Tutorial 02
Microphones 101
Microphone introduction and basic techniques

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Overview
Microphones are the first tool used in any sound recording process and what many professionals will argue is the most important link in the chain. If a poor quality or inappropriate microphone is used to record a sound, every subsequent step in the sound production process can be affected, so it's important to get the best quality source material right from the start. Understanding how different mics work can help you choose the right tool for the job.

An easy way to understand how a microphone works is to think of it as the reverse of a speaker. A speaker takes the electronic signal from a stereo or other piece of sound equipment and turns that electronic signal into a series of vibrations in the speaker cone (the material stretched out to create the cone shape of most speakers). These vibrations cause air to vibrate creating sound waves. The human ear picks up these sound waves vibrations and sends them to the brain. A microphone picks up these vibrations with a diaphragm very similar to a speaker cone and converts them back into an electronic signal.

Trivia: It is actually possible to use a speaker as a microphone and a microphone as a speaker as they both function in similar ways by converting between sound wave vibrations and electrical signals. It is simply a case of wether a speaker is attached to an input or an output line as to howit behaves. Obviously a speaker will make a poor microphone, and a mic will not work well as a speaker, but the theory is sound.

The greater the amplitude of the sound wave the more the diaphragm vibrates and the louder the sound generated by the microphone. Very loud sounds need special microphones to deal with the high sound pressure levels (SPL). These microphones often have larger diaphragms much like big speakers are needed to produce very loud music.

Microphone types

Dynamic microphones
Dynamic microphones are the most like speakers in their function. The vibrations of the diaphragm cause an induction coil (lots of wire wound up) attached to it to move. This induction coil is suspended in between magnets and has a current running though it. When the coil vibrates between the magnet the current running through it varies (this is caused by magnetic induction. Go look it up on wiki). A dynamic microphone may include several membranes to allow it to respond to a wider range of vibrations. Dynamic microphones are fairly hardy and as such are very popular for on stage performance work where a more delicate mechanism might be prone to damage. Dynamics mics are general relatively inexpensive.

Figure 1. Dynamic Microphone diaphragm
A dynamic microphone is very similar in function to a loud speaker. The diaphragm movement is sound being captured rather than sound being produced as with a speaker.

Condenser microphones
With a condenser microphone the diaphragm acts as one of two plates of a capacitor. The vibrations from sound waves will alter the distance between the two plates and this motion will in turn result in a fluctuation of the voltage held between the plates. This becomes the signal sent from the microphone. Condenser mics require a power source to establish the voltage in the plates. This power can be supplied either by a battery within the microphone or by a power source provided inside the microphone lead referred to as phantom power. Condenser mics produce very high quality signals and as such are commonly used in studios. Condenser mics can range in price from relatively cheap to extremely expensive depending on the quality of construction and designed application.

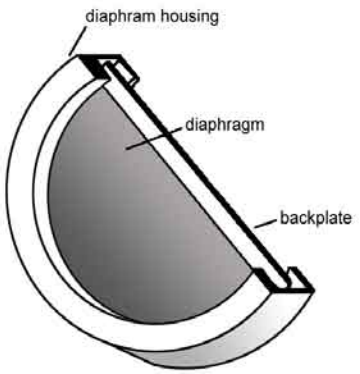

Figure 2. Condenser microphone capacitor
The diaphragm and back plate hold a charge and movement in the diaphragm varies the current in this charge. This becomes the signal produced by the microphone. Condender mics require a power source to provide the initial charge.

Electret Condenser microphones

Electret condensers function in basically the same was as a condenser mic except the condenser material holds a permanent electrostatic charge. This removes the need for a external power source. The process of applying the permanent charge to the material is similar in nature to creating a magnet by passing a charge through an appropriate material. Electret were originally designed as a low cost solution and were often very average quality. Devices with built in mics like telephones and small recording devices often utilise electret condensers. Advances in technology have greatly increased the quality of these mics.

