The brain. (A most complicated part)
At first I most emphasise that we are human beings. We have developed a language and an enormous capacity of memory. ***We can remember***. That capacity alone is what differentiates us from the animals. But more important, the simple fact that we have survived the harsh nature as animals, despite our as single individual very low probability of surveillance, tells that we further must have developed our sense of hearing. Remember that half the time of your existence is in the dark and further in sleep.
When you listen, the brain sorts in the signals, building up an understandable picture of the event, based on recognition of sound and reflections built up from early childhood if it can. ***The result of this selection is what you seem to hear***.

Listening to reproduced sound and the recorded overtones and reflections are mixed by distortion or disturbed in phase, the brain can't detect them correctly and therefore they will be interpreted as sound formed around the instruments, whereby the sound stage becomes flat.
If the amount of low level information is lesser disturbed, then the brain will detect it as filling the room between the artists, the walls and the ceiling as reverberation and hopefully some of it as overtones attached to the single instrument. You can now detect a room, but still it is attached to the sound of the instruments, as if the artists turn their back to you. The instruments become like reflected sounds supplied with some sort of distortion, hard for the brain to interpret, why it puts that on the instruments, and they at some notes sound a bit distorted.
NB! Sometimes it helps turning the absolute phase.
First when all information are reproduced sufficiently correct, the brain can do its job, to separate the instruments from the sounds from the surroundings. Listen for the ***silence between the sound and its echoes.***
The needed information for a good perception is normally present in many recordings, but can be very troublesome to dig out.
That production of discs and records vary so much in quality, is an other story. But let us communicate to find good labels and discs, easy for the brain to understand.
The brain tries to make sense in the tiny sound of noise and wrongdoing, and will try to interpret them as parts of it all. If they can't be translated as overtones or reverberation, what they often will be, we'll hear them as distortion. So even if you think, you have a big sound of reverberation, it doesn't mean that it is in order. To find out if it is, you should listen for the silence between the primary sound (the artist) and the secondary sound (the reverberation), clearly heard on recording of classical music or recordings from a church.
A phenomenon, you further have to take in consideration, which the brain can detect, is ***the absolute phase.*** It can be heard as distortion or as an unsettled picture of sound.
This phasing must be correct, else you will not be able to judge the

correctness of the reproduced signal at all.
The absolute phase differs from disc to disc and can furthermore differ in one take from instrument to instrument, believe it or not.
All needed by the recording should according to Richard Heyser be a single clap of a pair of hands. In that clap all necessary information for later improvements of the recording are present. As it is now, ***you are the judge***. There are no help to find anywhere, than in your brains capacity to distinguish between over- and under-pressure. It would be wonderful if someone could develop a device that could tell us this absolute phase from the signal itself. It should be possible, as transients have a tendency to generate a low frequency unbalance, which could be used for that purpose.
Try to change the absolute phase, playing a recording made in a church. If you can't hear the difference, something is very wrong somewhere in your equipment.
This absolute phase has also to be correct, all the way from the main outlet through cables and components to the loudspeakers.
This goes for power source, the one you can feel with your fingertips on the cabinets, and equally important, cable direction must be correct. Why? I don't know for sure.
A bet would be that it is a question of treatment of distortion slightly different for the positive and negative half caused by net polar diode-effect between the crystals and the facts that high and low level aren't treated equally. To make it even more complicated the direction is further dependent of the frequency the wire is carrying. When it is used for digital transfer, you can't be sure that the direction is the same as for analogue transfer.
Should you be the owner of a single-end amplifier you even have an absolute phasing between that and your loudspeaker to complicate it all.

The brain, the near future, and some thoughts.
In this chapter I will try to give an explanation of how I think the brain works with sound. It must be understood that our hearing is the latest of our senses to be developed and that it is ***the most important one*** for our surveillance, as it out of our 5 senses is the only one always turned on. Even when you are unconscious it still works. You can't react on its information, but they will be stored no matter what.
Our nerve system has a reaction time at about ***one tenth of a second***. In this little time the brain interprets the information received, before they are presented for your conscious mind.
From the information it somehow builds expectations of what to come, to verify rhythm and melody in music or concentrate on speech, whereby it suppresses disturbing sounds. It so to say reduces and sorts in the amount of information received from the ear nerves to concentrate on, what it expects to come – to listen for.
But there is also ***a short cut***, always open for transients and some unexpected silent sounds. These serve as a signal of danger, to zoom into and especially listen for in the sounds treated by the brain. These specific sounds serve in the same time as a trigger signal for

