Can Current Stereo Recording Techniques Improve? A Creative Analysis and Experiment on Stereo Recording

Gabriel Asher Jones

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A Creative Analysis and Experiment on Stereo Recording

Gabriel Asher Jones

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Thesis Advisor:  

Department Chair:  

Honors Program Director:  

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Abstract
Listening to music in stereo has become the societal norm and because of its popularity, it has become, “invisible by its own success” (Théberge 1). Contrary to its growth, the older and more commonly used stereo microphone techniques are still being used today and very few new and unique techniques have made a similar impact. To test if the commonly used techniques have room for improvement this project compares them to brand-new ones. In order to understand and utilize stereo microphone placements numerous fundamental ideas need to be considered to achieve a certain sound and level of quality. Every microphone technique variation is used for a certain reason based on how it changes the stereo image, phasing, localization, practicality, and creative manipulation abilities. The purpose of this project is to learn about the evolution and art form of stereo microphone techniques and then analyze the information to create new and unique stereo microphone techniques to compare against the common techniques indicating if they could be improved or not.

Introduction
Stereo recording techniques are used to increase the overall immersion and enjoyment of listening by capturing a sense of space that can “ground” a listener with the music (Roginska 1). Unique immersive experiences are created by sound interacting with the location of the listener, sound source, and dimensions of the room. In this case, thinking about the recording
aspect, the listener would be replaced with microphones that record the sound source interacting
with the space. Listening to music creates a very immersive experience because compared to
other senses sound is, “perceived from all directions simultaneously” (Roginska 1). The spacious
sounds that are recorded can then be used to enrich music, movies, live performances, and
anything else that involves sound.

To make clear, the concept of stereo, scientifically known as stereophonic sound, is the
reproduction technique of creating a surround sound illusion through two loudspeakers heard at
the same time. Binaural sounds are a slightly different concept compared to stereophonic sounds
that go a step up creating the, “most perfect re-creation of an acoustic event,” by recording and
reproducing sounds as close to how we would hear them in the real world (Lipshitz 717). This
idea needs to be differentiated to focus on the main topic of the article which is stereo
microphone techniques.

Stereophonic sounds have been recorded, reproduced, and listened to for about 140
years (Pfanzagl-Cardone, The Art and Science of Surround and Stereo Recording 570). Since
then a large number of microphone techniques have emerged, but only a handful are still
commonly used today. There are no statistics specifically looking at the number of times each
stereo microphone technique is used, therefore the amount is based on the overall level of online
attention, research on the technique, and personal encounters. One technique that was made this
decade is called the Blumlein-Pfanzagl-Triple (BPT) and is not widely known indicating that
there is a small demand to expand upon the commonly used techniques and room for more
development.
When recording in stereo the placement of the microphones has a significant effect on the overall immersion that can cause positive or negative effects ("Stereo Microphone Techniques" para. 5). In order to prevent these negative effects a handful of fundamental stereo ideas need to be taken into account to achieve a quality sound and immersion. After learning the history and fundamental ideas of stereo recording techniques, all the information will be used to create unique and high-quality techniques to compare to the commonly used ones and determine if there is room for any improvement.

**Stereo Microphone Technique History**

The history of stereo microphone techniques is unique because the development of stereo microphone techniques coincides with the reproduction techniques of stereo sounds. Neither could have developed without the other and both will be analyzed due to their strong connection. It is also worth noting that it is difficult to find specifics on when and how old specific microphone techniques were created because of the lack of documentation for older techniques from over 100 years ago that were way ahead of their time (Barry Fox 36).

**Invention**

There is no definitive origin of the first specific stereo-recording technique used. The earliest historical date to indicate the use of stereo recording techniques is the first public display of a stereo transmission. In 1881 at the Paris Exhibition of Electricity, Clément Ader transmitted a stereo image using two separate telephones on either ear to create a stereo sound of an orchestra playing (Théberge 6). To capture the stereophonic sound, Ader used 10 microphones
around the edge of the Paris Opera Stage and listeners thought it had a more spacious sound (Pfanzagl-Cardone, The Art and Science of Surround and Stereo Recording 571). The desire for stereophonic sounds did not receive much popularity because, “the public was only just coming to terms with the idea of a mono telephone, let alone a stereo version” (Barry Fox 36). The stereophonic techniques created by Ader will go on to be rediscovered multiple times and slowly developed due to the lack of commercial success from the anti-social nature of listening with headphones (Barry Fox 36). In the 1920s and early 1930s loudspeaker systems were being worked on to increase their popularity and commercial success against the popularity of anti-social headphones (Barry Fox 36).

