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Sami Fong
University of the Pacific, s_fong11@u.pacific.edu

Sami Fong (class of 2020) recently graduated with a BM in Music Management. During the past four years at Pacific, Sami has gained working experience in digital marketing, music publishing, ...Read More

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From *Penny Lane* to *Stranger Things*: Technology's Influence on Music Production

By Sami Fong

Ray Kurzweil, inventor of the Kurzweil K250 electronic synthesizer and futurist, proposed in his "Law of Accelerating Returns," that the pace of technological progress speeds up exponentially. While the history of sound recording is relatively young, 142 years compared to geological time, its evolution has grown significantly in the last 40 years because of technological innovations in both hardware and software design. The majority of music listeners believe what they hear through their speakers or headphones are the actual sounds from skilled professional singers and musicians and are unaware of how today's technology has changed the music industry. New production technology has developed tools for composers, performers, and developers to help establish a new standard for music creation. Advancements in MIDI, notation, recording and sampling programs, and virtual instruments have changed how popular music and film scores are composed and performed.

Electronic Sound Recording

The origin of recorded audio is often attributed to Thomas Edison, who in 1877, filed his patent for the prototype phonograph or talking machine; and, Emile Berliner, who in 1888, invented the flat-disc Gramophone that was the forerunner to the modern record.[1] Berliner patented a wax coated zinc flat-disc as a recording medium. The gramophone would capture the sound like Edison's phonograph of etchings in soft wax. The disc would be dipped into an acid bath that permanently etched the pattern into the zinc disc. Berliner "prophesied [use of a master disc] the ability to make an unlimited number of copies and [provide] a system of royalty payments to

artists derived from the sale of the discs."[2] By 1900, the cylinder phonograph and the disc gramophone were the only two recording formats. Both inventions were closely guarded secrets and required the use of trained company employees to record or to playback recordings. The invention of electronic sound recording traces its beginning to the development of the transducer in the late 1920s. The transducer is "a device that converts any kind of energy into another form."[3] Today, common audio transducers include microphones for input, and speakers and headphones for output, to convert sound vibrations into electrical energy. Unlike Berliner's gramophone where sound vibrations cut grooves directly onto a wax disc (storage medium), vibrations are converted into electrical signals by intermediate devices such as magnetic coils inside a microphone. These electrical signals can be used for direct processing in sound hardware (loud speaker) or stored magnetically (audio tape) and with today's technology, converted into binary data that can be transmitted digitally to computers and other digital devices.[4] Along the way, there were two innovations that significantly contributed to the advancement of electronic recording, the condenser microphone, and magnetic tape recorder.

The condenser microphone enabled sounds to be captured over a wider sonic landscape, where musicians gathered around one mic and moved to various distances from the mic to set the music's tone and balance. Opera star, Rosa Ponselle, would recall in 1976, how she would mark the floor with chalk to show where to stand when singing high Cs, then run forward for the middle-and-low register notes.[5] Magnetic tape provided "a convenient means for storing and editing sound" and when used with the Ampex Model 200A Tape Recorder (1948), it provided for the first-time quality fidelity, convenience of editing, and the ability to time-delay performances, which appealed to both the music industry recording and broadcasting networks.[6] The downside of

magnetic tape was its sensitivity in tape handling and storage, sound leakage, print-through (result of transferring sound from one recorded layer of tape to another track layer), and stretching.[7] As technology evolved, The Beatles innovative use of electronic recording techniques such as tape-splicing, overdubbing, loops, and reverse playback towards the late 1960s, altered the views of sound engineers of what was possible and was a precursor of Digital Audio Workstations (DAWs) that simplified the recording and editing process with its "in the box" capability.

