

Are ageing ears really as sluggish

An article in the June issue — "Hifi Sound But Lofi Ears" — seemed to create considerable interest, being taken up, I understand, by groups catering for the hard of hearing. But it also raised again the old question: are ageing ears really as limited as the literature says?

In so phrasing the above introduction, I may appear to be drawing a distinction between theory and practice — an old source of contention referred to again in the last instalment of "Forum". But I'm not being inconsistent; some of the theory to do with aural perception is rather tentative, while a lot more remains to be done on the practical side as well.

But let's not get sidetracked.

On page 45 of the June issue, we published a table suggesting that, with "clinically normal" ears, the upper limit of hearing diminishes from about 18,000Hz at age 10, to about 4000Hz at age 80 — a loss of about 2000Hz for each additional 10 years in age.

On page 46, we showed a set of curves indicating the progressive loss in aural acuity for frequencies below the upper limit. It was apparent from the curves that the gradual loss in treble response is roughly equivalent to turning the treble control progressively back to full cut — a situation reached by people in the 50-60 year age group.

HISS LESS NOTICEABLE

A further set of curves on the same page showed how progressive high frequency hearing loss can diminish awareness of tape hiss, particularly for people in the over-50 age bracket.

While such curves must be regarded as an approximation only, they are at least "in the ballpark" and they are in accordance with everyday observations:

Adults do show a measurable, progressive loss in aural acuity, especially at the higher frequencies. Top-cut filters and tone controls do seem to be less drastic in their effect than once they were. Octogonarians do complain that people no longer speak distinctly — because they can no longer hear the sibilants and the explosive sounds.

With the passing years, tape hiss does seem to be less of a problem than once it was, with noise reduction systems appearing to be more of a fad than necessity!

For most people, the loss of aural acuity is very gradual, being rendered the

more so by a degree of unconscious accommodation. Indeed, some people can become quite resentful of any suggestion that their hearing is not as keen as it used to be.

Those who take it the hardest are people who have relied on their hearing for their livelihood: musicians, broadcast operators, studio panel operators, hifi equipment engineers, music critics — and hifi journalists; people like B.F. of North Sydney, a long-time reader of the magazine and one whose name we remember from other days. He writes as follows:

Dear Mr Williams,

It is getting too close for comfort to 40 years since I entered broadcasting. In my studies, I learned about the way hearing falls off with increasing age, as discussed in your recent article.

But, somehow, the old technicians seemed to have an ability to hear things, despite what the textbooks said. I have often wondered if people's hearing did not deteriorate as much as the books said — provided they had really been using the faculty of hearing high frequencies.

Faculties not used do tend to waste away and, in the pre-hifi days, why would people in western society need high frequency hearing? To those people who rubbish the advance in technology,

Referenced to clinically normal hearing of 20-year-old females (0dB), these curves give some idea of the gradual loss of aural acuity with increasing age. The dotted curve shows the response of a typical hifi amplifier system with the treble tone control set for maximum cut.



FORUM

Conducted by Neville Williams

the very availability of hifi equipment of a standard undreamed of when I began broadcasting, may have the effect of sustaining high frequency hearing.

Unfortunately, researching this would not be the sort of exercise that an academic could get into and out of quickly, with a research paper under his arm to help him in his upward climb. It would be a very long project to measure the hearing of broadcast technicians, when they first entered a station, then monitoring their hearing for the next 45 years, until retirement.

In my own case, one ear is markedly inferior to the other but, while it is 20 years since I left broadcasting and while I am getting too close to 60 for my liking, I still think my good ear has retained better high frequency hearing than I could have expected from the figures you gave.

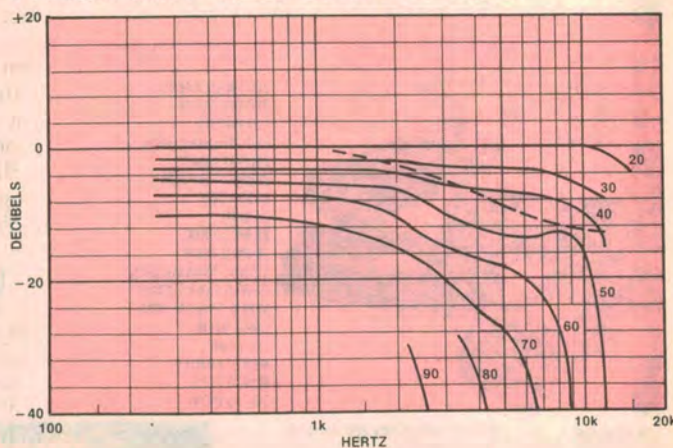
Roll on FM and high frequency sound! B.F. (North Sydney, NSW).

My first reaction to the letter was to say: "I know how you feel, B.F."

There is a certain frustration for a hifi enthusiast to feel well in other respects but to know that one's high frequency perception is sliding inexorably "down the drain".

