Worse Singers or Harder Songs?:

Pop Music Melodies from the 1970s to 2010s

Alison Tess Curl

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Reading Committee: Dr. Timothy Powell, Dr. Brian Patterson, Dr. Jessica Tomkins

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Abstract

Modern pop music on the radio is often difficult to sing, even for the recording artist. Many videos can be found of concerts where the singer is off-pitch or avoids singing certain sections of their songs. Rather than assuming the singer is untalented, this research sought to discover if songs were being written and produced with increasingly more difficult melodies. I created criteria which I used to analyze the top ten melodies from the seventies, eighties, nineties, etc. through the twenty-tens: the centeredness around the female passaggi, the range, and the tempo. The first criterion applied only to women, the second applied to all singers, and the third applied only to the musically untrained. Analysis of the data revealed that modern pop melodies did not increase or decrease in singing difficulty over time.

Literature Review

Like any industry, the pop music business has its idiosyncrasies and common practices that go largely unnoticed by the general public. Of these, there are two positions in the industry that are crucial when creating a song, namely the songwriter and the producer. While they have separate responsibilities, they often work collaboratively to craft the pop songs heard on the radio everyday. The practice of having dedicated songwriters and producers is by no means new, but as styles and tastes, as well as technology available, has changed, so has the sound of pop music. This research analyzes pop music melodies from the 1970s through the 2010s to discover if songs have become more difficult to sing.

Modern pop artists such as Ariana Grande, Taylor Swift, and Shawn Mendes are more often co-writers of their songs or altogether uninvolved with the writing process than they are the sole contributors. The practice of purchasing songs rather than writing them for oneself can be

traced back to the late 1890s and through the early 1900s, when the popular song became a commodity, created specifically to be sold.[1] Back then, songwriters wrote music and then either sold it outright to a publisher or collected royalties on the sheet music sales.[2] (Nowadays, artists purchase licenses which give them permission to record and perform a song, rather than buying the song itself.) The industry was concentrated in New York City, specifically on Twenty-eighth and Twenty-ninth streets between Fifth and Sixth avenues.[3] This location would come to be known as Tin Pan Alley.

Some of the most famous of these Tin Pan Alley songwriters were Irving Berlin and Charles K. Harris, and not only did they write songs, but also instructional manuals detailing their songwriting methods. By looking at these manuals, it can be plainly seen how selling a song was just as (if not, more) important that the actual composition of the piece itself.[4] Often, half of the chapters of these books would be related to the music business rather than advice for writing melodies and lyrics.[5] Of the advice they did give regarding songwriting, the most important quality a song should have would be its facility.[6] It had to be easily sung by the most average of singers and played by the most average of players. By adhering to this rule, the music was accessible to anyone, performer and consumer alike.

These kinds of guides for writing songs are still being written, often repeating much of the same information; but rather than focusing on how well the average person could sing the

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[1] David Suisman, "When Songs Become a Business," in *Selling Sounds: The Commercial Revolution in American Music,* (Cambridge: Harvard University Press, 2009), 18.
[2] Ibid.,"When Songs Become a Business," 23, 44.
[3] Ibid., "When Songs Become a Business," 20-21.
[4] Christopher Reali, "'Guided by Commercial Motives': Selling Songwriting," *Journal of the Music and Entertainment Industry Educators Association* 18, no. 1 (2018): 17.
[5] Reali, "'Guided by Commercial Motives': Selling Songwriting," 16-17, 19.
[6] Suisman, *Selling Sounds,* 22; Frank Ward O'Malley, "Irving Berlin Gives Nine Rules for Writing Popular Songs", *American Magazine,* July/October 1920*,* 242.

song, the goal has shifted to how it showcases the recording artist's talent.[7] While veteran songwriter Jason Blume warns against creating melodies that are too hard, he emphasizes that it should "challenge a skilled vocalist."[8] Compared to the early days of the popular music industry where the songs were written to be easily sung and played, now, the song must be impressive. What "impressive" means, however, is open to interpretation. Have songwriters been increasingly writing harder and harder tunes?