The Beatles' Analog Stroll Down Abbey Road

After their 1966 international tour to promote their *Revolver* album, The Beatles made the decision to stop performing live concerts. Their two-fold explanation: first, they were unable to hear themselves on stage because of screaming fans (pre-1990s invention of duo speaker in-ear monitors), and secondly, the inability to playback overdubs recorded in the studio to match the album's sound. They were determined to change the narrative of a recording studio from a means to an end, to that of a place where musical ideas and electronic technology could create works of art. Their efforts were rewarded in the album *Sgt. Pepper's Lonely-Hearts Club Band*, released in May 1967 and winner of that year's Grammy for Best Recorded Album in sound engineering. Songs from that era were recorded on four-track reel-to-reel analog tape compared to today's digital software that can hold up to 128 audio tracks. By having four tracks, most recordings would lay down a rhythm track with the backing instruments (drums, bass, guitar, and piano) then overdub the vocals. For the song "Penny Lane," the Beatles decided to record each instrument individually on "separate tracks to avoid sound leakage or bleed" for the rhythm section, then combine or bounce onto another track, and do reductions or pre-mixes after each bounce.[8] For example, flutes, trumpets, and piccolo were recorded on tracks 1, 2 and 3 and then bounced to an

instrumental backing track on track 4, which then allows the flugelhorn, oboes, cor-anglais (English horn) to be recorded on the bounced empty tracks 1, 2, and 3, respectively.[9] This track recording process was repeated until all the instruments were recorded, bounced, and pre-mixed to track 4. Vocals and harmonies were recorded on tracks 1 and 2, sound effects such as the ringing bells was recorded on track 3, and the three were then bounced to track 4 for mixing with the instruments. The finished recording used 26 tracks.

Songs could be built up layer-by-layer, but each time a track is bounced, the sound quality declines. The Beatles "spent three full weeks of studio time, compared to their usual 2-4 days," doing the instrumental tracks on "Penny Lane" because they wanted to record segments of a track and sometimes entire tracks in one take to avoid reducing sound quality by re-recording or performing a punch with additional overdubs to fix a bad note or musical line.[10] The Beatles also experimented with tape-splicing. The group recorded three different versions of "Strawberry Fields Forever" and decided to splice two of the versions together. Tape-splicing two versions played in different keys and different tempos was unheard of because "audio is a static process, once recorded it is difficult to manipulate tempo."[11] Today, a computer can change pitch and tempo of a recording independent of each other, but in the 1960s, they only had editing scissors, tape machines, and variable speed control. The problem is when tape is sped up, the pitch also goes up; slowing the tape has the opposite effect of slowing the tempo but also lowering the pitch. The Beatles' solution to match both pitch and tempo was to speed up the playback of the first take and slow down the playback of the second take, and instead of splicing the tapes at a 45-degree angle, it was cut at a 90-degree angle to produce an almost noiseless join to the naked ear.[12] EMI Records was very pleased with the results of these two songs, which led to releasing them as singles and

not including them in the *Sgt. Pepper Lonely-Hearts Club Band* album. Music technology has changed dramatically since "Penny Lane" and "Strawberry Fields Forever" were recorded 52 years ago. Digital technology enables a new level of recording and editing that was not possible on reel-to-reel analog tape.

The Shift from Analog to Digital Audio

The general theory behind digital audio is the process by which voltage levels from analog sound waves are encoded, processed, stored, and reproduced digitally (binary number system) to represent similar voltage levels.[13] While analog audio provides a continuous electrical signal that is a close representation of the original source, it is susceptible to noise and quality loss when copied because each time a copy of a copy is made, more noise is added. The advent of the Computer Age in the 1970s provided the means to convert analog sound waves into digital data. The data once digitally recorded could be stored in its memory and any part of that digital data could be retrieved, as originally recorded or altered. Mistakes could be edited out and timing errors corrected. It would take the compact disc or CD format for the music industry to recognize the importance of digital audio.

The CD is an optic disc that is able to store any kind of data from audio and video to documents digitally. It was created by a joint effort between Sony and Philips in 1980 after the so-called Red Book of standard specifications for the digital CD format was agreed upon, which included the size (12cm), length (74 minutes, 33 seconds), and storage (maximum 650 MB) of data.[14] Mark Knopfler, lead singer and guitarist of the British rock band Dire Straits, was an early convert to digital audio. Dire Straits would release in 1985 the album *Brothers in Arms* on CD that became an international blockbuster and is credited by many writers for launching the CD

format.[15] The CD became the fastest-growing home entertainment product in history and would overtake vinyl in 1988, cassettes in 1991[16] and global sales would "surpass 1 billion in 1992 and 2 billion in 1996."[17] The increase in CD sales was attributed to the repurchase of music already owned because of the higher quality of the digital CD format. However, by 1999, the gradual decline of CD sales would come from the MP3 as music began to transcend the CD physical format.