production of adrenaline - surely a reminiscence from our wild life.
The silent sounds are of great importance. Just remember, how scaring tiny sounds in silence could be from childhood in the dark.
These silent sounds are even stranger - how can we distinguish them from other more noisy sounds? Simply because they are not expected. They are out of order so to say.
If you are a trained listener, you often feel these signals more than you hear them, you get warm or irritated - the adrenaline productions is raised. A fact you are not consciously aware of.
By use of these signals, the brain can, so to say, ***look into the future*** (1/10 of a second or more) and simultaneously use them in the sort of the sound received. It if necessary even can clear the working area from which the conscious mind is fed, prepared with all capacity to recognise the echoes of these trigger signatures. Some information is thereby left untreated – masked - and so to say not heard. This is strange but true. Further it can listen for these recognisable echoes deep into the noise around us. (Up to -20 dB below the level of noise. Experienced in space communication).
The brain does more than that. Based on music or sound received, it somehow builds ***expectations for further development.***
When in a piece of music, unknown to you, a wrong key is struck, or your loudspeaker colours one tone, you react. Why? You know neither the piece nor the specific instrument.
Should it be a Steinway grand, its resonant character doesn't bother. Modern music, where the development can be hard to predict, is of most music lovers heard as noise.
A tone from a clarinet, sampled and used for the rest of a keyboard, sounds wrong except from the sampled one - again how can we know?
I'm sure that our perception of sound is heavily ***based on predictions***. Are they right you feel good, and starts singing along. Are they too often very wrong you get irritated.
Pianists, to get the music more tense, earlier used a playing technique where the rhythm was changed just a little bit, called rubato. - Disturbance of expectation.
Before we continue, I must emphasise, that ***sound happens in the run of time*** - that you can't freeze it, as you can with a picture.
All that really matters, are the brain and its tremendous work in the dimension of time, with that enormous amount of time-distorted information.
I really get more and more impressed of its capacity. That our hearing never rests even if you are unconscious, and that it is the last of our senses to be developed, tells the importance of that sense in particular.
It is well known that closing your eyes and open your mouth will improve your hearing capacity - you look foolish but what ever.
Anything that helps you understand the event better, should be judged as good no matter, what measurements say.
It is e.g.. well known, that distortion distributed in the right manner makes sounds more realistic, than with no distortion. Does air distort? Is that distortion part of our expectations?
It is also well known that ***a loudspeaker with linear frequency***

response sounds wrong, compared to one with mild decaying level towards the upper end.
But beware! There are traps of simplicity and emotional taste for the brain within to rest.
To understand, what I mean, think on pictures, painted contra photographs, or photos with low contra high resolution, graphics to pictures with a myriad of grey tones. What do you prefer?
You should of course prefer that with a myriad of grey tones following logic, and none of the others. But all the different ways of reproduction can be used, for you to see the subject. The principal question remains, if this analogy can be used for our hearing - which does the brain use?
I would guess the last two in combination. Graphics for instant recognition and gradually within parts of a second adding more and more detail much like a painting is started from raw sketch to the end result. In this work many hear it as right that the reproduction is marked with a multitude of resonance. Much the same as the intensity of colour on the TV is chosen too high. No matter how pleasant it may seem – it is wrong.
Our brain only needs few seconds of sound, to manipulate with the signals building a kind of basic understanding of the sound received, and expectations of, what to come. This ability creates by itself traps at listening, as ***the brain will try to glamorise*** it all, it's an active part, especially experienced with musicians, who as critical listeners often are of no use.
If you are a trained listener, you possibly can listen to a whole piece of music and detect some information of the reproduction. But if you really want to listen for anomalies, you must cut the time span down to 2 - 5 seconds with pauses on minutes. In this way you will learn to feel the amount of work, your brain must perform especially in the first second. ***It is like physical work - you get warm***, if the work is hard, and it shouldn't be.
To make it all even more complicated, our brain is a multi-way listening device, where all senses plays their part simultaneously.
Our methods of measuring are normally done in ***one dimension***. But the 'Melissa' way, using a kind of step response, from which all single parameters as well as their time dependency is calculated, could serve as an analogy on a possible behaviour, done likewise by our brain. Our hearing capacity is influenced by the resonance of the auditory canal, which is coincident with the most sensible part of the Fletcher-Munson curve.
There must be either an enormous part of memorised calculations or a chain of comparisons done again and again for the decaying echoes, or a third possibility as the bit rate is known to be rather low, but with a great number of parallel connections.
The way the brain works must explain, why faults always are clearly heard in treble as well as in bass, especially when the low sensibility of hearing in these parts is taken in consideration.
It is well known that the brain can add deep bass to a sound, if the 2nd and 3rd overtone from the deep bass note are present and the deep bass not. I'm sure that the same procedure is valid for the treble. ***It is much***