Alan Dower Blumlein and Harvey Fletcher worked at separate organizations at similar times and are both attributed to the invention of stereophonic recording and reproduction (Streicher 3005). Blumlein is responsible for 128 patents on stereophonic sounds including work on two-track recordings systems on disc/film, phasing techniques for creating stereo images through loudspeakers, using crosstalk and phasing to his advantage, and conducting some of the first stereo recording tests. Looking at stereo microphone techniques there is no account for specific techniques used until Blumlein's patents in the 1930s where he created the first coincident pairs of stereo microphone techniques (Barry Fox 36). Fletcher worked on similar concepts around the same time and is known for his work on a three-track recording and playback system that evolved into the common movie/home theater sound system (Streicher 3005). According to Streicher, Blumlein and Fletcher were the two inventors of modern stereophonic recording and transmission techniques, and their fundamental work paved the way for future developments (3005).
Development

The late 1950s into the 1960s is the start of stereo commercial success. This is mainly due to stereophonic turntables becoming affordable in 1958 allowing more people to listen in stereo and the development of multitrack recording (Théberge 2). In the 1960s listening “in stereo” started to become the standard way to listen to music. The major record labels started to market their music saying it had more presence and a 360 sound now that it was becoming common to have household stereo playback systems (Théberge 2). Over time the idea of a stereo image changed and developed alongside technology.

The initial idea for stereo was to recreate a realistic sound of how a band would sound playing live right in front of the listener. By the 1970s the idea of creating a spatial environment shifted from a realistic sound to a more surreal atmosphere by manipulating the staging of the stereo image for different musical genres (Théberge 10-11). Tzanetakis indicates that this shift also comes from the advances in sound-related technology. “Facilitated by technological advances including multi-track recording, tape editing, equalization, and compression, the creative contributions of record producers became increasingly important in defining the sound of artists, groups, and styles” (Tzanetakis 1). Since then the idea of stereo continued to gain popularity and going back to the Théberge quote, stereo listening’s growth causes it to become, “invisible by its own success” (pg. 1).

Stereo Fundamentals

To create and use stereo microphone techniques effectively and manipulate them a few fundamental ideas need to be considered. Each idea can be looked at in great scientific depth
however for this paper a basic explanation will be given for the most important ideas. Phase, signal de-correlation, and reverberation radius are all related to the interaction between sound waves traveling to the microphones, and polar patterns are related to how microphones record sound waves in different ways.

**Phase**

Phase measures where the wave is during its cycle relative to the start of the cycle. In this case, we are talking about sound waves which acoustically are created from the changes in air pressure or are created electrically (Heller 32). Knowing where in the cycle a sound wave’s phase is can most importantly show how it will interact with other sound waves. When two sound waves are combined and interact with each other, through microphones, speakers, or electronically, they create a whole new sound wave known as summing (Heller 32).

Two main outcomes will occur when two or more phases combine, constructive or deconstructive interference. Constructive interference is the more desired outcome of the two and occurs when both sound waves are in phase with each other and are at the same point in their cycle (Heller 32). The common rule is when a sound source is picked up by two equally spaced microphones at the same time and becomes in phase the volume will increase. Deconstructive interference causes the opposite effect and will decrease the overall volume if the sound source is picked up at different points of the cycle. The more out of phase the two sound waves are the quieter the combined sound will be. Once the phase becomes completely out of phase at 180 degrees offset to each other, also called antiphase, then the sound waves cancel each other out producing no sound (Heller 33). Another effect of phasing is comb filtering which occurs when
extreme phasing occurs across a wide frequency range that creates a whooshing sound that is also described as “phasiness” (Heller 33).

Most phasing issues appear from the distance of the microphones from the sound source. This means that the easiest solution to reduce as much deconstructive interference as possible is to ensure that the distance from every microphone to the sound source is the same. A simpler solution is to use the least amount of microphones possible. If multiple microphones are needed to be used at separate distances from one source using the 3:1 rule will also help reduce phasing issues. The 3:1 rule states if you have a microphone one foot away from a sound source the second microphone should be at least 3 feet apart (Heller 34). This rule is used to help space out microphones that are close together which greatly increases the possibility of deconstructive interference. If there are phasing issues that did not get fixed while recording, in the Digital Audio Workstation (DAW) the timing of the individual tracks can be slightly adjusted to reduce the phasing issues. This works best when there is minimal bleeding between the microphones so when the two sounds are played back after being fixed in the DAW then there will be fewer phasing problems. Even minuscule timing changes down to the millisecond can have effects on the phase which also translate to the same time differences in the timing of the microphones themselves (Heller 35).

