Book Editor's note: In this day of electronic publishing, tapes and compact discs come within the area formerly occupied by books alone, so that a review of such is appropriate to this column.

Auditory Demonstrations on Compact Disc

Prepared by A. J. M. Houtsma, T. D. Rossing, and W. M. Wagenaars.

Issued by the Acoustical Society of America, the Institute of Perception Research, and Northern Illinois University.
Price $20.00 per disc ($17.00 per disc on bulk orders of 5 or more to a single address). Available from the Acoustical Society of America, 500 Sunnyside Blvd., Woodbury NY 11797.

Auditory Demonstrations on Compact Disc, currently distributed by the Acoustical Society of America, is the direct descendant of the 1978 collection of psychoacoustical demonstrations popularly known as the Harvard tapes. Those taped demonstrations were created in the laboratory of Professor David M. Green, then at Harvard University. They included 20 demonstrations, selected by an international committee, and were recorded for the most part by Daniel Weber, now at Wright State University.

The Harvard tapes were an immediate success. The topics chosen illustrated the major principles of hearing that are typically emphasized in an introduction to psychoacoustics. The demonstrations were cleverly executed so that a listener could appreciate the principles involved, even when presented through loudspeakers in a lecture hall. The narration by Professor Ira Hirsh (Central Institute for the Deaf) was concise and informative, and a booklet accompanying the tapes included background information, pertinent details of the demonstrations, and references. The Harvard tapes had two major shortcomings. First, not enough copies were produced to satisfy an eager hearing science community. Second, the intrinsic limitations of the cassette tape medium compromised the audio quality, especially for narrow-band signals.

The compact disc demonstration package, created at the Institute for Perception Research in Eindhoven and produced by Philips in Holland, should become even more popular than the original Harvard tapes. There are 39 demonstrations as listed in Table I. Numbers in parentheses are cross references to demonstration numbers on the Harvard tapes. Where the cross reference number is followed by an asterisk, the compact disc demonstration is essentially identical to the Harvard tape version. The table shows that some Harvard demonstrations have been divided into two compact disc examples. Missing from the compact disc are Harvard demonstrations numbered 8 and 13, both having to do with speech. The compact disc is entirely psychoacoustical.

Contributing to the success of the compact disc is the fact that this package retains all of the best features of the Harvard tapes. The narration, again by Ira Hirsh, is even more concise. The sound quality on the compact disc is superb. Although many of the demonstrations are the same, the production and recording are new, and in the digital domain from start to finish. Sine tones recorded on the compact disc come out bearing a striking resemblance to sine tones. The 39 demonstrations are conveniently indexed by 80 track numbers, permitting considerable selectivity. It is easy to find any particular demonstration rapidly.

The accompanying booklet is boxed with the compact disc and is well written. Most important, it is well correlated with the recorded demonstrations and seems to make accurate statements about what is actually record-

TABLE I. Thirty-nine demonstrations included in *Auditory Demonstrations on Compact Disc.*

Section I. Frequency analysis and critical bands
(1) Cancelled harmonics (10)
(2) Critical bands by masking (1*)
(3) Critical bands by loudness comparison

Section II. Sound pressure, power, loudness
(4) The decibel scale (17)
(5) Filtered noise (15*)
(6) Frequency response of the ear (9*)
(7) Loudness scaling (17)
(8) Temporal integration (7*)

Section III. Masking
(9) Asymmetry of masking by pulsed tones (4*)
(10) Backward and forward masking (20*)
(11) Pulsation threshold (18)

Section IV. Pitch
A. Pitch of pure tones
(12) Dependence of pitch on intensity
(13) Pitch salience and tone duration
(14) Influence of masking noise on pitch
(15) Octave matching
(16) Stretched and compressed scales
(17) Difference limen or jnd
(18) Linear and logarithmic tone scales
(19) Pitch streaming (18)

B. Pitch of complex tones
(20) Virtual pitch (16)
(21) Shift of virtual pitch
(22) Masking spectral and virtual pitch (16)
(23) Virtual pitch with random harmonics
(24) Strike note of a chime
(25) Analytic versus synthetic pitch

C. Repetition pitch
(26) Scales with repetition pitch

D. Pitch paradox
(27) Circularity in pitch judgment (5*)

Section V. Timbre
(28) Effect of spectrum on timbre
(29) Effect of tone envelope on timbre
(30) Change in timbre with transposition
(31) Tones and tuning with stretched partials

Section VI. Beats, combination tones, distortion, echoes
(32) Primary and secondary beats (19*)
(33) Distortion (12*)
(34) Aural combination tones (19*)
(35) Effects of echoes (2*)

Section VII. Binaural effects
(36) Binaural beats (6)
(37) Binaural lateralization (14)
(38) Masking level differences (11)
(39) An auditory illusion

ed. Together the recordings and the booklet are not so complete that a beginning student can be given them and told to learn some psychoacoustics without further help from an instructor, but anyone with a background in some branch of acoustics could find the package a fascinating introduction to psychoacoustical principles, and the references in the booklet serve as a good start for further reading.