Figure 3. Electret Condenser microphones
Electret microphones can be preoduced in very small sizes and so are idea for use in phones, digital recorders and other small devices. Initially electrets produced poor quality sound. Modern electrets are capable of high quality sound production.
(Image taken from the internet.)

Microphone pickup patterns

Different configurations of microphone have different pickup patterns. The pickup pattern refers to the area in which the microphone can most effectively receive sound waves. The different pickup patterns work best for different recording situations.

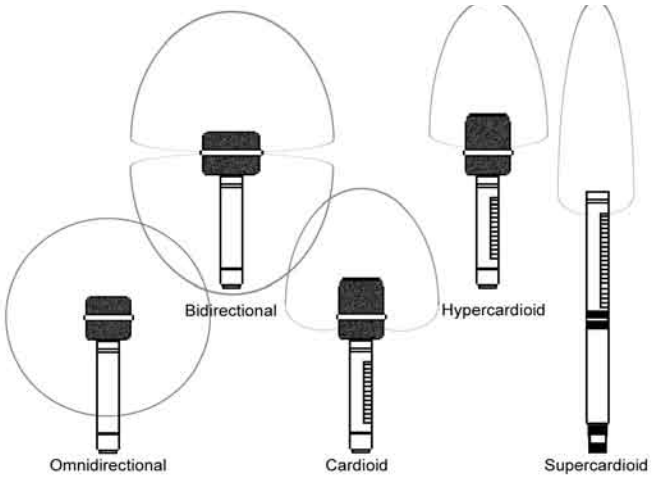

Figure 4. Microphone pickup patterns
Different microphone types have different pickup patterns. These are the areas in which the microphone is most sensative and will recieve the strongest signal. A microphone's pickup pattern helps to define the roles it will be most suitable for.

Omni directional

This pattern covers a 360 degree area which means the microphone signal will be constant all around it. As such, an omni directional microphone is useful for capturing sound from any direction. This could be useful for recording ambient sounds at a location or any situation where it is important to record all sounds in a certain area regardless of where they are in relation to the microphone position. A job that requires a fixed sound source to be more important than anywhere else would not be suitable for an omnidirectional mic.

Bidirectional

A bidirectional mic has a pattern that has two main areas of sensitivity in which the signal will be strongest. Between these areas is a dead space that will receive a much weaker signal. Microphones seldom have any area that is completely without signal, but depending on the pickup pattern "dead" zones can be much less likely to be head than in the primary pickup area.

Cardioid

Cardioid is a rough heart shaped pattern that produces a dead zone, usually located behind the microphone. Both Dynamic and Condenser microphones can utilise cardioid patterns. A cardioid pattern microphone works by having small holes positioned where the dead zone needs to be. These holes receive audio information in the same way as the main diaphragm; however this signal is reversed so as to cancel out any of this unwanted sound material being captured by the main diaphragm. The dead zone behind a cardioid microphone makes them very useful for a range of purposes. On stage where you want to hear the singer or instrument in front of the mic and not the crowd behind it. In studios where you need to mic different instruments and you need an individual mic for each instrument. It is important that a mic only picks up the instrument it is pointed at and not others. In general any microphone used to speak or sing into will have some form of cardioid pattern so it highlights the user and reduces unwanted sounds being picked up.

HyperCardioid

The hypercardioid pattern is an elongated directional pattern like the cardioid but more so. This allows for a greater degree of targeting of the sound source. This pattern is often referred to as a mini shotgun microphone as it can be used to isolate a sound source from surrounding sound material. Hypercardioid mics tend to have a longer body with more noise cancelling vents long its surface. It is the greater number of vents that increase its directional capability.

