoed from the cochlea in response to a brief click or toneburst, normally of a wide band range, see Figure 2. These waves are gathered by placing a probe tip into the ear canal from which a click is emitted and several milliseconds later the microphone, which is in the probe tip, picks up a waveform, measurements are taken from between 500Hz to 4000Hz. This waveform is then filtered and analyzed from the background noise by the software program. The waveforms picked up by the microphone are small so there are a number of repetitions done. Again, the noise of the patient and environment is reflected in the noise floor, which is measured concurrently with the emission.

One interesting characteristic of click evoked TOAEs is that they are stronger in females than in males (Goldstein, 1999). This difference in TOAE strength has been related to differences in the concentration of male hormones (androgens) during prenatal development. In a 1998 study McFadden and Pasanen reported that homosexual females have TOAE strength, which is midway between the strengths observed in heterosexual males and heterosexual females. McFadden and Pasanen studied 237 subjects, measuring click-evoked TOAEs and spontaneous otoacoustic emissions in heterosexual, homosexual and bisexual, males and females. All subjects had been screened for normal middle ear function and hearing, those not passing the criteria were not included in the study. The results of the study were found to support the original hypothesis of the paper which was that homosexual female's otoacoustic emissions would fall between the emissions of heterosexual men and women due to the theory that homosexual females are exposed to male hormones during the gestational period. They theorize that the TOAEs of the homosexual females are reflective of an overall brain and peripheral auditory system effect of higher levels of androgens present during prenatal development of these women. In
other words, they believe that the higher levels of androgens masculinize the homosexual females and affect brain structures responsible for sexual orientation, an effect that is reflected in the relative weakness of the homosexual female’s TOAEs.

McFadden and Pasanen focused on click-evoked transient otoacoustic emissions and did not use commercial measurement equipment. It is the purpose of this study to attempt to replicate the click-evoked TOAE results in homosexual and heterosexual females using commercially available equipment, and further to determine if the OAE strength differences also exist in distortion product OAEs, which were not evaluated in the McFadden and Pasanen study.
CHAPTER II
METHODS

Subjects
The homosexual subjects for this study were recruited from the gay and lesbian organization on the UNI campus. Subjects signed up for the study and self-identified as lesbian or bisexual. Due to lack of bisexual volunteers, only lesbians were used for the homosexual half of the study. Heterosexual volunteers were recruited from the Department of Communicative Disorders of UNI. Subjects were all graduate and undergraduate students. Heterosexual subjects had an age range from 22 to 30 with a mean of 23.7 years. Homosexual subjects had an age range from 22 to 46 with a mean of 31.2 years. Any subjects not meeting established criteria were excluded from the study. Out of 21 volunteers, one homosexual subject was dismissed because of pure tone frequencies falling below 20 dB HL.

Materials and Instrumentation
Subjects first read over a subject consent form (see Appendix A), outlining the procedures, all procedures were then elaborated upon and explained, at which time any questions could be asked. A Hotchkiss otoscope was used for all otoscopic procedures. The GSI 33 middle ear analyzer was used to conduct the imminence screening measurements. Pure tone thresholds were established using the GSI 61 audiometer and insert earphones. Both TOAE and DPOAEs were obtained using the ILO96 otoacoustic analyzer, running on a personal computer.

Procedure
Self-identified heterosexual and homosexual subjects were scheduled and upon arrival in the clinic read and signed a subject consent form outlining the procedures and rational for the study. They were then informed of the process for the testing and any questions were answered. Ears were checked to make sure they were free of cerumen and
no infection or perforations were present. Screening tympanometric and acoustic reflex measurements were taken to be sure of the integrity of the middle ear system. The subjects were placed in a soundproof booth where pure tone thresholds were obtained at frequencies from 250 Hz to 8000 Hz. Any subject with pure tone thresholds falling below 20 dB HL was excused from the study. The final step was inserting the OAE probe tip into the subject’s ear and having them relax in a quiet room while the stimulus was presented and measured. Transient and Distortion product otoacoustic emission measures were counterbalanced as were right and left ears. OAE measures were taken twice on each ear.

For transient otoacoustic emissions, amplitude measurements were taken from the Band level, octave level screen, for response in dB and noise level SPL. Distortion product otoacoustic emission amplitude measurements were taken from the analysis screen and the measurements were taken from all frequencies for 2f1-f2 and 2f2-f1 along with their corresponding signal to noise levels.
CHAPTER III

RESULTS AND DISCUSSION

After all subjects were tested, analysis of the data was begun. A +6 dB emission amplitude to noise amplitude was necessary for an emission to be included in the data analysis. This signal to noise ratio (SNR) was chosen because it is commonly used in current clinical practice and provides some assurance that an emission was actually present. Since this fairly stringent SNR eliminated frequencies inconsistently across the subjects, all of the amplitudes for the emissions that were considered present were averaged across all of the frequencies. T-tests were performed between the right and left ear emission strengths, and since they were not significantly different the amplitudes for the two ears were averaged together.

