

Why Is A Home Theatre System Marketed As A 5.1 System Rather Than A 6 System Even Though There Are 6 Loudspeakers?

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While this is not necessarily a question that an audiologist may ask, it summarizes much about room acoustics and speech acoustics. Simply stated, why are low bass notes non-directional and seem to spread out evenly in all directions, whereas this is not the case for the treble notes.

The short answer is that home theatre systems indeed have 6 loudspeakers, but the bass woofer (or sub-woofer) can be placed anywhere, facing the wall and behind a couch. This system then really functions as 5 loudspeakers coming from different parts of the room, and also “from somewhere”, the bass sounds. Manufacturers and marketers of such a system are quite honest and acknowledge that there really are only five directionally separate loudspeakers ... and one other, so this is marketed as a “5.1 loudspeaker system” (5 + 1) rather than a “6 loudspeaker system”.

The slightly longer answer is: Bass sounds have longer wavelengths than treble sounds. And as a rule of thumb in acoustics, for a sound to be obstructed by a wall, baffle, or even a couch, the obstruction must be at least $\frac{1}{2}$ the wavelength of the sound. A 4000 Hz wavelength is on the order of 8.5 cm $[(34,000 \text{ cm/sec})/4000/\text{sec}]$ whereas a 250 Hz wavelength is approximately 1.36 meters. Therefore, lower frequency, longer wavelengths are “blind” to an obstruction so sub-woofer loudspeakers can be placed behind couches in a room with no attenuation of their output. And specifically, 250 Hz sound energy would be “blind” to any obstruction whose diameter was thinner than 68 cm ($1/2$ of 1.36 meters)

But why are they also not directional? This is related to the obstructing, reflecting, or diffracting sound waves. Low frequencies do not “see” anything that would obstruct or reflect them. Coming out of a tuba, sounds do not see the brass wall of the tuba and as such the loudness of a tube is the same whether the sound is measured above the top of the instrument, behind, or in front of the tube player, as long as the distance is the same. Tubas, and other bass instruments are not directional. However, higher frequency, shorter wavelength instruments (such as consonants from the human vocal tract) have energy that bounce around and reflect off surfaces, emanating in almost a straight-line laser-like direction.

This is one reason why trumpet players in a symphony are placed on risers- the mid and higher frequencies emanating from a trumpet come out in almost a straight uni-directional line. Musicians downwind from the trumpet section are acoustically safer because literally all of the damaging energy of the trumpet section goes over their heads. And of course, trumpet players like to be seen-part of their “brass mentality” ... but that’s an entirely different issue.