The frustration is heightened by the thought that there is really not much one can do about it. The curves might suggest the possibility of compensating the

FREQUENCY RESPONSE V. AGE



as the books say?

droop by advancing the treble control — but only providing the amplifier and tweeters can handle the higher output and the family can put up with the sssibilant ssssound!

And even then, no practical amount of treble boost can compensate for the usual "brick wall" roll off at the top end. If the hearing rolls off at six or eight or 10kHz, then that's it, treble boost or no treble boost!

Nor do I know of anything to support B.F.'s fond hope that high frequency acuity has been — or will be — preserved by "exercise", as provided by wide-range hifi equipment. After all, there are plenty of age-old natural sounds which have an aurally delicious high frequency content, but they haven't kept us aurally fit.

VOICES FROM THE PAST

In acknowledging B.F.'s letter privately, I could only concede that: "technicians may develop a certain skill in using the aural faculty that remains, but not of actually hearing what, to them, is inaudible". Reading it again, I must admit that it sounds like a fairly lame statement.

There the matter might have remained had I not, quite by accident, come across an item in the October 1951 issue, while looking up references for last month's: "Let's Buy An Argument — Where It All Started". It was a letter written by "Diallist" of "Wireless World" fame, which we reprinted under the heading "To Hear Or Not To Hear". . .

It seems that Sir Ernest Fisk, at that time Chairman of EMI Britain, had just announced to the Royal Society of Arts that his Company had been successful in recording frequencies on wax disc of up to 20,000 c/s. (Hz came much later). Diallist's first reaction was to suggest that "aged dodderers" like himself, who normally have a cut-off in the neighbourhood of 10,000-12,000 c/s, might well retort: "So what?".

Somewhat abbreviated, his letter continues:

But when Sir Malcolm Sargent and others maintain that even higher frequencies may have to be recorded in order to obtain complete realism in reproduction, you begin to do some thinking.

At first blast, the idea seems utter nonsense. How can we be affected by the presence or absence of frequencies that we can't hear? And then something at the back of your mind whispers: $f_1 - f_2 = f_3$ in other words: two supersonic frequencies may produce an audible beat frequency.

It seems possible that, when an or-

chestra is in action, the supersonic harmonics of certain instruments do produce such beats. If they are absent from an electro-mechanical reproduction, it doesn't sound quite real.

If the original supersonic harmonics are, say, 19,000 and 21,000 c/s, the beat will be at the audible frequency of 2000 c/s. Assuming that there is such a beat and that I record and reproduce up to, perhaps, 6000 c/s, why should not the beat frequency of 2000 c/s be adequately brought out, even though the generating frequencies are removed by the cut-off at 6000 c/s?

The answer is that non-linearity is required somewhere in the system to produce the beats. If the recording system is totally free from non-linear distortion, the beats will not be generated as such in the record, nor will they be present in the reproducing equipment if it is similarly distortion-free.

Not until the original supersonic frequencies reach that non-linear device known as the human ear will the audible beat frequency emerge.

So, if you want to cut off at 16 kc/s in recording, you must do your mixing before that and introduce some non-linearity before or in the cutter head, if you want to generate and record those beats. Which poses the question: if one records only audible frequencies, how much non-linear distortion should be introduced for realistic reproduction? ("Diallist").

MUSICAL BEATS . . .

Perhaps I should explain that, a couple of months prior to the publication of Diallist's letter, there had been spirited debate in the "Let's Buy an Argument" columns on the subject of musical beats — the effect that musicians make use of to help tune musical instruments. There seemed to be fairly common agreement, at the time, that our awareness of beats was a by-product of basic non-linearity in the human ear.

The letter from "Diallist" added a new dimension to this discussion. On the assumption that the ear could indeed behave as a non-linear mixer, he was suggesting that the intermodulation products would range far beyond the slow, pulsating beats observed by instrument tuners; that they would cover a whole range of audible frequencies and be produced even by the intermodulation of overtones in the supersonic range.

(For this argument to hold good, frequencies outside a person's audible range would still have to be processed by some part of their hearing mechanism

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FORUM — continued

— eg the outer and middle ear — to produce the beats which could penetrate the otherwise unresponsive inner ear. Whether or not it could happen this way, I leave to others to decide).

The argument advanced by Diallist was clear enough, however: when listening to a live musical performance, the subjective listening experience is not confined to frequencies which are generated and heard directly, but include a whole spectrum of intermodulation products.

How the brain might interpret these modulation products is a fertile area for speculation:

- Optimistically, the brain might learn to perform a kind of "instant Fourier analysis" and add further overtones to the frequencies which the ears are processing directly.

- Pessimistically, and especially in the presence of high aural non-linearity, the brain may not be able to cope with the modulation products and may register a strong dislike of complex musical sound. There are any number of people who do react in this manner and it could be for this very reason.