more a question of phase than of level.
No matter how, our brain receives impulses from our ears constantly, and finds somehow connections in time, interpreted to music, speech and reverberation.
It is like watching a movie where every picture is doubled with its negative. Then there should be no picture at all. But if you now displace the film of negatives one picture, there still should be no clear picture. But now there are disturbances reflecting the differences between the two to show the movements in the dimension of time.
A waterfall plot illustrates the reflected sound and amount of resonance. The immediate plot being moved into the paper with constant speed should show how the sound itself develops. This movement will create the time in which the sound exists, and the reverberation following it in a further time span to form that mess from which your brain must extract the right information – not a simple task at all.
As you probably know, e.g. bats scream and build their orientation of the surroundings from echoes of this sound. I believe that we unwittingly use the same technique, but with parts of the sound itself. It is the drift of these parts in the time domain, shown on the waterfall plot, that is the cause of the strange differences, between what you can hear, but can't measure by one-dimensional measurements.
Sound is time dependent by nature, therefore all measurements concerning reproduction of sound should likewise be done in the time domain.
Our hearing capacity is more than 120 dB in the most sensible area around 3 kHz, therefore we must look for connections from top to bottom of this vast depth of level somehow centred around this frequency, where also you'll find the resonance for the auditory canal. Experiments with the digital medium has shown the importance of these low level signals, present in the signal or induced by the vibrating fields around the active parts of the hardware.
This medium has shown to be trustworthy as a storage medium, where film, tape and LP's have failed. CD is further the only medium to hold up to 100 dB of dynamic, it is still not enough, but it will come soon. I have recently heard the DAD solution on 24 bit 96 kHz. - Surely a quantum leap, even if the postulated resolution isn't totally true yet. By playing you shouldn't expect more than 20-bit resolution for now, but that seems to be close enough. To reach 24 bit of resolution would demand so low level of noise that it will correspond to the noise from a 47-ohm resistor, why HDCD-technique probably will be needed, but less will do – of course.
Inspired of this I bought a Denon DVD 3000. This machine is particularly developed for DVD-video, where faults are visible. I shouldn't wonder, if exactly that explains the neutrality of this machine used as CD player alone. Our eyes are much more sensitive for change in colour than our ears are for change in sound, probably caused its resonant character. The bigger model is developed for the sound marked with HDCD and DTS – all sails are set – but neutral it isn't.

The “3000” was really a positive surprise. Not only have I got a new machine but also a new collection of CDs. It really tries to get the sound right. I can’t help it, but also this machine has undergone some modifications resulting in a sound I didn’t believe possible from a digital source.
The capacity of more information, especially of level, seems to cause problems. The silent parts aren't treated satisfactory well yet with 16 bit 44.1 kHz nor by the speakers, therefore parts of the silent sounds will be unconnected with the musical event, and be heard as distortion. This goes especially for overtones, which with the new standard, are treated far better. But at last we can detect these weak sounds, with an increased demand on the loudspeakers and the rest of the chain. That of course only if you want more than a soundpicture postcard.
This is for now my understanding of parts of the brain’s work, and I am more and more convinced, that in the brain’s complicated work, these trigger signals received the quick way play a much more important role than thought of. Isn't it possible that these guide the brain’s ability to concentrate on specific sounds?
A slightly change of these sounds and their drift in frequency and time gives a great change in the results the brain present to you, as the sound received one tenth of a second ago. This could be a possible cause of the spoiled sound from wire insulated with plastic. See under “Cables”
Those of you, who have worked with loudspeakers, have probably met this strange phenomenon. A change in the network for the treble can very well have consequences in the bass response, and the other way around the treble can start to lisp, so the whole frequency band and the whole hearing capacity is strangely connected. In other words - ***every single loudspeaker in a multi-way construction must follow the mathematically calculated slope of level to the level of noise. That is one goal to work for***.
A multi-way loudspeaker normally doesn't act as a minimum phase unit as a whole, which is the problem. But with my solution they all together behave as one and form an allpass function, which also like minimum phase systems where variation in phase and level is to calculate. With speakers attached to it, it forms a new bandpass-function with fare broader frequency-band and a turn of phase determined by the order and the Q of the crossover. **But there is no room for mistakes or rules of thump.**.
The turn of phase, the frequency response and step response is all-important. These should be mathematically connected as a whole, but are normally not. The more of the loudspeaker’s reproduction for these to be in order, the better it is understood by the brain. I shouldn't wonder if the step response would show to be the most important one. It shows all three at once if we can present it in an understandable three-dimensional way.
Let the enlarged middle-band be treated by one loudspeaker and add treble and bass with care - you'll never go wrong. But if you want the outmost from your speaker, you must go deeper. It can be done. The first construction in “Loudspeaker in practise” is an example on that

when normal/nearly normal speakers are used.

How the brain works in detail is still a mystery, but great efforts are done in that area in order to reduce the amount of information to be stored on disc. Also in the very interesting work on further development of Q-sound, hopefully ending in full surround sound created by two, yes! Two loudspeakers.
That I’m sure will bee the future - may these two be eminent.
We still are at the starting point of cleaning up in sound reproduction, to prepare the whole system to handle these very increased amounts of information now possible to store.
There is so much to do, as the hi-fi manufacturer still rummage about in the fifties to the seventies - there is refinements yes! But no real break-through. Hopefully this paper can serve to point out the direction, in which we have to move and develop.