Getting techno-physical

By Jörg Wuttke

Some basic knowledge for microphone users

Two different views of microphones

The artistic viewpoint sees the microphone almost as a musical instrument – an extra member of the orchestra or an accompanist to a singer. With such a view it can be very difficult to judge the microphone objectively. Elements of fashion, nostalgia and a degree of sympathetic magic can lead to a very subjective choice that owes little to rationality. The techno-physical approach is the reverse of this – a wholly reasoned and objective view that requires a basic knowledge of physics. Within certain restrictions the choice of microphone will produce a sound that is predictable and can be tailored with some precision to what is required.

Physics versus emotion

Despite what many would regard as the benefits of the techno-physical approach a great deal of the literature and advice on the use of microphones is based on apparently non-technical considerations. Often a microphone will be listed as best suited for vocals simply because it has, by chance, sounded pleasant on a previous occasion or looks similar in shape to one that was used in that way. Given that the majority of users of microphones have no engineering background and are far more familiar with the world of art this should not be surprising. They have no other guidelines to follow. Art and emotion do, without question, have a central position within music but, equally, the key to the successful recording of it is a technical understanding of the devices that need to be used.

Trying to muddle up both approaches in some haphazard fashion is no help either. That leads to quaint notions such as that tube (valve) microphones give “a warm sound” because they become physically warm in use – or that large microphones yield a bigger “sound image” (whatever that means) than smaller designs. This latter notion undoubtedly stems from folk-lore that has been fostered by those with vested interests in the promotion of large diaphragm microphones. In purely physical terms there is, of course, no requirement for the diaphragm to be large in order to be able to respond to low frequencies. Unlike a loudspeaker, where the diaphragm has to pump air to create the changes in air pressure that we call sound, the microphone is merely required to sample delicately these variations. Moreover a glance through this CD-ROM at the on-axis response curves for large diaphragm microphones should soon set the record straight about high frequencies too – and off-axis things are even less favourable. It is always a little surprising to find users intentionally choosing a microphone with an uneven response in the middle of the audio range and an early high-end roll- off governed by diaphragm dimensions, yet insisting on bandwidths flat to far beyond the limits of human hearing for every other item of audio equipment.

Exact science

If we can place emotions securely within the artistic realm then we can avoid treading on them when we deal with purely technical matters. That really is the only way forward. Alchemists laboured in vain for centuries using intuition, guesswork, fancies and feelings to achieve bold but impossible chemical transmutations, and it was only with the advent of a true science - one that builds one solidly proven step upon another - that progress became possible. This is something that students (of any age) should keep firmly in mind when working in a new field. If no real effort is made to study the history and the body of academic understanding that underpins it then the chance of advancing beyond the current state of wisdom is slender. Continually re-inventing the same wheel is a singularly pointless exercise. What the scientific approach specifically enables is a continuation from the point to which the subject had been developed previously and the opportunity to advance a further step. For example there is little hope of any progress in surround sound techniques without a familiarity with the underlying principles of stereophony, which itself is founded in monophonic acoustics and the process of hearing.

Vintage techniques for the future?

Nostalgia is a poor guide, no matter how comforting it can be to hang on to old technologies and techniques. There is indeed a wealth of marvellous old recordings but we have to be aware that their beauty and value may lie in the music, the performance or the occasion rather than necessarily in the use of an archaic recording technique. After all if we really believed that yesterday's methods and equipment were best we could never improve on what we know already. The industry would never have developed beyond the shellac disc and the sharpened thorn.

This is not to say that every development results in better equipment or, more importantly, better recordings. Every innovation needs to be tested and proven – which leads us to the awkward problem that some of the steps forward are very small ones. To hear them requires controlled listening under good conditions and, above all, with a proper reference but all too frequently a new product or design is assayed in splendid isolation. Expectation or fervent belief that it must be better strains judgement and within a short time highly coloured opinions are circulating and a myth is built which is as baseless as it is hard to eradicate.

Making comparisons

There really is no alternative to properly controlled listening tests if audio devices are to be compared in an impartial way. AB tests are limited to distinguishing the better of two options but they alone can reveal what differences there are and if, in- deed, they actually exist. And "properly controlled" should not be skimmed over lightly – for instance, adjusting levels needs to be carried out with great precision since, with signals of equally high quality, even an almost imperceptibly higher level on one will skew judgements in favour of it. Such experimental pernicketiness has to be refined even to the extent of intentionally adding a small imbalance of levels but on a reciprocal basis where, say, microphones have different frequency responses that affect perceived loudness.

Microphones for a particular use?

Although it is extremely common to be told that such and such a microphone is good for, say, violins this poses the question of why it should be considered to be so. Should a microphone be chosen purely on the grounds of what the sound source is? We don't, after all, have more than one set of ears to hear everything and common sense dictates that if the microphone is an ideal one it transforms a sound into a perfectly corresponding electrical signal. That suggests that the closer a microphone is to the ideal, the more neutral it sounds, and the more universally it can be used. There is certainly a wide variety of very different top-quality microphones but it would be wiser to see these as physically suited to a particular application rather than a particular sound source.