Having differences in phases is not all bad. To create a sense of space and thickness to a sound, differences in phasing need to occur (Heller 35). This is when phasing can be used to your advantage. Heller suggests putting a second microphone slightly behind a sound source and then using an equalizer (EQ) to minimize the destructive interference (35). Stereo microphone
techniques are designed to eliminate phasing while picking up the spaciousness of the room from
the phase differences of the reverberation bouncing around.

**Reverberation Radius**

When listening to reverb, the direct sound and diffused sound need to be heard. Direct
sound is the sound waves that go straight to the ear and diffused sound is the signals that bounce
off and around the environment back to the ear. The reverberation radius, also called the critical
distance, is the point in a space where the direct and indirect sounds are at the same level
(Pfanzagal-Cardone, *The Art and Science of Surround and Stereo Recording* 478). To calculate
the reverberation a lot of different variables need to be taken into account. This concept is mainly
only used for recording in large environments but can have minor effects in smaller studio
recording rooms. To simplify, there is a point where the volume of the reverb and the direct
sound are the same and the farther the microphones are placed away from the reverberation
radius, the louder the reverb will sound. This also means that the closer the microphones are
placed in front of the reverberation radius, the louder the direct sound will be compared to the
reverb sound. This concept gets more complicated looking at the certain frequency-dependent
reverberation radiiuses which is why, “the decision of where to put… microphones in relation to
the reverberation radius of the room becomes crucial” (Pfanzagal-Cardone, *The Art and Science
of Surround and Stereo Recording* 478)

The reverberation radius is not easy to find by ear but can be calculated based on the
volume of the room and the average reverberation time (Pfanzagal-Cardone, *The Art and Science
of Surround and Stereo Recording* 479). The reverberation radius was found for each polar
pattern in relation to each other recording the same sound. The omni capsule needs the least amount of distance and is the baseline for other microphones. Cardioid polar patterns and bidirectional capture the same reverberation radius at 1.7 to 2 times more distance (Pfanzagal-Cardone, The BPT Array para. 1). The reverberation radius needs to be considered when capturing a desired spacious sound.

**Signal De-correlation**

One major problem that a lot of stereo microphone techniques have is the inability to de-correlate low frequencies. Below 500 Hz the majority of stereo microphone techniques have trouble creating a sense of space because the low-frequency sounds start to become more monophonic, unnatural, and boxy. Pfanzagal-Cardone argues that the only way to get a natural and spacious sound through a large speaker system is to use techniques with high signal de-correlation at low frequencies (The Art and Science of Surround and Stereo Recording 6-7). To de-correlate at low frequencies, the capsule spacing has to be larger than the reverberation radius. Having a larger spacing then allows for more localization distinction at lower frequencies. There are a few techniques that achieve this that will be discussed later.

**Polar Patterns**

One concept that needs to be explained to understand why microphones are arranged in certain arrays is a microphone’s polar pattern. Every microphone has a specific polar pattern that makes it more sensitive to sound in certain directions and it is the most important specification of a microphone (Arthur Fox para. 6). There are nine types of polar patterns currently:
omnidirectional, bidirectional, cardioid, supercardioid, hypercardioid, subcardioid/wide cardioid, lobar/shotgun, and boundary/PZMInfinitely variable. The polar patterns that will be discussed the most and are the most commonly used are omnidirectional, bidirectional, and cardioid.

The omnidirectional polar pattern is equally sensitive to sounds in all directions and when looked at on a 2D graph it is a complete circle. This polar pattern works on all pressure microphones that have one side of the diaphragm open and the other closed off at a constant pressure. The changes in pressure from sound waves traveling are how the microphone records sound. It is resistant to vocal plosives which are the harsh consonant sounds that happen on T’s, P’s, B’s, D’s, K’s, and G’s (Arthur Fox para. 112). It is not affected by the proximity effect where low frequencies become exaggerated the closer the sound gets to a microphone. It has low gain-before-feedback which refers to the amount of sound that can be played back before it starts to feedback. Lastly, omnidirectional microphones add the least coloration to sounds (Arthur Fox para. 120-132).

The bidirectional polar pattern is equally sensitive in the front and back with two null points on both sides. On a 2D graph, it looks like a wide figure-eight pattern. It works on some pressure-gradient microphones that have an opening on both sides of the diaphragm. It has to be a side-address microphone that records sound from the side when placed upright instead of straight from the top. It is also sensitive to vocal plosives and is the most affected by the proximity effect (Arthur Fox para. 139-153).