MP3 is a digital recording that is compressed to take up less space, as a download to a storage device, such as a MP3 player or computer hard drive. A typical music track on a CD takes approximately 60 megabytes compared to 5 megabytes when compressed at 128 kilobits per second (Kbps) via the MP3 codec. The bit rate can be anywhere from 96 to 320 Kbps, which will determine the sound quality and file size. Most download music sites recommend 192 Kbps or higher for a comparable sound of a CD and with a file size small enough to store hundreds of songs onto a smartphone or MP3 player. Digital technology would grow exponentially, as suggested by Kurzweil's "Law of Accelerating Returns," when digital data was able to be converted and compressed into something transferable. The next advancement would come when music instruments and surrounding platforms began to communicate with other devices.

MIDI Technology

MIDI stands for Music Instrument Digital Interface. It is hardware and software specifically designed to allow keyboard synthesizers, drum machines, effect processors, personal computers and other audio devices to communicate with one another. During the early days of electronic music production, and before the computer, each electronic instrument maker developed their own standards for the operation and transmission of information within their music systems.

This information consisted of electrical voltage values that were specific to their own manufactured product and incompatible with other electronic systems made by others. These voltage differences presented musicians the flexibility of combining different features from different manufacturers. In 1981, one year after the CD was announced, Dave Smith, designer of the first polyphonic synthesizer (Prophet 5), presented a paper at the Audio Engineering Society (AES) convention in New York. Smith proposed the adoption of a hardware and software music language protocol for electronic instruments that would enable communication between instruments made by different manufacturers.[18] The leading electronic music instruments makers including Yamaha, Roland, Moog, and Oberheim agreed a standard was needed. The result was the adoption of the MIDI Specification 1.0 that established for the first time a communication standard that all manufacturers could implement and utilize.[19] The MIDI language is a binary data message that can be used to represent and control all the parameters within a hardware synthesizer or software plug-in instrument. Every time a key is pressed on a MIDI keyboard, MIDI data is being generated. MIDI utilizes hardware keyboard synthesizers or synth, tone modules, and software plug-in instruments as primary devices for generating voices (sounds).[20] The number of voices available to the musician is determined by the capability of the hardware. Today, most keyboard synths and tone modules are polyphonic (capable of playing multiple notes at once) and multi-timbre with capabilities of 32, 64, and 128 simultaneous voices.[21] In 1983, the Yamaha Corporation would release the first ever FM MIDI keyboard synth, The Yamaha DX7 FM Synthesizer. The DX7 featured 6 oscillators (waveforms) arranged in a 32 algorithmic configuration to create and modify a voice. Its 16-note polyphony led to it becoming the most

widely used studio synth throughout the 1980s with over 200,000 sold.[22] The full power of the MIDI would be recognized with the advancement of audio sequencers and designed software.

The audio sequencer is a device or application software that can record, edit, and playback all the virtual MIDI instruments with both host and third-party plug-in processors.[23] Two notable sequencers in the 1980s were Cakewalk and Cubase. Cakewalk was able to recall up to 256 songs from a non-stop playlist from start to finish, which made it a favorite with live performers for providing pre-programmed accompaniment.[24] Cubase was known for its editing and synchronizing by being able to integrate with tape recorders developed for the movie industry. In the early 1990s, there were only two programs that had both a dedicated MIDI sequencer and digital audio capabilities: Opcode's Studio Vision and Mark of the Unicorn's Digital Performer, both were developed for the MacOS platform and would be called Digital Audio Workstations (DAW).[25] In 1996, Opcode would be acquired by Steinberg and merged Studio Vision with its own sequence program, Cubase. Mark of the Unicorn's Digital Performer was originally designed as part of Digidesign's Audiomedia, a hard disk recording system, which in 1989 would become Pro Tools. Avid would buy Digidesign in 1995 and Pro Tools has arguably become the industry standard for multi-track recording and processing audio. The DAW's most profound effect is the way musicians are able to achieve the same music results with fewer musicians and less cost. It was embraced by many film score composers because the audio and video elements could be used simultaneously in a nonlinear editing application.