The null hypothesis was that there would be no difference in TEOAE and DPOAE amplitudes in the heterosexual and homosexual females. T-test results showed that there were not significant differences between TEOAE or DPOAE amplitudes for homosexual and heterosexual subjects used in this study. Even though the t-test analysis failed to show a significant statistical difference between amplitudes, a difference is apparent when viewing graphs comparing TEOAE and DPOAE amplitudes for the two groups. A visual analysis of the data is considered valid in this study because of the small numbers of subjects and large variability in emission strength between subjects. Emission strength is known to be less variable within subjects and much more variable between subjects (Gelfand, 1997) so the variability was expected. Unfortunately the small numbers and large variability seriously compromises statistical procedures and so a graphic analysis is preferred.

Figure 3 shows the TEOAE results for heterosexual and homosexual subjects. The range of emission amplitudes between heterosexual and homosexual subjects is different with the homosexual subjects having a much larger range than the heterosexuals. The
Figure 3. Graph of Transient Otoacoustic Emissions.
Left: Heterosexual left and right ears combined.
Right: Homosexual left and right ears combined.
Figure 4. Graph of Distortion Product Otoacoustic Emissions: 2f1-f2. Left: Heterosexual left and right ears combined. Right: Homosexual left and right ears combined.
Figure 5. Graph of Distortion Product Otoacoustic Emissions: 2f2-f1.
Left: Heterosexual left and right ears combined.
Right: Homosexual left and right ears combined.
median emission amplitude fell lower on the graph and was smaller than the median amplitude of the heterosexuals. The weaker emission strength of the homosexual subjects is also reflected in the amplitude mean for the two groups. The mean differences for the heterosexual and homosexual subjects are 0.91305 and −1.23295 respectively.

The difference in the range of emission amplitude for the distortion products was also apparent for heterosexual and homosexual subjects, with the homosexuals again having the larger range (Figures 4-5). The median emission amplitude for both the 2f1-f2 and 2f2-f2 distortion products was weaker for the homosexuals than the heterosexuals. The mean emission amplitude for 2f1-f2 was 9.67525 and 6.813 while the standard deviation was 3.69165 and 4.02415 for heterosexuals and homosexuals respectively. The mean for 2f2-f2 was −3.3499 and −7.77365 while the standard deviation was 4.83655 and 5.66155 for heterosexuals and homosexuals respectively. By viewing the graphs and comparing the means from the graphs, the analysis of the data would support the findings of McFadden and Pasanen. Several factors could account for the lack of statistical significance in this study, first a small group of subjects was used. Secondly, the subjects in this study self-reported sexual orientation. The McFadden and Pasanen study used a sexual orientation inventory to categorize their subjects. Because of the lower criteria for sexuality used in this study, there may have been a greater mix of sexual orientations that reduced the contrast between heterosexual and homosexual groups. For example, this study included both assertive and passive homosexuals in the homosexual group, perhaps the assertiveness and passivity is reflective of more masculinization or less masculinization during development. The passive homosexuals might have had emission strength closer to heterosexual females and the assertive homosexuals closer to heterosexual males. By combining them in one group the effects of masculinization on OAEs may have been diluted.
CHAPTER IV

CONCLUSION

The results of this study did not show a statistically significant difference between OAE strength in heterosexual and homosexual females. This lack of statistical significance may be the result of small sample size or very heterogeneous mixture of homosexuals. Review of a graphic representation of the results suggest that the homosexual females did in fact have weaker OAEs than heterosexual females in both TEOAE and DPOAE measures, this result would be consistent with the theory proposed by McFadden and Pasanen. Further study is needed with a much larger sample size (McFadden and Pasanen had 237 subjects) and a better-defined group of homosexuals.
REFERENCES


APPENDIX A: Subject Consent Form
SUBJECT CONSENT FORM

The purpose of this study is to discern if there is a difference in the otoacoustic emissions between heterosexual and homosexual females, which could potentially aid in showing a biologic difference between the two groups, depending upon the results of the tests. The testing process will include a hearing evaluation, and a click-evoked and distortion-product otoacoustic emission test on the left and right ears. As only initials will be used in the recording data, participation in the study will be kept confidential.

Participation in the study is voluntary. No risk, discomfort or pain is associated with the study as all tests are routine clinical procedures.

If I have any questions concerning the study I may contact Ingrid Ellingson or Dr. Smaldino in the Department of Communicative Disorders at 273-2560 or 273-2542. If I have any questions about the research, or the rights of the research subjects, I may contact the Human Subjects Coordinator, University of Northern Iowa, (319) 273-2748. If at any time I wish to discontinue my participation in this study, I may do so without penalty.

I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement.

_________________________           __________________
Signature of subject or responsible agent       Date

_________________________
Printed name of subject

_________________________
Signature of Investigator