Lastly, the cardioid polar pattern is the most commonly used and is sensitive to sounds directly in front, and has a null point at the rear. It looks like a horseshoe on a 2D graph. It works on pressure-gradient microphones, is sensitive to vocal plosives, is affected by the proximity
effect, and has great gain-before-feedback. Super-cardioid, hyper-cardioid, and subcardioid all have a very similar front-facing sensitivity but with an additional small sensitivity to the rear. Cardioid patterns are most commonly used for vocal microphones and other sounds where you want limited bleed from other sounds like on snare drums and guitar amps (Arthur Fox para. 157-78).

**Why Stereo?**

The obvious answer to this question is that listening in stereo is better than mono. Stereophonics allow humans to listen to sounds in a realistic way that can recreate real-world environments like sitting in front of a live orchestra in a cathedral or a rock band in a basement. Looking back on the later development of stereo it can also be used to recreate surreal spaces tricking the human brain into hearing in ways that are not possible in the real world. Listening in stereo sounds better than mono because of the immersive stereo image created that compliments how humans hear binaurally.

**Stereo Image**

According to a study done by Lessiter, Jane, and Jonathan Freeman, they found that when listening to music in stereo compared to 5.1 surround sound there was no increase in the overall presentation of the audio either way (pg. 1). This shows that creating stereophonic sounds are still very relevant today even with the increase in surround sound systems. The stereo image can be thought about as when sounds are moved more on the left or right side of the speaker
creating a two-channeled image (McAllister para. 3) The ability to create a quality stereo image takes a lot of experience when balancing the placement of every sound in the stereo image.

To understand and create a good stereo image Théberge uses the idea of staging. Imagine a performance stage where all the sound will be coming from to create a stereo image. The hypothetical stage can be as complex or simplistic depending on what is being recorded and the desired sound. Once the specific space for a sound is found the next step is to pick the type of sound (Théberge 11). Two common terms when creating a stereo image are width and depth. The width of a stereo image refers to the panning of sounds to the left or right and how they can be narrow, wide, or hard-panned to one side (McAllister para. 5). The depth deals with the volume level of sounds changing how close or far they are creating a sense of spaciousness (McAllister para. 6). Knowing the stereo image you want to create and how to describe it will help to choose the stereo microphone placement that best suits the desired sound (Bartlett 2-3).

How We Hear

Understanding how the human ear works is vital to understanding what makes a good stereo microphone technique. We can locate a sound both vertically and horizontally with almost perfect accuracy from our binaural hearing system (Middlebrooks 99). There are five different frequency-dependent pieces of information humans use to locate sound binaurally (Pfanzagl-Cardone 34). The two most important pieces of information humans need are the internal time difference (ITD) which is the slight difference in timing for a sound source to reach each ear and the internal level difference (ILD) which is the difference in loudness caused when waves that are smaller than the diameter of the human head go to the opposite ear. The remaining pieces of
information the human brain takes are small and help locate a sound that has the same ITD and ILD, meaning it hits both ears at the same time and loudness. The third piece is the frequency response of a small part of the ear called the pinnae. The fourth is making small head turns to change the ITD. Lastly, in strong reverberant rooms, humans have sensitive inter-aural signal coherence that develops from years of practice.

**Stereo Microphone Techniques**

There can be an endless number of microphone placements from all the minor adjustments that can be made. The type of polar pattern, distance from the source, angle of the source, angle of the microphone, the direction of the microphone, the height of the microphone, and even the equipment used to hold the microphone can all be changed to create varying techniques. Stereo recordings are used to convey the depth, distance, and spatial sense of the room acoustics of a sound (Bartlett 1). There are many factors that can change how a recording will sound and the placement of the microphones plays a crucial role when recording in stereo. The purpose of each specific microphone technique is, “to create the right distribution of the sound between the loudspeakers” (“Stereo Recording Techniques and Setups” para. 1) and every type creates a different result. There are four main types of microphone placement which include coincident pairs, spaced pairs, near-coincident pairs, and baffled-omni pairs/artificial heads.

**Common Techniques**

Coincident pairs use directional microphones that are placed as close as possible and facing toward each other to ensure that each microphone has the same time delay from the sound
source to the microphone (Zotter 1). There are three commonly used techniques of coincident pairs: Blumlein, mid-side (MS), and XY. Blumlein, created by Alan Blumlein in the 1930s, stacks two bidirectional microphones on top of each other to get a good width of sound (Zotter 2) (Fig. 1). The Blumlein technique is known for its realistic sound and the ability to de-correlate sounds.

