technique | recording strings

strings attached

RECORDING STRINGS

Tired of those sampled string sounds? **Hugh Robjohns** outlines a number of techniques and tips for recording reallive string soloists and string sections.

The art and the challenge of recording is all about capturing the best possible rendition of the musical performance without colouring the tonal quality of the instruments or swamping their subtleties in undesirable mechanical noises. In this workshop I shall be looking at some of the techniques and pitfalls involved in recording violins, cellos and basses, be it as solo instruments or in the context of quartets and larger string sections.

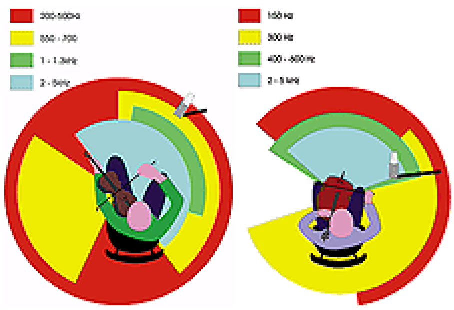
As regular readers will know, one of my hobby horses is that finding the best position for the microphone is far easier with an understanding of how the particular instrument works - in other words, where the sound is produced, how it radiates into the room, and what its frequency spectrum is. With that in mind, let's start with an overview of the characteristics of stringed instruments.

The String Family

The string section as we know it today -- violins, violas, cellos and basses -- emerged around the beginning of the 17th century. Before that, stringed and bowed instruments tended to be of the vertically held viol and *lyras da braccio* form, the latter superficially resembling a modern violin, but typically having five played strings and two or more drone strings. The early and unwieldy bass violin, also with five strings, was displaced by the grandfather of the modern four-stringed cello at about the same time.

One of the most important characteristics shared by all instruments in the string family is the wide range of tonal colours that different instruments are capable of producing. This is principally due to the individual qualities of the wood used in their construction, the details of their internal design and the skill and technique of the performer.

The basic source of sound is obviously a vibrating string which is encouraged into oscillation by dragging a bow across it. The bow is traditionally formed from horsehair made slightly 'sticky' with rosin. The frequency of oscillation is determined by two things: first, the tension of



the string (set by the tuning pegs or nuts), and second, the length which is free to vibrate. The free length extends between the bridge (towards the bottom of the instrument) and the position of the fingers on the fingerboard which 'stop' the string to a desired length. Unlike guitars, there are no frets on the fingerboards, so correct tuning is determined solely by the skill of the performer. However, the lack of frets makes it possible to introduce vibrato on sustained notes with a gentle rocking action of the hand, effectively altering the length of the string in a cyclic manner. It is the independent vibrato produced by each member of a string section, all with random frequency and phase relationships, which contributes so much towards the rich, full symphonic sound associated with the best orchestras and string sections -- an effect which is hard to achieve by artificial means.

The vibrations from the string alone are far too weak to stimulate enough air to be loud enough, so an acoustic amplifier is employed. The body of the instrument is, in effect, a resonant box designed and tuned to amplify the sound from the vibrating strings across their working range -- hence smaller bodies for higher pitched instruments and larger bodies for deeper ones. String vibrations are passed to the body through the bridge, setting up sympathetic vibrations in the various body panels, as well as in the enclosed volume of air.

These resonances are inherently fixed in frequency due to the physical size of the panels and cannot translate with the played pitch, as tends to happen in wind instruments. The tonal character of stringed instruments, therefore, changes from note to note as different resonances are stimulated. Also, since different body panels, and sections of panels, resonate and therefore radiate sound in different frequency bands, the direction in which the strongest sounds emerge from the instrument also varies with different notes (see the diagrams of the polar responses of the violin and cello, above).