From *Lion King* to *Stranger Things*

Hans Zimmer is a German film score composer and 11-time Academy Award nominee. Zimmer would win the 1995 original score Oscar for *The Lion King*. In a 2010 interview with

Steinberg Media Technologies, he discussed how he uses Cubase as his preferred DAW for all of his film scores. He used the Cubase system known for its timecode protocol that was developed for the movie industry standard called SMPTE (Society of Motion Picture and Television Engineers).[26] SMPTE is used to synchronize audio, MIDI, video, and film. When asked how he incorporates DAWs into his film scoring he points out that traditional building blocks of music such as tempo, rhythm, tonality, harmony, dynamics, and timbre are at the disposal of the composer to create meaning and enhance the experience of the film and is why a composer needs to "reinvent themselves every time with a blank page." Creating musical tracks is the first step in building a musical interpretation of the film. The DAW enables him to record and edit tracks instantly, while "300-400 MIDI tracks are going at the same time with most of the synths kept virtual all the way through the mix," saving both time and money.[27] Cubase could not have been able to process all of Zimmer's data without the corresponding advancements of semiconductor chips. Today multi-core chips with 8 or more GB of RAM allows more work in memory, so processing performance in a host DAW can process the high-definition and bandwidth data that film and video require without slowing down.

The scoring for Netflix's most watched show, *Stranger Things*, which premiered in 2017, was by the relatively unknown music producers Kyle Dixon and Michael Stein. Their *Stranger Things* score would win the 2017 Emmy for Outstanding Original Main Title Theme. In an interview with *Sound on Sound*, they discussed how they used 1980s analog synths combined with MIDI for the show's eerie sound and how they were selected to score the show. They pointed out that over the years they had built and stored hundreds of their own sample library tracks from which they selected and sent about 50 tracks to the Duffer Brothers, because "the series teeters

between wholesome family time …dimensional travel and there happens to be some sort of monster," for their work and creative skills to be gauged.[28] Their self-created sample library also demonstrates how playing a synth or MIDI virtual instrument does not always sound alike, as many music purists argue detracts from originality. For example, the sound can be more expressive by: Velocity – hitting the keys harder on the 73 E-Piano changes the sound in the lower register. Changing from a mellower, rounder sound to a harder, edgier, slightly distorted sound; Range – playing in different registers to take advantage of their unique timbres; or, using a Hold Pedal – to more closely mimic the sound technique of a traditional piano.[29] From their self-created samples library, they utilized loops to help the series develop a characteristic theme. The rising and falling sequence of notes in the *Stranger Things* opening is an arpeggio, which is a series of three or four notes played, one after another, to create harmonies. *Stranger Things* used a C Major chord with a B note and an extra C. Dixon and Stein laid down takes of various notes directly into MIDI Logic and set the arpeggiator style to the "Up and Down" mode, which built tension as the program added multiple layers of sound with diverse polyphonic patterns that were repeated to a synchronized set and tempo.[30] Later, they added a "woozy sub-bass" to darken the mood and intensity.

Howard Shore is another award-winning film composer. He has scored over 45 films to date that include *Lord of the Rings*, *Crash*, and *Silence of the Lambs*. Shore was also the first musical director for *Saturday Night Live* doing 120 shows between 1975-1980. In an interview included in *Masters of Music: Conversations with Berklee Greats*,[31] Shore said he approaches a score as a single composition that he later digitally edits into individual cues. The music to *Crash* was originally written as a chamber piece with three harps. However, to create a larger sound he

built the piece around six guitars (two guitarists doubling each harp), two percussion, and three woodwinds, recorded live. He used a string section for two cues and added reverb and delay. He would spend a week manipulating the recording, using it as samples in his DAW. For *Crash*, "about 25 percent of the score was created after the recording with editing and digital manipulation."[32] The four composers, Zimmer, Shore, Dixon, and Stein, acknowledge that technology has increased functionality, but not talent and vision. Charlie Puth is another artist that shows how the process of creation is still about capturing one's own unique vision with the use of digital technology and Pro Tools.