![Blumlein coincident stereo microphone technique](image)

**Fig. 1** Blumlein coincident stereo microphone technique

(Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 130)

Mid-side utilizes one bidirectional polar pattern perpendicular to the sound source and an omnidirectional or cardioid microphone facing toward the sound (Zotter 3) (Fig. 2).
Fig. 2 Mid-side coincident stereo microphone technique

(Bartlett 6)

XY places two microphones side by side facing forward and toward one another to create an imaginary intersection creating a 90-degree angle between them (“Stereo Recording Techniques and Setups” para 18-24) (Fig. 3).

Fig. 3 XY coincident stereo microphone technique with cardioid and super cardioid polar patterns

(Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 128)
Any directional polar pattern can be used and typically two cardioid microphones are used to get a wide stereo sound from the front. To create a wide stereo image the angle between the microphones can be increased and the polar patterns can be narrower based on one's liking (Bartlett 4).

Spaced pairs are more self-explanatory, they are two identical microphones spaced apart and at the same distance away from the sound source. The mics can have any poplar pattern and the more space between the microphones the wider the stereo spread (Bartlett 6). The most common spaced pair technique is called AB where both microphones are omnidirectional (Fig. 4).

Fig. 4 AB space pair stereo microphone technique

(“Stereo Recording Techniques and Setups” para. 7)

AB recording is preferred when the sound source and microphones are far apart because when the source is close to the microphones there is almost no localization. It is preferred to use this technique farther away from the sound source because omnidirectional microphones can capture
low frequencies regardless of the distance (“Stereo Recording Techniques and Setups” para 16). The large AB technique exceeds the reverberation radius level and the larger the distance between the microphones past the reverberation distance the more de-correlated the sound will be (Pfanzagl-Cardone, The Art and Science of Surround and Stereo Recording 104). Some engineers avoid using spaced pairs because they are the most likely to have phase issues (Heller 34).

Near-coincident pairs are very similar to coincident pairs but they are angled away from each other adding a small space between the microphones (Bartlett 8). This technique adds more stereo spread compared to coincident pairs because the larger the angle between the microphones the more stereo spread will be captured (Bartlett 8). The most commonly used near-coincident pair is called ORTF, which stands for Office de Radiodif- fusion Television Française created by the French Radio Organization (Bartlett 8). ORTF uses two cardioid microphones 17 cm apart and with a 110° angle between them. These specific measurements are used to simulate the distance between our ears and how our ears use localization (Bates 2) (Fig. 5).

![Fig. 5 ORTF near-coincident stereo microphone technique](Pfanzagl-Cardone, The Art and Science of Surround and Stereo Recording 155)
There are a few other configurations for the distance and angle that Bates talks about that are less commonly used. These include NOS (30 cm apart and angled at 90º), RAI (21 cm apart and angled at 100º), DIN (20 cm apart and angled at 90º), and Olson (20 cm apart and angled at 135º) (Bates 2-3).

Baffled-omni pairs are any spaced microphone placement (ORTF or AB normally) with an acoustic baffle put in the middle to create more separation between the two channels (Bates 5). Bartlett notes that the baffle can also be a hard-sphere with microphones placed flush against either side (8). This technique allows the shadow effect to have a positive effect which deals with how we recognize where a sound is coming from. When spaced pair microphones are placed too close together it causes little separation in the stereo spread. When a baffle is placed in between it helps create the separation needed to localize the sounds. Bates describes one well-known baffled stereo principle called the Jecklin Disc where two omnidirectional microphones are spaced 36 cm with a special absorbent disc-shaped baffle with a diameter of 35 cm put between the microphones (5). This technique is another way to record sounds as our ears would hear them. At low frequencies, nothing changes compared to the regular AB technique but the higher the frequency the more separation between the two microphones as it diffracts around the baffle (Pfanzagal-Cardone 150) (Fig. 6).
Lastly, the artificial heads are microphones placed inside of a human dummy head to emulate human hearing creating a binaural recording. This uses the same principles as the baffled-omni pairs but adds the dimensions of a human head to interact with the sound waves. It is used for ambient sounds or virtual reality and is not very practical to use for musical recordings because they often can’t be adjusted easily (Bates 5) (Fig. 7).