As far as the "perfect" microphone goes omnidirectional capacitor (condenser) designs approach the ideal very closely. Where you want to favour sound from a single direction and exclude neighbouring instruments or unwanted sound then of course you need a directional microphone which will be a little further from perfection. For a start any directional microphone (such as a cardioid) will demonstrate the so-called proximity effect when used close to a sound source. Low frequencies will be accentuated. For a microphone that will commonly be used in this situation a compensating frequency response can be designed into the capsule. Such a microphone can therefore be described correctly as suitable for close use – its designed task – but not specifically for any one instrument.

Of course it would be possible to choose a far-from-ideal microphone that would produce a particular characteristic variation to the sound – more accurately termed a "distortion" of it – but this seems a perverse approach if you are listening to a Stradivarius. Of course, if the microphone is less than perfect because it cannot handle high frequencies it might still be adequate for use with a bass drum (though this is not the same thing as saying that it is intended for that purpose).

Certain distortions produced by non-ideal microphones may not, in themselves, be unattractive but it is better to achieve these effects by starting with a near-perfect microphone and using equalizers and similar devices since this approach allows sonic changes to be measured and adjusted precisely. The good cook always prefers to start with a dish that is unseasoned and then to add salt and spices for subtlety and brilliance, rather than to tame one which comes to them with rank and unidentifiable flavours.

Placing the microphone

If the choice of a microphone requires some understanding then placing it needs at least twice the thought. Not only is its position relative to the instrument or sound source critical but also its position within the room or acoustic environment. When it comes to stereophonic recordings (we will stick to the simple, classic type with just two microphones) then two additional factors have to be considered - the precision of localisation and the sense of spaciousness.

If equations with four unknowns are frightening then the techno-physical approach does provide a steadying hand. Michael Williams (see Recording Angles) has determined a set of laws that determine the angle and distance between microphones as a function of the directivity pattern and the width of the sound source in order to give accurate localisation.

The use of extremes

Another helping hand in coping with complex conditions is to examine extreme positions and then work “inwards” towards a more useful middle position. For microphones there are three pairs of opposites that are useful to analyse.

1. The soundfield.

The direct sound component of a soundfield exists close to the sound source. It arrives before any other sound and from one single direction. Conversely diffuse or reverberant sound is the result of all the many reflections that exist in a room or sound space. It has no preferred direction of propagation - unlike simple reflections or echoes and no defined phase. Direct sound gives clarity and intelligibility, diffuse sound gives a sense of space and context.

2. The working principle.

For the principles of operation of a microphone the extremes are that of the pressure-operated transducer and the pressure-gradient type (the pressure-gradient is proportional to the velocity). The pressure-operated transducer senses sound pressure at a single point and is thus inherently omnidirectional. Pressure-gradient capsules sense the difference in sound pressure at two points and are inherently bi-directional (figure-of-eight). All other directivity patterns, such as cardioids, can be analysed in theory
(and sometimes even in practice) as combinations of the omni and figure-of-eight patterns – except for the special cases involving parabolic reflectors or interference tubes (shotgun micro- phones).

3. Fundamental stereo principles using differences of level or time.

The last pair of extremes involves the relationship of stereophonic microphone pairs – which we will conveniently define as a “main micro- phone” in that the pair provides the essential spatial information for a stereo “stage” irrespective of any additional spot microphones. One extreme places both capsules very close together, perhaps even in the same housing. Usually one capsule is vertically above the other and the separation is effectively zero in terms of the wave- length of sound. The capsules are physically “coincident” and since the sound arrives at both simultaneously they are also coincident in the time domain.

The contrasting extreme is A/B where the capsules are spread far apart. “Small A/B” indicates distances of 40-80 cm, “Large A/B” is even more extreme with distances of some metres. In terms of both position and time they are far from coincident.

Coincident stereo techniques carry the benefit of excellent localisation but at the cost of a centre image that is over-emphasised since much of the sound is recorded in mono. This will also explain the feeling of a lack of spaciousness. The percentage is dependent on the directivity of the capsules but is 50% for cardioids -you remember, a cardioid can be resolved into a combination of a figure-of-eight and an omni, and two onmis in the same spot capture the same signal.

Conversely the spaced A/B technique carries an enormous, if somewhat artificial, sense of spaciousness (Stanley Lipshitz calls it “phasiness”) that coincident techniques cannot match (except Blumlein). The reason is that differences in arrival time at the widely spaced microphones translate to differences in phase in the stereo output and thus 50% of the direct sound is transmitted out-of-phase.

Soundfields and the operating principles of micro- phones rarely raise many passions but the spacing of stereo microphones generates intense debate. Positions become extremist rather than simply extreme and the techniques become viewed as radically different philosophies rather than points on a continuum. We can analyse the techniques scientifically but the choice of does come down to personal taste – even perhaps, emotion – in the end.

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