BACK TO B.F.'s LETTER

Curiously, this kind of thinking, extrapolated from what Diallist penned in 1951, brings us back to the letter from B.F., mentioned earlier. B.F. is searching for a reason why older broadcast station operators (allegedly) seem to be able to sense more about sound quality than would seem likely from their aural response, as measured with a single, variable tone audiometer.

Superficially, I can advance no reason why broadcast operators and their ilk should have any more extended hearing than the statistics suggest. Indeed, they might even end up below average if they have been indiscreet in the matter of listening levels! But could it be — just could it be — that they have learned to make better than average use of the intermodulation products which are still within their range of hearing?

Diallist — in 1951 anyway — seemed to support that possibility.

It's a very tenuous proposition, B.F., and I'm not suggesting that it could be a substitute for the athletic hearing of youth, but it may just be a small compensation; a reason why a musically educated brain may develop what I suggested earlier: "a certain skill in using the aural faculty that remains."

Of one thing you can be certain B.F. There are plenty of people who would share your fervent hopes that there is more to hearing than a straight-out single-tone audiometer test; people who would welcome even a temporary "stay

of execution" in the auditory sense!

But let's think again about Diallist's letter:

When he wrote as he did in 1951, he was speculating both about intermodulation effects in human hearing and the role of non-linearity distortion in sound recording and reproduction systems. If it was not possible to cope with the entire energy spectrum of music, he wondered, might it not be wise to design a specific amount of non-linearity into the system to create and retain intermodulation products of the magnitude that the listener's brain expects?

When I re-read this letter, a couple of weeks ago, it reminded me of a test record issued some time back by Ortofon; in fact two similar test records: a direct-cut version 0001 and a tape-mastered version 0002.

One group of tracks on the first side carries pairs of high frequencies, spaced 1kHz apart, which are intended primarily to provide a measure of the intermodulation distortion percentage in a disc replay system.

The first such track contains frequencies of 20kHz and 19kHz. Both are well above the range of normal hearing but, when the track is played, a 1kHz difference tone can be heard, not loudly but quite distinctly. Following tracks provide frequency pairs at 18/17kHz, 16/15kHz, 14/13kHz, etc, some of which will also lie beyond the hearing range of many mature adults.

For the purpose of identification, the high frequency signal pairs are coded into repetitive long and short dashes, forming the Morse code letter "N". A pure 1kHz reference tone occupies the intervening spaces, thereby forming the Morse code letter "A". If the difference tone (letter N) is less loud than the reference tone (letter A) it is an indication that the intermodulation distortion through the entire system, as heard, is less than 2%.

First Aussie valve?

"Wireless Weekly" for Sept. 29, 1933 carried a picture of a rather modern looking "80" type rectifier with a caption to the effect that it was the first valve to be manufactured in Australia. It may have been the first valve from the then newly constituted Amalgamated Wireless Valve Company but, in his book "70 Years of Radio Tubes and Valves", New Zealand Author John Stokes states that valve manufacture had been undertaken in Australia by AWA "as early as 1920", an early example being the AWA "Expanse B" valve.

In the relevant explanatory notes, Ortofon observes that, if the reference tone "A" is the louder, the system is All right. If the difference tone "N" is the louder, then that is Not good!

In my own system, the test indicated that the intermodulation distortion was a lot less than 2% — ostensibly a desirable result. But, even so, the difference product from the two test tones was clearly audible suggesting that, even with a direct cut analog disc and good quality everything else, spurious intermodulation products are present.

How much worse they must have been in 1951!

I took the opportunity to repeat the tests with the treble control and filter both set for minimum response, thereby virtually eliminating the high frequency source tones from the power amplifier and loudspeakers. It made virtually no difference to the N/A ratio, indicating that the 1kHz difference tone had already been generated in the record/replay system and prior to the tone control stage; the contribution from the output system and from my ears seemed to be negligibly small.

Perhaps, if Diallist had been able to make similar observations in 1951, he might have reached a different conclusion.

NON-LINEARITY . . . NO!

Having just been through the exercise, however, I cannot escape the conviction that non-linearity distortion is a liability at any level, and I doubt very much its ability to compensate for frequencies which fall outside the passband of either equipment or ears.

Sorry Diallist and sorry B.F. for having dangled a carrot, earlier in the article, only to whip it away at the end!

In offering the foregoing opinion, I had better be right because, if I'm wrong, the world audio industry will share the egg on my face.

In recent years, the entire hifi industry has embraced sampling and digital techniques, ranging from FM-stereo multiplex to digital tapes and discs. All of these systems involve a sharp roll-off filter operating just above the audible frequency range — by implication rejecting the musical significance of possible supersonic overtones.

Not only that, but systems like the compact disc and VCR-based digital tape recording have further transgressed Diallist's proposition by virtually eliminating distortion and the consequent generation within the system of spurious difference tones.

Nothing personal . . . but one can only hope that Diallist was wrong on this particular occasion.