The nature of the body resonances also has a strong effect upon the harmonic structure of stringed instruments. For example, in the upper registers of a violin, the fundamental of any particular note is generally the strongest component (the highest note being around 2.6kHz). However, in the lower registers the fundamental is typically 20 to 25dB lower than its strongest overtones, which are usually either the octave or the third harmonic. This is primarily because the body is not sufficiently large to resonate at the true fundamental frequency. The lowest open string vibrates at 196Hz, with a wavelength of around 0.6 metres. The effect of this weakened fundamental is that the upper strings tend to have a slightly more mellow and fuller sound than the lower ones.

The viola is tuned a fifth lower than a violin and so generates frequencies with a wavelength 1.5 times larger (the lowest fundamental note being 130Hz). However, the viola body is typically less than 1.2 times bigger than the violin, so it has even more trouble resonating at the fundamental frequencies of the lower registers. This results in even weaker fundamentals compared with the overtones, the outcome being its characteristic 'nasal' quality of sound. The cello is tuned an octave below the viola, with the bottom, open C string producing a fundamental at 65Hz. Like the violin and viola, the body of the instrument is poor at amplifying such low fundamentals. The air cavity of the body actually resonates at around 110Hz, amplifying the first overtone extremely well.

The double bass produces fundamentals as low as 41Hz for a four-stringed instrument and 31Hz for the five-stringed version, but, as with the cello, the lowest resonance peak in the body (which is the air resonance) is an octave above this. Hence the fundamental is a relatively weak component of the sound of the lowest strings, and the majority of the sound energy is contained in the band between 70 and 250Hz.

In terms of the high-frequency spectrum created by these stringed instruments, the double bass has harmonics which extend to around 2.5kHz and the cello produces little above about 3kHz. The violin can generate surprisingly strong harmonics up to around 10kHz or even higher, but the range of overtones produced by all stringed instruments is strongly affected by playing technique. The length of an open string (that is, one played at its full length) is precisely defined by the nut at the top of the neck and the bridge at the bottom, and so tends to have a richer harmonic structure than a stopped string. However, if the player presses the string harder against the fingerboard, the number and strength of upper harmonics can be increased considerably. The use of the bow also influences the sound quite substantially: if drawn over the string close to the bridge, the resulting vibrations are rich in harmonics, whereas bowing nearer the finger board gives a softer timbre.

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Interestingly, the mechanical noise components created by the bowing action are actually a vital element of the sound of the string family and, relative to the harmonic components, can be as much as 25dB stronger than the mechanical noises associated with most wind instruments. Usually, these bowing noises are masked by the harmonic sequence of the played notes but, in the case of the double bass (and, to a lesser extent, the cello) the mechanical noises often extend to higher frequencies than the harmonic content of the played strings, creating an audible and characteristic buzzing effect.

The starting transient of a bowed string is extremely complex, taking 30mS to 60mS to complete, depending on the string. Cello and double bass transients often last as long as 100mS on the lowest strings (higher strings start vibrating quicker than the lower ones). An added complication is that during this transient phase, the pitch of the played note can be up to 20 cents flatter than the final steady tone, although it is rarely perceived as such. No wonder synthesized strings often sound such a poor imitation of the real thing!

In terms of dynamic range, a violin can typically produce sound extending between 45 and 80dB SPL (measured at a rather distant six metres). Unlike wind instruments, the full expanse of harmonics can be retained across this whole range, as they are more dependent on finger pressure and the position of the bow than the energy provided by the bowing action. The cello has a similar dynamic range to the violin, although the top strings tend not to be quite as strong as the lower ones, and the double bass is roughly 3dB louder across its whole frequency range. Although the viola can play as quietly as the violin, it can not perform as loudly, peaking at about 72dB SPL at six metres.