Fig. 6 Jecklin Disc baffled-omni stereo microphone technique

(Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 149)

Fig. 7 Artificial head binaural microphone technique

Looking at the stereophonic potential, Bartlett compares all four types of stereo microphone techniques comparing the differences in the stereo image. Coincident pairs have a sharp image and the stereo spread can range from narrow to accurate. Spaced pairs can capture off-centered images and a warm sense of ambiance. Near-coincident pairs capture sharp images and the stereo spread is accurate most of the time. Baffled-omni pairs/artificial heads have sharp images and the stereo image is accurate most of the time just like near coincident pairs (Bartlett 9-11).

Uncommon Techniques

Most of the lesser-known stereo microphone techniques are slight variations on the common techniques, mainly made by changes in the polar pattern of the microphones. Some variations were already mentioned above but the ones listed below are even less common. XY variations include the use of hyper-cardioid polar patterns and due to the stronger directional sensitivity a wider angle is made between the microphones and they can be placed at a farther distance from the sound source (Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 127-128). For spaced pair variations there is Faulkner's 'Phased Array' (FPA) with two bidirectional polar patterns 20cm apart that creates good localization while having an open sound (Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 148) (Fig. 8).
A recent variation on the Blumlein technique called the Blumlein-Pfanzagl-Triple (BPT), created by Dr. Edwin Pfanzagl-Cardone, adds a third bidirectional microphone facing forward (Fig. 9).
It is common to place an acoustic barrier behind the microphones so the microphone can be placed further away from the instruments creating a better balance between them. With an added rear acoustic barrier bidirectional polar patterns can capture the same reverberation radius 2.4 times the distance explaining why adding the acoustic barrier helps (Pfanzagal-Cardone, Sound on Sound, para. 1). Adding the third microphone also gives a more centered sound so the mix can be adjusted to create either a more stereophonic or monophonic sound. The Nevaton BPT is a microphone designed by Dr. Edwin Pfanzagl-Cardone and created with three capsules inside to create the same polar pattern array without having to use three separate microphones (“Nevaton BPT” para. 2) (Fig. 10).

![Fig. 10 The Nevaton BPT Stereo Microphone](Image)

(Pfanzagal-Cardone, The BPT Array para. 8)

The DECCA-tree is a triangular array of three microphones developed in 1953 by Roy Wallace primarily used for orchestra recordings ("Stereo Microphone Techniques" para. 3). The
common way to set up the DECCA-tree is to have a spaced pair with a center microphone in front half the distance between the spaced pair. Typically all microphones are omnidirectional or cardioid (Fig. 11).

![Decca tree stereo microphone technique](image)

**Fig. 11** Decca tree stereo microphone technique

("Stereo Microphone Techniques" para. 3)

The DECCA-tree has a lot of time discrepancies between microphones creating a good sense of space but less localization (Pfanzagal-Cardone, The Art and Science of Surround and Stereo Recording 223). There are numerous variations of the DECCA tree that changes the distance between microphones and polar patterns.

**New Stereo Techniques**

I created four new stereo microphone techniques in an attempt to be a contender to the already established techniques. My main goal was to create techniques that were unique and had a similar level of quality compared to the other techniques. I prioritized making a new technique that was not already established before thinking about the overall quality that it would produce. In the design process, I kept all the fundamental ideas in mind by making every microphone
equal distance to the sound source to reduce deconstructive interference, having a capsule
spacing larger than the reverberation radius to minimize re-correlation, and using effective polar
patterns. I ended up making two variations of FPA and two variations of the BPT pattern.

Specific Details

The first technique I created is called the Double Indirect XY (D.I. XY) where two XY
cardioid microphone arrays angled 90 degrees apart are set up spaced apart and facing towards
each other. This creates a similar pattern to FPA but instead of two figure eight patterns facing
forward and back, the polar pattern is angled inwards (Fig. 12).

![Fig. 12 Double indirect XY (D.I. XY) spaced pair stereo microphone technique](image)

The biggest problem with this technique is that you need four separate microphones which have
more potential to create phasing issues. To prevent deconstructive phasing the distance and angle
of the microphones have to be the same to ensure the sound hits each microphone at the same
time.
The goal of this technique was to capture a tighter stereo sound from a spaced pair and eliminate the bidirectional polar pattern high proximity effect. This technique would be best used for recording multiple instruments because there is no central front-facing microphone. The tighter stereo image would complement instruments that are meant to blend together and do not want a lot of room sounds like orchestra instruments and background vocals. Low-frequency instruments would be good to record because it reduces the proximity effect. Because the rear-facing microphones are facing inwards the sound will be less spacious which would be good to use in a recording studio where there is less reverberation or to reduce reverb in a more spacious atmosphere.