Attention: Music Production In A Box – Take It Anywhere

Charlie Puth is a Grammy nominated American singer/songwriter and pop producer who first gained fame for the song "See You Again" recorded with rapper Wiz Khalifa. The song was a track on the soundtrack *Furious 7*, released in 2015, as a tribute to actor Paul Walker. In a 2017 interview and recorded video with *Rolling Stone*, Puth spoke on how the song "Attention," which was the first single from his album *Voicenotes*, was conceived while touring, as the opening act for Shawn Mendes. Today, artists are no longer tethered to the studio because the internet and DAW can provide the mobility to produce from anywhere. "I record instruments, shakers and pianos on here [DAW] and I put them directly into the session . . . 'Attention' was the first song for the album, and it started out as this really sad, depressing piano ballad – as most of my songs start out as – and then they become groovy, fun pop songs."[33] Using Pro Tools, he started with a melody on strings from the Native Instruments' string sample library, but felt the sound was too much like the style of a Disney movie with its sweeping orchestral sound. Instead of getting rid of the melody, he switches to a guitar sample with a palm muting sound. Using an iOS app that records voice memos

from his iPhone, he played the notes individually (searching for an arpeggio), layered them, and cut up the waveforms. By doubling the tracks, he was able to create a stereo image and added a Rhodes piano sound to sonically model Terry Lewis and Jimmy Jam from 1988 – 1990s. Later, he would add a fake tape machine (vinyl crackle sound) using a plug-in to eliminate the bright sound from the guitar. The bass line was created on a MIDI keyboard. He chose to use a bass sample because he wanted to emulate the sounds of the disco era. To transition into the chorus he would add classic sweep sounds to make the choruses sound different from one another with vocal layering and harmonies. The technique of layering is more prevalent in today's music by creating thickness and fullness to the instruments or vocals in a song. The last thing he did was add an acoustic guitar, buried in the background, which was used more as a percussive element rather than for chords or melody. In the *Rolling Stone's* interview video, Puth explains the process with the Pro Tools session in the background, where there are waveforms from the audio tracks, which is helpful in searching for visual cues, such as high notes and frequencies that will spike or arc. Puth received a 2019 Grammy nominee for Best Engineered Album (non-classical) for his 2018 release of *Voicenotes*, which was also RIAA certified as a Gold album (500,000 streams and sales) within 5 days upon its release in May 2018.

The Next Big Idea

The technological innovations in hardware and software have made it possible for artists to create and record without the financial backing of major record labels, if they choose. The advent of digital technology has lessened the need for studio space as musicians can literally produce recordings anywhere with "in the box" workstations, and the production process may now be shortened from weeks to days.

The digital audio revolution that started in the 1980s showed the limitations of analog. The digital data once recorded could be stored and retrieved as originally recorded or altered. The cassette tape gave way to CDs allowing for longer albums, and digital processing soon let producers correct sound of not only instruments but also vocals. The CD would eventually give way to MP3 technology that provided the means for transferring digital data files as internet downloads. By the late 1990s, Studio Vision and Digital Performer laid the groundwork for digital audio workstations with multiple track recording, and the Pro Tools software platform became the first true DAW and revolutionized music production by bringing the studio into the computer.

Each successive generation of DAW technology has given producers and musicians more opportunities and flexibility to create. Today, one of the more interesting and newest forms of synthesis is music modeling. While some virtual instruments have been known to resemble the sounds of wave samples, music modeling is comprised of a series of parameters that represent real acoustic instrument properties. Properties such as: type of material the instrument is made from; how the instrument is played – pluck, palm muted, or struck; and, for string instruments – tension of the strings, and the location of the sound opening or pickups. These parameters, when adjusted by the software's algorithm, will produce an instrument sound that is dynamic and extremely authentic. Technology has established a new standard of music creation that has changed how popular music and film scores are composed and performed without sacrificing the quality of its sound. After thirty-six years, MIDI continues to evolve as microprocessors get smaller, faster, and more powerful. Future innovations such as Audio Fusion's design of a Virtual Reality 3D Studio, and the use of cloud computing to crunch large data to tweak and improve the mastering process from equalization and compression to saturation automatically are moving from big ideas to

reality. Providing composers and musicians another tool, results in TV and movie viewers and music listeners having the good fortune of reaping the benefits that diversity in new and creative music brings to the world of art.