What also must be taken into consideration, however, is that the original composer's intentions are often changed once the song is in the hands of the artist. The intent of the lyrics, as well as any portion of melody or the overall song's structure can be added, removed, or changed to suit the artist. An example reported by CBS This Morning tells the story of Flo Rida's hit "My House." The songwriter, Ross Golan, explains that he originally wrote the song about how he and his wife often stay home by themselves, yet when Flo Rida joined the writing sessions, he added a rap which altered the original lyrics to mean he was throwing a house party.[9] The song, after release, became very successful, eventually peaking at number four on the Billboard charts in 2016.[10]

This demonstrates that while the song may or may not have been written at the same difficulty of the fully produced song, the only thing listeners hear is the final product. They will likely attempt to sing along, sometimes finding they cannot perform it at a comparable level to the recording artist. If the listener is a non-singer, then this probably comes at no surprise.

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[7] Jason Blume, *6 Steps to Songwriting Success* (New York: Billboard Books, 2008), 108.
[8] Blume, *6 Steps*, 108.
[9] Ross Golan interviewed by Don Dahler, "Songwriters share their process for writing hit music," YouTube video, 6:15, posted by "CBS This Morning," February 9, 2017, https://www.youtube.com/watch?v=BVrUtMi__0E.
[10] "Chart History: Flo Rida," *Billboard*, accessed April 29, 2020. https://www.billboard.com/music/flo-rida/chart-history/HSI/song/883251

However, if the listener is a singer, the confusion that arises from the inability to sound somewhat like the recording is jarring. What causes this difficulty?

To investigate this perceived phenomenon, I created criteria that explicitly define what makes a song difficult. There is surprisingly little research on this, considering that music classes everywhere use practice books that increase in difficulty to teach their students. These books help students learn to sing by sight, meaning that they can look at the sheet music and then sing it without needing an instrument or recording. These exercises start simply with quarter note patterns in common time and notes within the staff. This is understandable as a beginner cannot be expected to read or perform Mozart. Taking this into consideration, it is clear that some music is inherently more difficult than others. What factors contribute to this?

For this research, I propose that three factors be taken into account to determine the difficulty of a vocal piece: the passaggio, range, and the tempo. The passaggio is aptly defined in Robert Miller's *The Structure of Singing* as the "vocal register pivotal point."[11] The singing voice has multiple registers, or a set of consecutive pitches which have a similar timbre.[12] Training for classical singers includes "unifying the registers," meaning being able to easily sing between them with little noticeable difference in sound quality.[13] The passaggio, then, is where these registers switch, and untrained singers often avoid it or have difficulty singing through it. This is because, physiologically, the vocal cords vibrate differently depending on which register the singer is using. The passaggio in the adult female voice is located at different notes depending on the singer's vocal category (contralto, mezzo-soprano, or soprano), but all have

[11] Robert Miller, *The Structure of Singing: System and Art in Vocal Technique* (New York: Schimer Books, 1986), 312.
[12] Ibid., *The Structure of Singing,* 312.
[13] Ibid., *The Structure of Singing,* 132.

two passaggi.[14] According to Miller, a contralto's passaggi are generally located at G_4 and D_5, for a mezzo-soprano at F_4 and E_5, and for a soprano at E_4 and $F\#_5$.[15] I propose that any melody centered around these pitches will be more difficult for adult female singers to adequately perform precisely because these pitches are the points where the register switches.

The passaggi for male voices are a bit more complicated. While there are three generally accepted types of female voices, male voices have at least nine types, ranging from basso profondo to tenor.[16] Each of these categories has slightly different passaggi, which, together, cover the entire range of possible notes within an octave.[17] Rather than conclude, as I have with the female voice types, that songs centered around the passaggi are more difficult to sing for men (simply because the logical conclusion, then, would be that *all* songs are harder to sing for some men, depending on their voice type), I will abstain from creating an overarching criterion that uses the male passaggi.