The second spaced pair is very similar to FPA and is called the Angled Phased Array APA. It is the same technique as FPA but the figure eight polar pattern of the two microphones is angled inward at a 45-degree angle or towards the centered sound source (Fig. 13).

**Fig. 13** Angled phased array spaced pair stereo microphone technique

This microphone technique is meant to create a slightly tighter stereo image compared to the regular FPA and captures a wider reverberation sound with half the microphones compared to the
D.I. XY. This technique would best be used to record instruments that have natural reverb that can be complemented by wider rear-facing polar patterns like string or percussion instruments.

The next two techniques are similar to each other and take a simple approach to the BPT. These two techniques are called XYZ direct and XYZ indirect. In an attempt to create a new stereo image, both techniques include three microphones using the cardioid polar pattern instead of bidirectional like the BPT. This causes less sensitivity to sounds in all directions in comparison. Every microphone has a 120-degree between them. XYZ direct has one microphone facing forward and the other two facing backward to capture a wide reverberation sound and a strong direct sound at the same time (Fig.14). This technique will have less localization and because of that, it will be great for single-sourced sounds where the reverberation sounds want to be recorded. With the increased localization facing the rear, this technique would be great for places with a delay.

Fig. 14 XYZ direct coincident pair stereo microphone technique
XYZ indirect is the same pattern but flipped and there is no centered front-facing microphone capturing a wider direct sound but less reverberation (Fig. 15). This technique would be used for a group of instruments and similar to the D.I. XY it will capture less spacious sounds.

Fig. 15 XYZ in-direct coincident stereo microphone technique

**Comparison**

To compare my new techniques I recorded the same things for each technique and their similar counterparts which are FPA and BPT. For each recording, I clapped and talked six feet away in the center, roughly three feet to the right and left, and clapped and talked while walking from the left to the right side. I then played a song through monitor speakers six feet away in stereo where the speakers were placed two feet apart slightly facing inwards. When played in mono the two speakers were side by side facing forward. After recording, I listened back to the
recordings through stereo monitor speakers while looking at the PAZ stereo analyzer listening for localization, spacious sound, stereo image, and antiphase. The PAZ analyzer shows the out-of-phase frequencies which as mentioned earlier will cancel each other out. I also listened to the recordings with headphones to hear more detailed differences. As a note, unless a microphone was pointed straight forward or backward each microphone was panned hard left or right respectfully to ensure the stereo image is played back through the loudspeakers.

To access the material used in the comparison click this to go to a shareable OneDrive: Honors Thesis Material. There are three folders that show pictures of the PAZ analyzers, how the microphone techniques were set up, and the audio files for each technique sound test.

The D.I. XY at two feet has a decent sense of localization with no extreme stereo separation or narrowness. At the same time, it keeps a full and large spacious sound by keeping the volume loud through both sides giving it a medium-sized stereo image. The PAZ analyzer reflects this by showing a wide stereo image and no clear increase from either side. There is also a notable amount of antiphase most likely due to the number of microphones because the fewer microphones used the fewer chances there are for phase differences. When spaced at six feet the D.I. XY understandably creates a wider stereo image and stronger localization compared to when placed two feet apart. There are similar full and large spacious sounds and with the increased localization it has a large stereo image. On the PAZ analyzer, the localization cannot be easily seen and there is a similar amount of antiphase due to the number of microphones.

The APA at six feet has a similar spacious sound with less localization but it has a tighter overall sound which is surprising. The bidirectional polar patterns potentially picked up more sound from the reverberation radius making the sound have less reverberation compared to
the D.I. XY. Or because there are two fewer microphones, the sound blended better together with fewer phasing issues. On the PAZ analyzer, there is again no clear indication of localization and a notable amount of antiphase but slightly less than the D.I. XY. The bidirectional polar pattern potentially picked up more sound from the reverberation radius. At two feet apart the same thing happened for the D.I. XY where there is a tighter stereo image.

For comparison, FPA at six feet apart had the best localization and it can be seen on the PAZ analyzer. This causes the sound to be less blended between the two microphones like the APA and D.I. XY. With the separated sound there is a smaller sense of fullness and spaciousness because more reverberation is being picked up by one microphone instead of multiple ones. There was also a medium amount of antiphase which is interesting because the timing between all spaced pair microphones should be relatively similar but is likely due to the separated sound combining into stereo. At two feet apart again the sound became narrower with only slightly less localization.