Supercardioid

The supercardioid pattern is the most extreme of the cardioid patterns and is usually referred to as a Shotgun mic. These mics are often very long cylinders with many sound cancelling vents along the body. Because of their extreme directional behavior they are used for capturing vocals for both film and TV as well as being extremely useful for recording location sound effects. The extreme sensitivity of supercarioid mics requires the user to be very aware of where the mic is being pointed as they can often pic up sounds over a great distance. As such it is important to make sure there is no contamination beyond the sound you are targeting that might be picked up by the mic. The other issue with the extreme directionality of supercardioid pattern mics is the need to stay on target. Tracking a sound source carefully is important as if it moves out of the sweet spot then recorded material can alter considerably. This is especially important when recording dialogue on a set.

Super cardioid directional microphone
This is probably still my favorite microphone and I have used it to record thousands of sounds, but like any microphone it has its limits.

•Good for directional location recording
•Sound effects
•Location Vocals
•Fairly high output level sounds
•Robust build excellent for location work.

This mic works very well in the field and is an excellent general purpose mic for recording mono sounds outside. It is however not a good mic for recording indoors in small spaces and does not cope well with many musical instruments. Its extreme directional focus makes it unsuitable for any ambient environments and requires it to be aimed carefully. It is not really suitable for recording vocals in a studio environment.

The right tool for the job
Many sound recordists (me included) can often fall into the trap of using only one microphone for many different roles. Even the best mic will not be appropriate under all circumstances and it is important to select a mic whose characteristics which are appropriate for the situation. Only recently I have realized that in some circumstances a $200 mic is more appropriate and will give better results than a $2000 mic, it depends on what you are trying to record. Following are various microphone designs and some of the things they are good for as well as some of the things they are not so good for.

Figure 5. Sennheiser MKH 60
The MKH 60 is a supercardioid condenser “shotgun” microphone. This unit is excellent for location recording as well as location vocal recordings because of its very direct recording pattern.

Figure 6. Rode NT4 stereo condenser
The NT4 uses twin condenser capsules in a standard near field arrangement to produce stereo recordings. This mic can supply its own power via a 9Volt battery placed inside the unit.

Stereo Condenser microphone
The NT4 by Rode is a well built stereo mic that works very well for indoor recordings and is excellent for both music and vocals recorded at medium distance. Outdoors it is very susceptible to wind noise and needs good quality wind shielding to protect it. Such sensitivity is not ideal for capturing ambience outdoors without the aid of a mic preamp. It is suitable for studio use and could be used for Foley recording under circumstances where stereo is needed. The NT4 utilises two small condenser mics set in capsules. Each mic has its own cardioid pattern and they are positioned to overlap to capture an effective stereo image.

Figure 7. Shure Beta 58A Dynamic
Shure have always built tough and reliable mics. As a dynamic mic the 58A is capable of capturing good quality sounds at high SPL and does not require a power source to function.

Dynamic vocal microphone
Shure are well known for building tough well constructed but simple vocal and instrument mics. The sm 57 and 58 range have the reputation for being nigh on indestructible and this reputation is pretty well earned. The Shure beta range retain the robust build of the sm series while producing higher quality sound in general. The beta 58A is excellent for on stage or live situations, and would also work well for recording vocals where a visible mic is suitable.

It can also be used for a range of sound effects situations where a mic with a close field pickup is useful. The sturdy construction of these mics allow a user to make use of them in situations that might be risky to flimsier mics. As a dynamic mic these require no battery or phantom power to operate. The 58 beta has a super cardioid pattern and a frequency range of 15Hz to 16 KHz.

Firgure 8. AKG D112 High SPL Dynamic microphone
The D112 was primarily designed as a bass kick drum microphone, but its large diaphram and rubust build make it very useful for recording any high SPL sound source.

High SPL microphone
The d112 is primarily designed as a bass drum mic. It has a large diaphragm that allows it to capture high SPL sounds without distorting. This feature can make it very useful for recording other loud sounds such as machinery or loud vehicles. The large diaphragm is especially good for recording low frequency material. The d112 has a range from 20Hz up to 17KHz. This microphone also has sturdy construction probably designed to cope well with live stage performances, but which also make it suitable for risky recording locations. Its unusual shape and size do mean it requires careful planning if it needs to be positioned in a small area (say under the bonnet of a car). The D112 has a standard Cardioid pattern.