Another factor that I propose makes a song harder to sing is its range. How high and low will the singer need to be able to sing to perform the song? Even Miller, whose audience is professionally trained classical singers, claims "more than one singer has been disturbed to read that a professional singer ought to possess a performing range of three octaves."[18] He goes further to say "an amazingly high percentage of all vocal writing...is contained within the range of a tenth."[19] Essentially, many pieces a classical singer might perform are well within their performing range, often being written with notes spanning barely under an octave and a half (or

[14] Ibid., *The Structure of Singing,* 134-5.
[15] Ibid., *The Structure of Singing,* 134-5.
[16] Ibid., *The Structure of Singing,* 117.
[17] Ibid., *The Structure of Singing,* 117.
[18] Ibid., *The Structure of Singing,* 161.
[19] Ibid., *The Structure of Singing,* 161.

18 half steps). With this in mind, I propose any song written with more than an octave and a half in range will be more difficult for any adult singer.

The ranges of children (approximately 5 to 11 years old), on the other hand, are more limited. A little more than two-thirds (67.4%) of first graders and most (97.9%) sixth graders can sing at least an octave.[20] While slightly over half (52.2%) of sixth graders have a range of two or more octaves, it is around this time that puberty begins to alter the voice, rendering this range accessible for a limited amount of time.[21] Also, when the limits of the range are approached by a melody, children often modulate to a different key to continue singing.[22] Of course, this means they have changed the song, so the singing can no longer be considered accurate. It is for this reason that I propose a melody with more than an octave range (12 half steps) will be more difficult for a child from ages 5 to 11 to replicate.

Adolescent and young adult voices (from approximately 12 - 21 years old) develop and change as they mature. Both female and male voices go through a few (albeit different) stages of development which affect various characteristics such as range, timbre, and fundamental speaking frequency. I will focus primarily on range as it is most pertinent to this research.

Changing male voices (or cambiata) have been studied extensively throughout the years. The most recent and widely accepted study of the development of cambiata singers outlines five stages through which the male voice travels: Unchanged (range[23]: F#$_3$ to E$_5$), Stage I (range: F#$_3$ to D$_5$), Stage II (range: D#$_3$ to B$_4$), Stage III (range: C#$_3$ - C$_5$), Stage IV (range: A#$_2$ - G$_4$), and

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[20] Sylvesta Wassum, "Elementary School Children's Vocal Range," *Journal of Research in Music Education* 27, no. 4 (1979): 219.
[21] Ibid., "Elementary School Children's Vocal Range," 219.
[22] Patricia J. Flowers and Deborah Dunne-Sousa, "Pitch-Pattern Accuracy, Tonality, and Vocal Range in Preschool Children's Singing," *Journal of Research in Music Education* 38, no. 2 (1990): 112.
[23] Every time range is used here, it means at its widest. It does not indicate that all male voices in these stages can sing to both extremes.

Stage V (range: E_2 - F_4).[24] It should be noted that during these stages the range sometimes exceeds an octave and a half; however, these reported ranges are extremes rather than averages. Also, by Stage I, these children begin to experience breathiness and strain above C_5, and by Stage II, the voice "loses agility."[25] Even during Stage IV, Cooksey reports that the voice is "light" and has yet to settle into its final form.[26] Because of this, I propose that the criteria be kept the same as it is for children, namely that any melody that exceeds an octave in range will be more difficult for adolescent male singers.[27]

Adolescent girls' voices, on the other hand, go through four stages: Prepubertal (range[28]: $B\flat_3$ - A_5), Pre-menarcheal (range: A_3 - A_5), Post-menarcheal (range: same as Pre-menarcheal, distinction made because of tessitura and timbre/sound quality changes), and Young Adult (range: G_3 - B_5).[29] While it appears that the female range is larger, it is important to remember that these are extremes, and most of the documented tessituras are much narrower. In addition, girls experience breathiness and hoarseness during the Pre- and Post-menarcheal stages in their upper ranges, which can make it uncomfortable and more difficult to sing.[30] With all this in mind, I propose that an adolescent girl will find songs with more than an octave range more difficult to sing.

