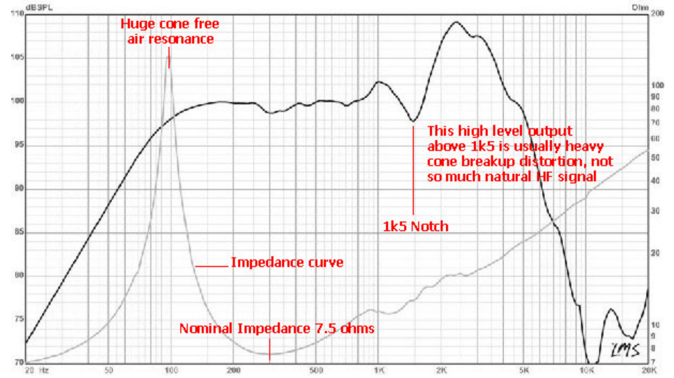
Do valve amplifiers and transistor amplifiers sound and behave differently?

It seems that this is frequently the case. But, as every scientific person knows, you cannot get something for nothing. Surely, there must be an explainable logical reason for this.

The first point of note is the obvious difference between a valve and transistor output stage. The latter does not employ an output transformer (OPTX). This component is rarely referred to in the gutar amp world and I shall explain why the humble OPTX has such a big effect on the tone and volume. The reason it's the single biggest contributor to the differences, is because it contains a large amount of copper windings which significantly increases the impedance of the output stage. This greater 'impedance' causes a reactive load to behave very differently to a simple resistive load which affects everything in ways you might not have thought about before.

We technicians should all know that valve amplifiers generally have their power measured at 1kHz into a resisitive dummy load allowing for 5% THD and referenced to the AC supply voltage, being either 230VAC or 115VAC, according to the local supply. This method measures power across the load resistor where the load is the same value, say 8 ohms, at all frequencies. The problem with this method is that a reactive speaker load with a nominal impedance of 8 ohms ***is not 8 ohms at all frequencies.*** With reference to Fig 1 above, you can plainly see the impedance curve of the 12" guitar speaker - the lower grey line with the big hump at about 80-90Hz! **The speaker is actually 12 ohms at 1kHz... not 8 ohms... so, with a speaker load, it cannot produce the rated 30 watts ouput - where: $VAC^2/R = 15.5^2/8 = 30W$.** Assuming that the AC voltage across the load is constant at all frequencies, *which it is not for a transformer output*, then the true power would only be around 20W. And at 3kHz the ouput power would fall to: $VAC^2/17ohms = 14W$. This is also true for a transitor amplifier too, but less of a problem for a valve amplifier, as I shall explain.

The response curves for an Eminance 'Cannabis Rex' speaker



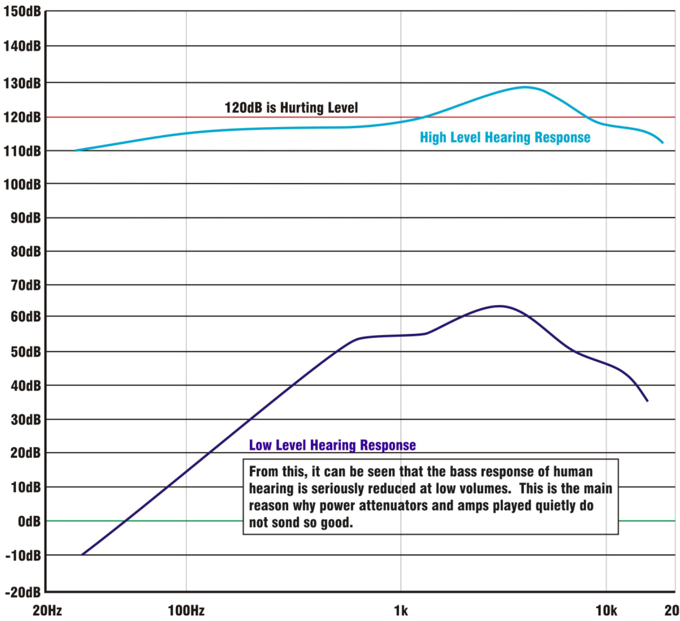
Because the output transformer (OPTX) has quite a lot of copper in it's construction for the windings, there is obviously going to be a fair amount of DC resistance in addition to the AC impedance of the windings. This all adds up and causes a high 'output impedance' compared to a transistor amplifier. We should also take into account the impedance of the power supply, but for simplicity, we'll just look at the output stage for the moment.

The 'resistance' in the OPTX windings is effectively in series with the load impedance; so for a pure resistive load, the voltage across it will be fairly constant regardless of its frequency. However, with a reactive speaker load, who's impedance changes enormously with frequency, the AC voltage across it will vary, because the current flow reduces through the speaker as frequency and impedance changes. As the OPTX windings 'resistances' are in series with the speaker, the resistance and speaker form a potential divider. So the AC voltage on the hot terminal of the speaker can be seen to vary as you 'sweep' an audio signal through the audio spectrum. As you do sweep the signal through the audio band, you will also note that the signal across the speaker will start to rise and fall at many different frequency 'spots', generally above 800Hz. They are called, resonance nodes and is caused by the cone having coincident resonances. At these nodes, the current flow through the speaker is decreasing, due to slightly increasing speaker impedance, and causing the corresponding rise in AC voltage. You will also be able to see the speaker's natural free air resonance peak, when you sweep the audio signal down to around 75-90Hz. This is a huge rise in speaker impedance, so the voltage increase at this node will be very large indeed.

So what happens here, that does not happen with a conventional transistor amplifier, is that as the AC voltage on the speaker's hot terminal rises due to rising speaker impedance and falling current flow. This rise also significantly offsets the fall in output... simply because the voltage across the load has risen and raises the ouput power proportionately. It's a kind of 'positive feedback.' This means that amplifiers with an OPTX driving a speaker load, will produce more acoustic output when the speaker's impedance rises. You'll hear a huge output at the speaker's resonant frequency around 80Hz and significantly increased treble output too. This is all due to the OPTX's high output impedance (incorporating resistance).

This *effect* will be absent from a conventional transistor amplifier, because the ouput stage has a very low output impedance. In fact, it can be just the value of the power transistor emmitter resistors... about 0R33... for practical consideration. So the voltage variation across the load will be practically constant regardless of the load impedance variations. Thus, the amplifier will not have the varying nodes visible either! Its output will sound flatter in the bass regions and less bright at the high end. Clearly what musicians mean by saying that "tanny amps sound cold." However, this can be cured and the tranny amp made to perform as if it had an OPTX, but I shall explain this later.

OK, back to valve amps. Let's not forget, that amplifiers with an OPTX will have some *insertion losses* too. Also, an OPTX cannot optimally match the speaker(s) at all frequencies, so we must bare in mind that the LF and HF band output will roll off a little in addition to the speaker's varying impedance. So at LF and HF there is quite a lot of mismatching going on. I think you can hear this, because a valve amplifier tends to have a much warmer mid range output than a tranny one. The tranny amp is efficient and accurate... that's not a fault - they do their job admirably. But it's the *beneficial defects* of a valve amplifier that creates the sounds we have come to expect and love.



From this, it can be seen that the bass response of human hearing is seriously reduced at low volumes. This is the main reason why power attenuators and amps played quietly do not sond so good.