According to the AKG web page the maximum SPL levels for this mic are outside measurement range, this essentially means they don't think you can record a sound too loud for it. I plan to put this to the test.

Figure 9. Aquarian H3 Hydrophone
The H3 consists of a capsule enclosed in water proof material containing a sensative condenser microphone. 3 meters of waterproof cable allows for the mic to be completely submerged and record material in a variety of underwater locations.

Purpose specific microphone
Some microphones are designed for very specific purposes. The hydrophone is one such mic. This mic has been specially designed to cope with being completely immersed in water up to several meters depth. The mic capsule itself is encased in rubber and sealed against water. The capsule is attached to a lead which comes in various lengths from 3 meters to 9 meters. This device has been designed to allow the user to record material in a variety of situations where normal microphones would not function. Under water, in mud, buried or in many other locations that would basically destroy an ordinary microphone is where this kind of unit is designed to be utilised.

Position is important because sound travels through air, but can reflect off various surfaces. Hard surfaces such as wood, metal, stone and glass will reflect sound waves. Placing a microphone in a corner can produce unusual results as the sound waves may bounce back and forth off the various surfaces. In general it is a good idea to place a microphone in the middle of a room. This way any reflected sound waves should be even in all directions. This of course will depend on where the target sound is positioned, but unless you specifically want to capture reflected sound avoid placing microphones too close to walls and other surfaces. This includes the floor. A microphone stand will allow for a mic to be lifted up away from the floor, the mic itself can then be tilted downwards to point more directly at the target sound.

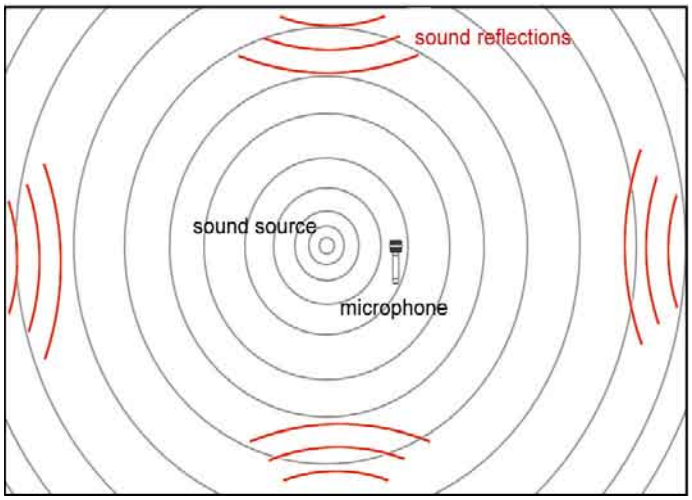

Figure 10. Sound wave behaviour
Sound waves radiate outwards from the sound source like ripples in water, but they will also reflect when they contact certain surfaces like wood, glass and metal. The angle at which a sound wave reflects matches the angle it is travelling. Fig 9. shows just the reflections at each 90 degree quadrant, but in reality every curved wave that hits a wall would reflect at a different angle. By positioning the microphone in the center of the room the reflected waves will be roughly even in all directions producing a balanced sound.

Basic setup techniques

Because of the nature of how microphones work there can be considerable difference in the sounds they capture depending on where they are positioned and even how they are orientated in relation to the sound source. As a basic rule, you point a microphone at the sound source you want to record, but there are various types of microphones and situations where this may not always be the best approach. It is also important to not place a microphone too close to a sound as this can cause distortion. Even if the input level coming from a microphone is reduced so that a signal does not max out, it is possible to record a distorted signal if the sound waves from the source have too much power for the microphones diaphragm to cope with.