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[24] John Cooksey, "Voice Transformation in Male Adolescents," in *Bodymind & Voice*, ed. Graham Welch and Leon Thurman (United Kingdom: VoiceCare Network, 2000), 735.
[25] Ibid., "Development of a Contemporary, Eclectic Theory," 13.
[26] Ibid., "Development of a Contemporary, Eclectic Theory," 14.
[27] The data gathered here are from two sources, both by Cooksey and colleagues. The exact ranges and names of the stages are from the more recent study (1985), whereas the data about the tonal quality during each stage is from the earlier study (1977). The names of each stage were changed between the two, so for simplicity's sake, I decided to only refer to them with the updated names, despite some of the information being drawn from the earlier research.
[28] Again, range here indicates extremes.
[29] Lynne Gackle, "The Adolescent Female Voice: Characteristics of Change and Stages of Development," *The Choral Journal* 31, no. 8 (1991): 22-3.
[30] Ibid., "Adolescent Female Voice," 22-3.

Older singers face difficulties, as well. While most young adults will not experience issues for a while, older singers must take into account how their aging voice will respond to a song. Older voices often experience a more limited range, unstable vibrato, and difficulty changing registers, among other struggles.[31] A female singer in her twenties has a different singing experience compared to a woman in her fifties or sixties. Male singers' voices age more slowly, but eventually they too begin to deteriorate. Compared to their younger counterparts, these older singers will find success with very different songs.

The final factor which I propose makes a song difficult to sing is its tempo; specifically, melodies at faster tempi will be harder to accurately reproduce for non-musicians. In a 2007 study surveying singing in the general population, a correlation between pitch accuracy and tempo was shown.[32] It was also observed in another experiment aiming to verify the results from the first.[33] In both, non-professional singers sang the tune "Happy Birthday" and were more successful remaining on-pitch at a slower tempo. Because the correlation did not always apply for those with musical training, however, any overarching statements about the relationship between tempo and pitch accuracy for both musicians and non-musicians alike must be avoided until more research can be conducted. Tempo also appears to have little to no impact with very young children's singing.[34] Taking all this into consideration, I will limit the tempo criterion so that it only applies to musically untrained adults.

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[31] Chad Whited et al., "The Aging Voice," in *The Performer's Voice,* ed. Michael S. Benninger et al. (San Diego: Plural Publishing, 2016), 95.
[32] Simone Dalla Bella et al., "Singing proficiency in the general population," *Journal of the Acoustical Society of America* 121, no. 2 (2007): 1185.
[33] Pauline Larrouy-Maestri and Dominique Morsomme, "Criteria and tools for objectively analysing the vocal accuracy of a popular song," *Logopedics Phoniatrics Vocology* 39, no. 1 (2014): 16.
[34] Patricia J. Flowers and Deborah Dunne-Sousa, "Pitch-Pattern Accuracy, Tonality, and Vocal Range in Preschool Children's Singing," *Journal of Research in Music Education* 38, no. 2 (1990): 108.

Children have varying singing abilities, as well. Much research has been conducted in this field, and while methodologies vary, it is commonly observed that short, pitch-matching exercises (either single note or short pattern) do not accurately predict a child's vocal accuracy when singing a song.[35] In fact, songs are second only to complex glides (glissandi with more than two up and down contours) in difficulty for very young singers to reproduce, according to a hierarchy of singing tasks developed by Welch and colleagues.[36] Another study analysing the difficulty of patterns for children from five to eight years old found that certain intervals, the length, and the range of a pattern determined how accurately children could repeat it.[37] While some previous research concluded that descending melodic contours are often more accurately sung, the more recent study found that ascending melodic contours were just as accurate as descending ones, and therefore had no effect on the difficulty of a pattern.[38] It is interesting to note, however, that the study which reported the inaccuracy of ascending contours specifically tested scale patterns, while the later study tested patterns consisting almost entirely of "skips," intervals of three or more.[39] This could suggest that larger intervals are easier for children to reproduce.