Looking at the coincident pairs the XYZ D has a narrow sound and stereo image with almost no localization which reflects the lack of left-right changes on the PAZ analyzer. Now that the microphones are all placed on top of each other there is almost no antiphase. There is a decent spacious sound from the two microphones facing away from the sound source that could be more spacious in a larger environment. The XYZ I.D. technique is very similar to XYZ D but with a more direct sound and slightly less spacious from the extra front-facing microphone.

Using the BPT for comparison it had some slight localization that could barely be noticed on the PAZ analyzer while having a tighter sound and less spaciousness at the same time. There was also some slight antiphase caused by the added polar patterns which could explain the
decrease in spaciousness. Along with the added polar patterns, there was a more direct sound causing the sound to be narrower.

In terms of setting up each technique for convenience, the more microphones there were the harder it was to set up. I estimated the height and angle measurements and it became more difficult when there were more than two microphones to align. The D.I. XY was the hardest to set up because it had four microphones that needed to mirror each other which took a lot of time to get close to perfect. The other spaced pairs were much easier to mirror and the other techniques where the microphones were on top of each other it was easiest.

Two things need to be kept in mind. Volume plays a big role in balancing multiple sounds affecting the stereo image. Increasing the volume can make the sound seem closer which would change the localization (Huff). When listening I tried to ensure that every channel was playing back at the same volume to keep a consistent stereo image for comparisons. It also needs to be kept in mind that art is mainly subjective and my thoughts on how each technique sounds and compares can be different from someone else with different experiences.

**Critical Reflection**

I think that I was partially successful in my effort to create a new stereo microphone technique. The techniques were all original with no other documentation on them that I could find. The sound quality of the stereo images was unique because they all captured a fuller and more spacious sound with less localization. Even with the limited localization, the sense of space was great with all of them having slight differences in the sound from the level of direct sound and wider or narrower reverberation sound.
If I were to do this project again I would have recorded in more spacious environments to compare how the techniques sound with more natural reverb compared to a small soundproof studio recording room. This could have made it easier to hear and see the differences but on the other hand, having the confined recording space forced me to listen more critically to find the differences. I also would have recorded more stereo sounds like multiple people making noise and music to compare the techniques in the context of a more realistic recording session.

The biggest question is if they stand up to the commonly used techniques in popularity and quality. In terms of popularity because there are no statistics on the usage of each stereo microphone technique it will take time to see if my techniques will gain the same level of attention as their counterparts compared to the most common techniques. The quality of each technique matched the commonly used techniques because they sounded very similar to their counterparts and there were no overwhelming phasing issues. I really like the sound of each technique enough to add them to my own practices but like all techniques, they all depend on what type of sound is desired. For example, the XYZ indirect would be a poor technique to record vocals or solo instruments because there is no front-facing microphone capturing the direct sound waves.

This project also reveals that every stereo microphone technique is not confined to the commonly used ones. Every commonly used technique can be slightly adjusted to a variation in order to record a specific sound. More importantly, this project demonstrates that the more knowledge of fundamental ideas and techniques the easier someone can capture their desired sound. Having a strong understanding of stereo recording makes it easier to choose the best technique for different scenarios, make small adjustments, and recognize problems in the
recording. Art is all subjective but with more knowledge also comes a better sense of what a quality stereo recording sounds like and how to capture it. Overall this project helped me learn a lot about fundamental ideas and stereo microphone techniques along with new and I made four quality microphone techniques that I can take credit for inventing.

Knowledge is clearly very important in the audio engineering field and this project has helped me not only learn about specific fundamental ideas about stereo microphone techniques but also ideas about the art form of recording itself. I learned how important the relationship between technology and music is with each other in their development and they should be embraced. I also gained a better understanding of how to use the stereo image effectively giving me tools to know how to achieve a specific sound. Lastly, learning about a lot of uncommon stereo microphone techniques shows how there is always room for creativity which gives me the confidence to branch out and use uncommon techniques to express my art.

Conclusion

Stereo microphone techniques are very unique as they have multiple fundamental ideas to consider and allow for very unique microphone placements to be used to record a wide range of desired sounds. Although it is hard to tell if the four new stereo microphone techniques will be able to become common techniques in the future they do provide a new unique sound proving that there are more stereo microphone techniques to be created. Using the knowledge of fundamental ideas of stereo recording and established stereo microphone techniques I was able to create four unique and functioning stereo microphone techniques.
Works Cited


Bate, Tom. “Coincident or Near-Coincident Mic Placement Techniques.” *DPA Microphones*.