Using a microphone stand can also reduce unwanted vibrations. Holding a mic in the hand can produce sounds from vibrations and movement noise. Special mounts for microphones are available that further reduce vibrations by suspending the microphone in rubber clips to absorb vibrations. Although placing a mic on a table or bench top might reduce the noise from being held, it can create issues with vibrations travelling through the table as well as sounds reflecting off the surface top.

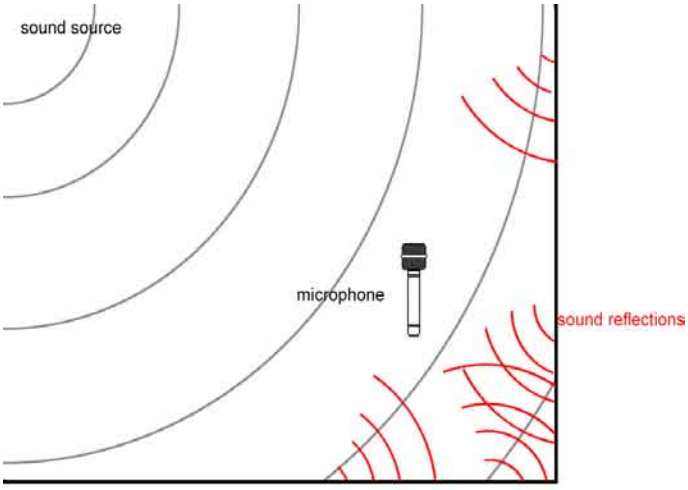

Figure 11. Sound reflections in a corner

When sound waves have multiple surfaces to reflect off of in a small area, the reflected waves will also reflect. This produces secondary and teriary reflections. This can produce an echo effect. Positioning a microphone in a corner in this way can result in unlcear sound as there is more reflected material than material from the original source. Also primary reflections from the other surfaces in the room will arrive at the microphone after the secondary reflections from the nearest surface. This will further add to the sound seeming unclear and muddy.

Stereo Microphone placement

There is no one perfect solution for all recording setups, but there are several methods recognised by most people as a good approach to stereo recording.

The first of these is the near coincident pair. This involves placing two microphones close to each other in one of two positions. One is the crossed pair where one microphone is positioned directly under the other in an x shape with the microphone heads angled 100°-120° away from each other. This creates a cross over of the mic pickup fields and allows for all sounds in front of the pair of mics to be captured with good stereo imaging.

The second setup involves the mics being positioned level in a V formation with the bases of the mics close together and the heads at approximately 90° to each other. This is a more open pattern and while it does produce a wider stereo image, it may need to be placed further back from the sound source.

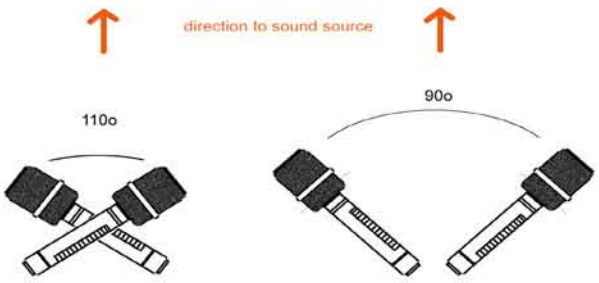

Figure 12. Nearfield Stereo microphone setups
The above diagram shows two methods of setting up microphones to record stereo images.

It is of course possible to position microphones at a distance to capture a much wider stereo image, but this can have issues with synching as some sounds may take longer to reach each microphone. This should not be an issue in a small venue, but in a large hall or church it could cause noticeable effects like ghosting or echoes that are a by product of the microphone placement. It is important to remember that the speed that sound travels can be noticeable under certain circumstances, especially when there are sound reflections involved.

Often the best way to understand how a microphone works and to learn the best methods of placing and positioning are to experiment with the mic itself and see how it behaves. Practical tests will reveal far more than a written tutorial because you need to hear the results to understand what is occurring. The first thing to do with a new microphone is to test it under a variety of scenarios and see what it is capable of and what weaknesses it may display.