Most research regarding children and pitch-matching abilities also find that as a young singer ages, their accuracy improves.[40] In a makeshift longitudinal study (the data were obtained

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[35] Susan C. Guerrini, "The Developing Singer: Comparing the Singing Accuracy of Elementary Students on Three Selected Vocal Tasks," *Bulletin of the Council for Research in Music Education*, no. 167 (2006): 29.
[36] Graham F. Welch et al., "The Singing Competencies of Five-Year-Old Developing Singers," *Bulletin of the Council for Research in Music Education*, no. 127 (1995/1996): 159.
[37] Debbie Lynn Wolf, "A Hierarchy of Tonal Performance Patterns for Children Ages Five to Eight Years in Kindergarten and Primary Grades," *Bulletin of the Council for Research in Music Education*, no. 163 (2005): 66.
[38] Ibid., "Hierarchy of Tonal Patterns," 66.
[39] Clifford K. Madsen**,** "The Effect of Scale Direction on Pitch Acuity in Solo Vocal Performance," *Journal of Research in Music Education* 14, no. 4 (1966): 275.; Debbie Lynn Wolf, "A Hierarchy of Tonal Performance Patterns for Children Ages Five to Eight Years in Kindergarten and Primary Grades," *Bulletin of the Council for Research in Music Education*, no. 163 (2005): 65.
[40] Graham F Welch et al., "Age, Sex, and Vocal Task as Factors in Singing "In Tune" during the First Years of Schooling," *Bulletin of the Council for Research in Music Education*, no. 133 (1997): 156-7.; Nancy A. Cooper,

from two separate studies and then reanalyzed according to the same criteria), it was shown that children do indeed improve as they get older; however, the adults in the study seemed to regress, performing about as well as the kindergarteners.[41] A plausible explanation expressed in the study posited that around middle school, many students stop taking required music classes. The lack of constant practice then causes their acquired music skills to deteriorate.[42] This results in a general population of adults who are either musically adept or not. Despite one's status, however, pop music seems hard to sing.

Methodology

To determine if pop music compositions are being written and produced at a more difficult singing level, I examined the top ten songs from each decade from the 1970s through the 2010s according to the Billboard charts.[43] For the purposes of this study, "pop music" refers to music that appears on the Billboard charts. Some decades, for an unknown reason, did not include a number one, so the eleventh song on the list was utilized in its place. I analyzed the first verse and the chorus of each song according to the criteria presented in the literature review, specifically, the range, tempo, and centeredness around the passaggi.[44] I defined the melody as the notes the main vocalist(s) sang. The range was scored with a positive or negative integer,

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"Children's Singing Accuracy as a Function of Grade Level, Gender, and Individual versus Unison Singing," *Journal of Research in Music Education* 43, no. 3 (1995): 229.

[41] Steven M. Demorest and Peter Q. Pfordresher, "Singing Accuracy Development from K-Adult: A Comparative Study," *Music Perception: An Interdisciplinary Journal* 32, no. 3 (2015): 298.

[42] Ibid., "Singing Accuracy K-Adult," 298.

[43] From Billboard: "This top Billboard Hot 100 songs of each decade is ranked based on each title's performance on the Hot 100 through the chart dated Nov. 1, 2014. Songs are ranked based on an inverse point system, with weeks at No. 1 earning the greatest value and weeks at No. 100 earning the least. To ensure equitable representation of the biggest hits across multiple decades, time frames are weighted to account for fluctuating chart turnover rates due to different methodologies utilized." Elias Leight, "The Top 20 Billboard Hot 100 Hits of the 1980s," *Billboard*, last modified October 29, 2014, https://www.billboard.com/articles/news/6296897/billboard-hot-100-1980.