Recording Strings -- The Basics

As can be seen from the diagrams of the polar responses of the violin and cello, the large frontal surface of each instrument is the main radiator of sound across most of the frequency range. However, the width of the projected sound beam varies with frequency, as does its axis, even emerging predominantly behind the player in some parts of the spectrum! The precise radiation pattern will depend on the nature of the particular instrument, and although the diagrams suggest microphone positions which have been optimised to capture the most uniform balance of the instrument's frequency range, these should only be taken as a guide. There is no substitute for taking the time to move around the instrument in the studio listening carefully for the position where the optimal balance exists. Indeed, because of their varying polar response, strings afford great scope to alter the balance of the recorded sound with different microphone positions -- for example, to capture a more brilliant, detailed sound, or a smoother, darker tone.

In general, assuming the circumstances permit, it is best to position string players in a relatively large environment which has fairly reflective surfaces -- and the more wood on the floor and walls the better! Like most instruments, the sound generated by strings ideally needs space to become properly balanced and coherent, so relatively distant miking in a large and pleasantly reverberant room is usually an important factor in a successful recording.

Every recording engineer has their own view on the most appropriate mics to use for strings, but most favour condenser microphones. The high sensitivity permits a more distant placing than most dynamic microphones could cope with, and the wide frequency response, combined with tonal accuracy, suit the complex sound character of string sections very well. However, take care to avoid condenser mics with pronounced presence peaks as they will tend to over-emphasise the upper harmonics, particularly on violins, producing an unpleasantly hard sound quality.

The larger professional studios would typically opt for large-diaphragm mics on string sections, such as the Sony C800G valve microphone, the Neumann U47 and U87, or the AKG C414ULS. At the project end of the market there are several large-diaphragm mid-price microphones which would be equally suitable, such as the AKG C4000B, the Rode NT1 and the Audio Technica AT4033a, for example. There are plenty of other microphone models which could be used, as long as you remember that, essentially, the aim is to use a smooth-sounding but detailed microphone -- and ideally one which has a very controlled off-axis response so that the room ambience does not become coloured.

Large-diaphragm mics aren't the only way of recording strings, and many engineers prefer the sound of smaller capsule microphones like the Neumann KM84, and KM100 series, Sennheiser MKH20 and MKH40, AKG C460, and the Schoeps Collette series. These are all particularly smooth-sounding mics which are capable of capturing a lot of detail too. I have had a great deal of success with the MKH20 and MKH40 (omni and cardioid respectively), which are really lovely microphones for this kind of application.

Some engineers still favour ribbon microphones for string sections, as these share many of the desirable

Signal Processing

String sections normally require relatively little processing. Equalisation may be required when close miking, but rarely for the more distant techniques. Compression is also rarely required, although this depends a lot on the nature of the music, style of the performance, and the rest of the track's instrumentation. Usually, if compression is needed it is just to apply a little gentle squashing to the louder peaks. Something worth avoiding is trying to bring up the level of quieter passages with a compressor, particularly when a distant miking technique has been used because the necessary gain make up will tend to emphasise the room noise and ambience. Far better to have a word with the conductor to see if the dynamics can be changed by the players themselves.

The most common form of signal processing needed is reverb, especially when a close-miking technique has been used, and here it really is a case of matching the reverb to the material. I would tend to favour medium to large room presets, ideally with a dense, smooth and 'woody' quality to their programming. The Wooden Room preset in Yamaha's REV 500 and 03D is very good for this. Try to create a suitable and believable virtual room for the instruments to perform in. Decay times need not be very long - perhaps between 1.5 and 2.5 seconds to suit the music, although longer times up to four seconds can sometimes be useful if you want that 'swimmy strings' kind of sound! Whatever you do, don't go overboard on the reverb level. Most qualities of condensers without the tendency to harshness which some of the latter exhibit. They also almost always have figure-of-eight polar responses, which affords a great deal of control over separation from unwanted spill. However, ribbon mics are notoriously fragile beasts and tend to be relatively rare these days.

people add far too much reverb in the mix, resulting in a muddled and imprecise mix. My handy tip here is to bring up the reverb return fader until the fake acoustic is obvious, then back it off about 5dB.