Notes

1. Reebee Garofalo and Steve Waksman, *Rockin' Out* (Upper Saddle River: Pearson, 6th edition, 2014), 21.

2. Garofalo and Waksman, *Rockin' Out*, 22.

3. Hubert Howe, *Electronic Music Synthesis* (New York: W.W, Norton & Co., 1975), 35.

4. Peter Kirn, *Real World Digital Audio*, (Berkeley: Peach Pit Press, 2006), 30.

5. Susan Horning Schmidt, *Chasing Sound: Technology, Culture, and the art of studio recording from Edison to the LP*, (Baltimore: John Hopkins University Press, 2013), 21, Accessed September 24, 2019, https://0-ebookcentral.proquest.com.pacific.edu/lib.

6. Howe, *Electronic Music Synthesis*, 42.

7. David Miles Hubert and Robert E. Runstein, *Modern Recording Techniques*, (Burlington: Focal Press, 8th edition, 2014), 192.

8. Geoff Emerick and Howard Massey, *Here, There and Everywhere: My Life Recording the Music of THE BEATLES,* (New York: Penguin Group, 2006) 142.

9. Ibid., 143.

10. Ibid., 144.

11. Jason Gains, *Composing for moving pictures: the essential guide*, (Oxford: Oxford University Press, 2015), 70.

12. Emerick and Massey, *Here, There and Everywhere*, 134.

13. Hubert and Runstein, *Modern Recording Techniques*, 199-201

14. Dorian Lynskey, *How the compact disc lost its shine*, (*The Guardian*, 2015), Rock's Backpages. Accessed October 17, 2019, http://0-www.rockbackpages.com.pacificatclassic.pacific.edu/library.

15. Ibid.

16. Felix Richter, *The Rise and Fall of the Compact Disc*, Statista, 2019, Accessed September 24, 2019, https://www.statista.com/chart/12950/cd-sales-in-the-us/.

17. Lynskey, *How the compact disc lost its shine.1983*

18. *Dave Smith, Sequential Circuits MIDI Specifications*, (Mix Online, 2017), Accessed October 11, 2019,

https://www.mixonline.com/technology/1983-dave-smith-sequential-circuits-midi-specification-383642.

19. Ibid.

20. Hubert and Runstein, *Modern Recording Techniques*, 342

21. James Russell, *Software Round-up: Synths with 'Effects' Versions*. E-musician, updated June 7, 2019, Accessed October 11, 2019, https://www.emusician.com/gear/software-roundup-synth-effects-version.

22. *1983 Yamaha DX7 Synthesizer*, Review by Staff, Mix Online, updated Nov. 15, 2017, Accessed October 11, 2019, https://www.mixonline.com/technology/1983-yamaha-dx7-synthesizer-383673.

23. Kirn, *Real World Digital Audio*, 268.

24. Mikail Graham, *The Plug-In Zone*, (New York: Keyboard, 1997), Vol. 23, Iss. 8, 32. Accessed October 12, 2019, https://0-search.proquest.com.pacificatclassic.pacific.edu/docview/1359925/208708B2381B44EFPQ.

25. Paul de Benedictus, *HISTORY 101 – Opcode: Lest We Forget*, (New York: EQ,

2006), Vol. 17, Iss. 4, 39. Accessed October 12, 2019, https://0-search.proquest.com.pacificatclassic.pacific.edu/docview/756579564/ED3B5DDEDF984940PQ.

26. Gains, *Composing for moving pictures: the essential guide*, 128.

27. *Hans Zimmer on Inception and His DAW of Choice*, Steinberg Media Technologies, 2010, Accessed October 9, 2019, https://www.steinberg.net/en/community/stories/hans_zimmer.html.