[44] This was done where possible to save time and exclude any departures from the melody line which might occur later in the song. A few songs did not employ the standard verse-chorus format, while others did not include sung verses.

indicating how many half steps over or under an octave the melody went. A score over six indicated a melody with a range of more than an octave and a half, and a score over zero indicated a range of more than an octave.

First, I created a Musical Instrument Digital Interface (MIDI) file of each melody. MIDI is a standard way of representing musical information that is easily understood by computers. Each note is assigned a value from 0 to 127, for example, C_4 (middle C) is the number 60. This allowed me to play the melody of a song on the keyboard, and the computer would register the notes. This streamlined my analysis later on. Many of the songs already had MIDI versions created by various people online, so to save time, I downloaded these files and edited them to fix any rhythmic or melodic errors. I used the Digital Audio Workstation (DAW) Studio One Artist 2 to make these changes. From this point, I input the MIDI files into an online MIDI file analyser to examine the range of each melody.[45] I used the equation H - (L+12) to render the Range Score. [46] H and L were the MIDI values for each note, as indicated by Figure 1.

Note	-1	0	1	2	3	4	5	6	7	8	9
C	0	12	24	36	48	60	72	84	96	108	120
C#	1	13	25	37	49	61	73	85	97	109	121
D	2	14	26	38	50	62	74	86	98	110	122
D#	3	15	27	39	51	63	75	87	99	111	123
E	4	16	28	40	52	64	76	88	100	112	124
F	5	17	29	41	53	65	77	89	101	113	125
F#	6	18	30	42	54	66	78	90	102	114	126
G	7	19	31	43	55	67	79	91	103	115	127
G#	8	20	32	44	56	68	80	92	104	116	
A	9	21	33	45	57	69	81	93	105	117	
A#	10	22	34	46	58	70	82	94	106	118	
B	11	23	35	47	59	71	83	95	107	119	

Figure 1

[45] "Midi file analyser," Stream Dev Projects, accessed November 27, 2020, http://streamdevprojects.com/midi
[46] H indicates the highest note; L indicates the lowest. The +12 is for each half step in an octave.

To analyse the MIDI data for the most common notes of each melody, I needed a simple Python program. As I have no programming experience, I enlisted the help of one of my peers studying computer science, Oscar Ibanez. He wrote a program called Midi-Master which would simply list the number of times a note appeared in the MIDI file.[47] I compiled this data for each song, noting the top three most frequent notes in the melody. Because I gathered this data to determine a melody's centeredness around the passaggi, I focused on the four notes from E_4 to G_4 (which encompasse the passaggi for sopranos, mezzo-sopranos, and contraltos). Almost none of the melodies included notes around the second passaggio (D_5 to $F\#_5$), rendering that portion of the criteria irrelevant.

As for the tempi, many of the songs included tempo changes or inconsistent tempos which did not align perfectly to a metronome. The listed tempi in the following charts are the closest approximation for the duration of the studied portion of the song.

Data and Discussion

Of the songs, only four included over 51% of the melody notes within the range of the first female passaggio: "Call Me" (1980), "Bette Davis Eyes" (1981), "Eye of the Tiger" (1982), and "Gold Digger" (2005). The latter only had a total of 22 sung notes (the rest was rapped or spoken), so this criterion does not accurately reflect the entire song. Even if the threshold were lowered to 40%, only three more songs met the criterion. I also looked at an octave down from the first passaggio to discover if there were any songs a woman might have difficulty with once transposed up to her octave, but this only added two more songs to the list (at 40% or more of the notes in the passaggio). Despite the fact that there are so few songs centered around this span of

[47] See appendix for program code.

notes across all decades, the data does not show an avoidance of this range. In fact, 33 of the 50 songs include at least ten notes in this range, often more. It appears the passaggio is neither avoided nor prominently featured in the songs analyzed.