Recording Large String Sections

There is nothing to beat the sound of a full string section. While the London Philharmonic is above the budget of most *SOS* readers, virtually every town has at least one amateur orchestra, and most can turn out a pretty decent sound given half a chance. There is invariably a budding orchestrator in their midst who would probably be only too willing to help translate your ideas into the appropriate notation.

There are three basic approaches to recording an orchestra in 'living' stereo, and the concepts do not change significantly whether you are working with a full complement of musicians, or just a string orchestra. The most difficult solution is 'multi-miking' the orchestra, typically using one mic per two rows of violins and violas and one per pair of cellos and basses -- all panned into a fake stereo image of your own design! Even if you have enough mics to cover the orchestra and enough inputs on the mixing desk, creating a well-balanced natural orchestral sound from the component parts is no easy feat, although it can be done given the time.

There are obviously occasions where multi-miking is the best, or only, solution -- such as when working in poor acoustics or with a string section live on stage. The trick is to find a good compromise between the inherently unnatural sound quality derived from close mics, and the need to minimise spill from the other musicians. Although often overlooked these days, microphones with figure-of-eight polar patterns can be a godsend in this situation as they allow the mic to 'look' down on the wanted instruments from above whilst rejecting unwanted spill coming in from the sides.

Another increasingly popular multi-mic approach is to use bugs. These are usually contact mics temporarily fixed to the bridge of each and every instrument. Of course, this means lots of cables, dozens of desk channels, loads of panning, and plenty of grief because they will never, *ever* all work at the same time! A recent popular alternative uses miniature electret mics on goosenecks which mount on the bridge, but allow the capsule to be positioned over the soundboard (eg. the Accusound system), or even inside the body cavity through an f-hole. Some live performers have bugs fitted all the time anyway, but they can also be hired from most of the major pro-audio hire companies. As you might expect, bugs give superb separation from spill, but tend to sound pretty horrid in isolation and need a lot of corrective equalisation, not to mention room ambience and reverberation.

If the room acoustics and situation permit, I think most engineers would agree that far better results can be obtained by employing a technique which leaves the musical balancing up to the performers themselves, with the mics capturing the collective orchestral sound. The 'purists' prefer the classic Blumlein coincident pair, whereas most commercial classical music engineers tend to favour spaced arrays -- both techniques have their own advantages and disadvantages for any given situation.

"It is the independent

The coincident technique involves mounting a pair of cardioid or hypercardioid microphones such that their capsules are aligned vertically above one another, but vibrato produced by each member of a string section, all with random frequency and phase relationships, which contributes so much towards the rich, full symphonic sound..."

angled outwards between 45 and 65 degrees from the centre line (this is called the 'mutual angle'). Altering the mutual angle, polar pattern and distance of the array from the orchestra provides a great deal of flexibility in balancing the perspective, image width and ambience of the recording, although precise details are a little too complicated to go into here. A typical starting point might be with a pair of hypercardioids (my preferred pattern) around three metres above the floor and perhaps four metres behind the conductor, although this is very dependent on the required image width and perspective.

The coincident microphone technique provides excellent mono compatibility (which is to say that the sound doesn't change too drastically if the stereo recording is auditioned in mono), and tends to present a lot of precision and detail in the stereo image. Some hold these qualities in high regard. The inherent drawback of the technique, however, is that directional microphones have to be used. All pressure-gradient mics suffer to some extent from coloration to off-axis sounds as well as a limited and uneven bass response. Since the mics are aimed left and right of centre, the middle of the orchestra is inherently off-axis to both mics and this can present problems in obtaining a natural and consistent quality of sound for all sections of the orchestra.