One can, of course, always find things to complain about. The loudness versus bandwidth demonstration (number 3) suggests that the critical band at 1000 Hz is about 300 Hz wide. That this is about a factor of 2 larger than values found in masking experiments is not noted. The magnitude estimation stimuli in demonstration 7 include a standard on every trial. According to the procedures employed by Stevens and others (e.g., Stevens, 1971), this is neither necessary nor desirable. The corresponding demonstration on the Harvard tapes did not have a standard; using it, I found that the estimations from 150 students in a lecture class gave a good power law with the right exponent.

Most of the demonstrations on the compact disc that are not on the Harvard tapes have to do with pitch perception. These maintain the high standard of the other demonstrations, and some of them are very entertaining (for example, demonstration 16, the mistuned Hofbrauhaus tune originally from Ernst Terhardt). Generally, though, the pitch demonstrations are likely to be less successful than those on other topics because of the subtlety of pitch and the variability among listeners when there are only a few examples. Individual differences are bound to show up in such demonstrations as number 12, the dependence of pitch on intensity.

Demonstration 25 intends to show that a pair of upper harmonics can be heard either analytically or synthetically. I found a strong tendency for listeners to hear analytically and that they did not hear synthetically even when told what to listen for.

Demonstration number 13 on pitch salience and duration might have concentrated the stimuli at smaller durations to good advantage, and the text does not explain that equal pitch salience for different frequencies is neither the constant number of periods nor the constant duration but something in between. In demonstration 14 on noise induced pitch shifts, the noise band edge is far enough removed from the sine tone that a high reproduction level may be needed to exhibit the shift reliably.

Demonstration 32 on secondary beats and demonstration 34 on aural harmonics are somewhat dicey because they intend to demonstrate distortion in the auditory system. If there is distortion in the sound reproduction chain, one risks misrepresenting the effects attributable to the auditory system itself. Although these demonstrations are far better on compact disc than on cassette tape, the final result depends upon the accuracy of the loudspeakers. Paradoxically, if there is distortion in the loudspeakers, then the demonstrations appear to work better, better than they should.

When hearing these recordings, the listener must remember that the requirements for a good demonstration are quite different from the requirements for a good experiment. Experimetally, one tends to randomize stimuli whereas in a demonstration of the Harvard type there is a fixed sequence. The context provided by the sequence can produce unanticipated effects. For example, demonstration 8 on temporal integration has a broadband noise background and a regular series of eight noise bursts of decreasing level. I found that for some pulse durations I heard *nine* noise bursts, an observation that implicates auditory induction, which is not the point of the demonstration.

Demonstration 21 intends to show the "first effect of pitch shift" using three successive Fourier components separated by 200 Hz. The frequencies of the components are incremented in 20-Hz steps, starting with a harmonic complex (harmonics 4, 5, and 6) and ending with another (harmonics 5, 6, and 7). From Patterson's 1973 data or Goldstein's 1973 model one would expect the inharmonic tones to have multiple pitches with the most salient of these first high and then low compared to the standard harmonic pitch. I found that seven listeners out of seven heard a pitch contour that always rises with no significant descent anywhere in the pattern. This is probably the result of the regular sequence of frequency shifts. The demonstration, therefore, exhibits a new and unannounced form of the Escher–Shepard illusion. It is herewith announced.

Similarly, demonstration 26 on repetition pitch includes pulse pairs with a time separation that spans five octaves. At the top end, the corresponding pitch is nearly 2000 Hz. According to the data of McClellan and Small (1967), the pitch near 2000 Hz should be feeble indeed. One suspects that the sense of pitch that is actually heard in the recording owes much to the sequence, an ascending diatonic scale with the first several octaves in a range where repetition pitch is strong.

Minor complaints aside, the fact is that *Auditory Demonstrations on Compact Disc* is a landmark contribution to psychoacoustical pedagogy. The demonstrations were well conceived and beautifully executed. The pace of each demonstration is highly professional. In sum, it is a first class piece of work.

WILLIAM MORRIS HARTMANN
Physics Department
Michigan State University
East Lansing, Michigan 48824

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