However, upon further inspection, analysis of the data showed that 74% of the songs contained a majority of the notes (51%) below the passaggio. So, while this range is not necessarily avoided, it represents an upper boundary that about ¾ of songs do not exceed. Of the songs that prominently featured the passaggio range or above, one was "Gold Digger" (2005), so again, I ignored it as having insufficient data to determine its difficulty. The other twelve songs' data showed no patterns with regards to tempo or decade, but the Range Scores were primarily 4 or below.[48] This suggests that songs that do exceed the upper boundary of the passaggio compensate for this higher tessitura by limiting their range of notes. Essentially, when songs are difficult in one aspect, another aspect is made easier. This phenomenon also appeared when I analysed the cross-section of tempi by Range Score.

The tempi of the songs are summarized in Figure 2. The ranges as well as the averages remained fairly consistent, with the exception of the 1990s, which shows a slight trend toward slower tempi. The uniformity of the data shows that pop music tempos, when taken collectively, have neither increased nor decreased over time. Considered alone, the results of this criterion suggest that pop music has maintained its level of difficulty across the five decades studied.

[48] The exception was "One Sweet Day" (1995) with a Range Score of 10.

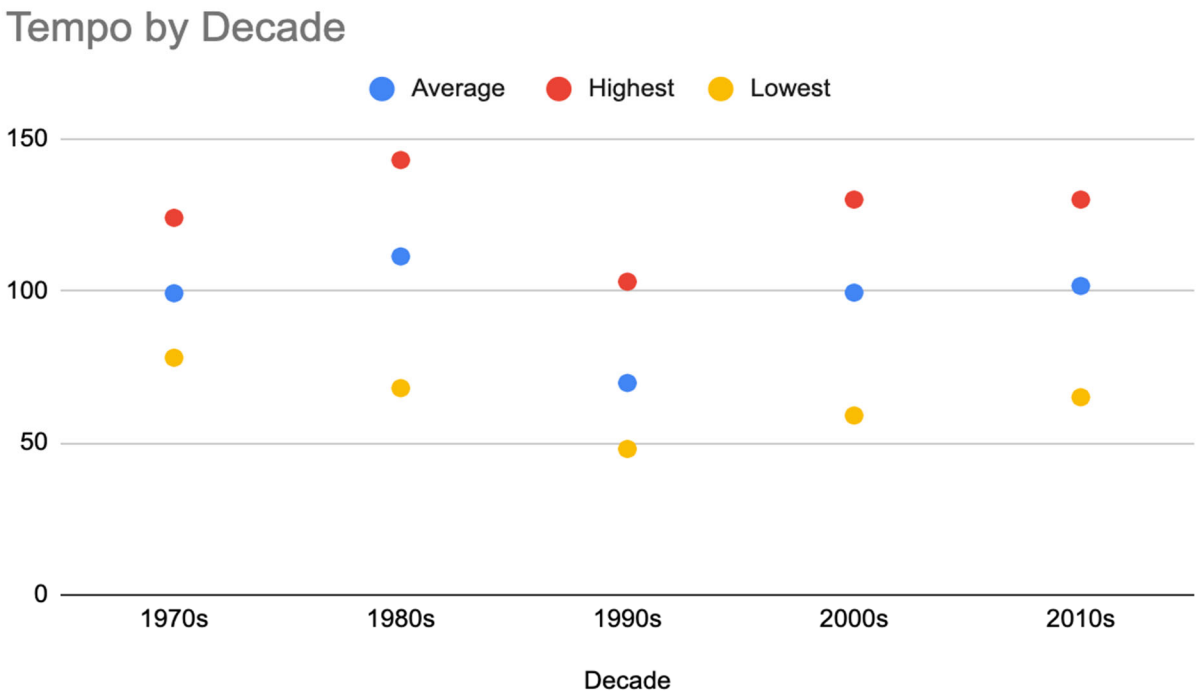

Figure 2

The final criterion studied was the Range Score, which I developed for this research. There were 16 songs which had a Range Score at or below 0, indicating they were exactly an octave or below. Of those, 2 had instrumental or rapped verses, so there was not much singing to analyze.[49] Ignoring the two songs with little singing, there were 3 songs which featured two or more singers on the studied portion of the track. It is likely these songs would be easily sung by children, adolescents, and adults precisely because the range of notes in the melody does not exceed the capabilities of any singer.