28. Will Betts, *Scoring Stranger Things*, *Sound on Sound*, Accessed October 30, 2019, https://www.soundonsound.com/techniques/scoring-stranger-things

29. Kirn, *Real World Digital Audio*, 293.

30. Betts, *Scoring Stranger Things*.

31. Mark Small and Andrew Taylor, *Howard Shore Subliminal Scores*, (Masters of Music, 2005). 260-7, Accessed October 9, 2019, https://www.berkleeshares.com/music_business__careers/howard_shore_music_tips

32. Ibid., 263.

33. Kory Grow, *See Charlie Puth Break Down Emotional Hit Song 'Attention'*, *Rolling*

Stone, Oct. 3, 2017, Accessed October 12, 2019, https://www.rollingstone.com/music/music-news/see-charlie-puth-break-down-emotional-hit-song-attention-253485/.

Bibliography

Betts, Will. *Scoring Stranger Things*. Sound on Sound. Accessed October 30, 2019. https://www.soundonsound.com/techniques/scoring-stranger-things

de Benedictis, Paul. *History 101—Opcode: Lest We Forget*. New York Times, Apr. 2006. Accessed October 12, 2019. https://0-search.proquest.com.pacificatclassic.pacific.edu/docview/756579564/ED3B5DDEDF984940PQ.

Emerick, Geoff, and Massey, Howard. "Here, There and Everywhere: My Life Recording the Music of THE BEATLES." New York: Penguin Group Inc., 2006.

Gaines, Jason. "Composing for moving pictures: the essential guide." Oxford, New York: Oxford University Press, 2015.

Garofalo, Reebee, and Waksman, Steve. "Rockin' Out." Upper Saddle River, New Jersey: Pearson, 6th edition, 2014.

Graham, Mikail. *The Plug in Zone*. New York Times, Aug. 1997. Accessed October 12, 2019. https://0-search.proquest.com.pacificatclassic.pacific.edu/docview/1359925/208708B2381B44EFPQ.

Grow, Kory. *See Charlie Puth Break Down Emotional Hit Song, 'Attention'*. Rolling Stone, October 3, 2017. Accessed October 12, 2019. https://www.rollingstone.com/music/music-news/see-charlie-puth-break-down-emotional-hit-song-attention-253485/.

Hans Zimmer on Inception and His DAW of Choice. Steinberg Media Technologies (2010). Accessed Oct. 17, 2019. https://www.steinberg.net/en/community/stories/hans_zimmer.html

Howe, Hubert. "Electronic Music Synthesis." New York: W.W. Norton & Company,1975.

Huber, David Miles, and Runstein, Robert E. "Modern Recording Techniques." Burlington, MA: Focal Press, 8th edition, 2014.

Kirn, Peter. "Real World Digital Audio." Berkeley, CA: Peach Pit Press, 2006.

Lynskey, Dorian. *How the compact disc lost its shine*. The Guardian, 2015. Rock's Backpages. Accessed October 17, 2019. http://0-www.rockbackpages.com.pacificatclassic.pacific.edu/Library/Article/how0the-compact-disc-lost-its-shine-.

Richter, Felix. *The Rise and Fall of the Compact Disc*. Statista, 2019. Accessed September 24, 2019. https://www.statista.com/chart/12950/cd-sales-in-the-us/.

Russell, James. *Software Round-up: Synths with 'Effects' Versions*. E-musician, updated June 7, 2019. Accessed October 11, 2019. https://www.emusician.com/gear/software-roundup-synth-effects-version

Schmidt Horning, Susan. "Chasing Sound: Technology, Culture, and the art of studio recording from Edison to the LP." Baltimore, Md.: John Hopkins University Press, 2013. Accessed September 24, 2019. https://0-ebookcentral.proquest.com.pacificatclassic.pacific.edu/lib/uopacific/detail.action?docID=3318775.

Small, Mark and Taylor, Andrew. *Howard Shore Subliminal Scores*. Masters of Music, 2005. Accessed October 9, 2019. https://www.berkleeshares.com/music_business__careers/howard_shore_music_tips

1983 Dave Smith, Sequential Circuits MIDI Specification. Mix Online, updated, Nov. 15, 2017. Accessed October 11, 2019. https://www.mixonline.com/technology/1983-dave-smith-sequential-circuits-midi-specifications-383642

1983 Yamaha DX7 Synthesizer. Review by Staff. Mix Online, updated Nov. 15, 2017. Accessed October 11, 2019. https://www.mixonline.com/technology/1983-yamaha-dx7-synthesizer-383673