The alternative approach involves variations on spaced microphone arrays. The stereo imaging created by spaced mics relies on sound arriving at each microphone at different times which produces imprecise imaging, but a fuller and, to some people's ears, a more natural soundscape. The technique also favours omni-directional microphones which generally have a very well-extended and smooth low-frequency response, together with near freedom from off-axis coloration. One very common technique is the Decca Tree arrangement, involving three omni-directional mics arranged in a triangle of roughly 1.2 metres on each side and with the central mic forward of the two outriggers. The mics are then panned fully left, right and centre to match their physical positions. Depending on the size of the orchestra, it may be necessary to add further outriggers to reinforce the distant edges. Since omni mics pick up more ambience than their directional relations they have to be sited much closer to the orchestra -- say three metres above the floor and only a couple of metres directly behind the conductor as a typical starting point.

Yet another approach is the 'dummy head' idea where omnidirectional mics are placed up to 10cm either side of a vertical baffle (the whole array usually being positioned as for the Decca Tree).The baffle is typically a wooden or Perspex disc of about 25cm diameter (representing the human head) covered in felt to reduce the amount of high frequency reflections reaching the mics (which equate to the ears). Although intended for use with binaural headphones, the technique also creates a lovely amorphous string sound on loudspeakers which sits nicely behind foreground instruments without offering any distracting imaging detail.

Both of these spaced microphone techniques employ time differences between the channels to relay positional information for stereo imaging and, if auditioned in mono, can often sound coloured or even phasey. This used to be of serious concern to broadcasters in particular, but these days mono compatibility is far less of an issue (try and buy a mono CD player!)

Soloists And Quartets

"In general, assuming the circumstances permit, it is best to position string players in a relatively large environment which has fairly reflective surfaces - and the more wood on the floor and walls the better!"

Recording string soloists is relatively simple. Choose a recording environment which has a reasonably lively but warm acoustic, select a smooth-sounding condenser microphone, find the best-sounding position about two metres above and in front of the instrument, and record it! Naturally, cellists and bassists tend to stay put relative to the microphone as their instruments are spiked to the floor, but violinists often twist their bodies back and forth as they play. This shouldn't be a problem with relatively distant miking technique, but when close miking, it often produces tonal variations as the high-frequency components of the sound are directed toward and away from the microphone. The only practical solution is to make sure the musician is aware of the issue... and hit them with a big stick whenever they start to sway!

If the recording venue sounds nice, it can be worthwhile recording a soloist in stereo, purely for the natural perspective and ambience. I would personally tend to favour a coincident technique in this situation for its more accurate imaging qualities. However, if the room sounds horrible, it might be as well to close-mike the instrument and rely on equalisation and artificial reverb -- not ideal, but sometimes the best way of handling a difficult situation. You might even try a commercial bug, or even a DIY bug. I have had some success using an oversized foam windshield to wedge a miniature electret mic into an f-hole on violins or the fretwork holes in the bridges of cellos and basses. It is important to take care arranging the cable so that it does not rattle against the instrument body, or could get caught up and pull the mic from its recess. Also, be warned that applying gaffer tape to the instrument in an effort to secure the mic cable may result in sudden death when the owner discovers that removing the tape also dislodges the varnish -- Blu-tack is often a much safer bet!

A quartet or other small string section can be approached in a variety of ways, most of which are a cross between close-miking as described above, and the orchestral miking techniques already discussed. Assuming space and room acoustics permit, good results can be obtained by siting a microphone between 1.5 and 2 metres in front and above the violins. With chamber-sized string sections, try using one mic positioned to the front and above each group of four violins. In a smaller ensemble where a more intimate sound is required, use one mic for each pair of violins, positioned a little closer and aimed more or less between them. The exact positioning depends on the width of the mic's pickup pattern, and how well balanced its response is to off-axis sounds. Narrower pattern mics obviously need to be located further away than wide-pattern mics.

A similar approach can be used for the cellos and basses in a large section, but with one mic covering each pair. Alternatively, try mounting a microphone on a banquet stand raised about 0.5 metres above the floor (roughly at the height of the bridge), and positioned about 0.6 metres in front of a solo cello. As might be expected, this provides a far more intimate sound. SOS

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