There were 14 songs with a Range Score over 6, half of which featured two or more singers on the studied portion of the track. This was unsurprising; including more singers (with varying ranges) allows the song's range to extend beyond what one singer is capable of

[49] "Party Rock Anthem" (2011) and "Gold Digger" (2005)

performing. These songs would be difficult for children, adolescents, and adults to sing because they are approaching - if not overtaking - the limits of a single average singer's range.

Analysis of the average Range Scores across the decades did not yield any indication of a positive or negative trend, as shown in Figure 3. The average Range Scores are all between 2 and 6, the highest is generally 12 or above, and the lowest is zero or below. It appears that pop music has maintained a level of difficulty that does not fluctuate very much from decade to decade.

Decade	Average	Highest	Lowest
1970s	4.7	15	-4
1980s	2.8	16	0
1990s	5.3	17	0
2000s	3.5	12	0
2010s	4.1	12	0

Figure 3

When the tempo and Range Score criteria were analyzed together, however, a fascinating pattern appeared: the top ten songs with the fastest tempi had an average Range Score of 2.3, and the bottom ten songs with the slowest tempi had an average Range Score of 7.6 (see Figures 4 and 5). This suggests that when a song is faster, it is more likely to limit the range of notes in the melody, and when the song is slower, it is more likely to have a wider range of notes in the melody. As posited above, when one aspect of the song is made harder, another is made easier; in this case, when the tempo is harder to keep up with, the melody is limited in its range and vice versa. This could be why the data, when taken as a whole, does not show any trends; it is simply because individual songs may be more difficult in one way, but easier in another, therefore balancing out the level of difficulty.

Figure 4

Tempo by Range Score	Range Score	Fastest
Say Say Say	3	118
Flashdance...What A Feeling	2	124
Silly Love Songs	7	124
Girls Like You	0	125
Low	3	127
I Gotta Feeling	3	128
We Found Love	0	128
Boom Boom Pow	5	130
Party Rock Anthem	0	130
Call Me	0	143
Average	2.3	

Figure 5

Tempo By Range Score	Range Score	Slowest
I'll Make Love To You	7	48
End Of The Road	17	50
Un-Break My Heart	7	56
Apologize	7	59
Candle In The Wind 1997	4	61
One Sweet Day	10	64
Foolish Games/You Were Meant For Me	4	65
Somebody That I Used To Know	12	65
(Everything I Do) I Do It For You	3	66
Lady	5	68
Average	7.6	

Conclusion

It has been widely reported that many famous singers, including Miley Cyrus, Keith Urban, and Adele have all had vocal cord surgery.[50] Whether this was due to poor technique, overwork, or the difficulty of the songs themselves remains unknown. This research suggests that the overall difficulty of pop songs has not changed from the 1970s through the 2010s. It does provide, however, a framework for determining the difficulty of a vocal piece by using the passaggio, range, and tempo. Limitations of this study include the amount of songs analyzed, the paucity of automation or computer-aided analysis, and the fact that melodic contour was not included as a criterion. Further research into this topic is much needed because a standard measure of determining musical difficulty, in both vocal and instrumental music, would aid music educators, composers, and performers in creating and performing suitable pieces for their level of music education and experience. It would also help avoid injury and injurious rehearsals. Ultimately, this research has barely scratched the surface of determining the difficulty of music, and there is much more work to be done.

[50]Andrea Wurzburger, "Miley Cyrus, Céline Dion and More Stars Who've Had to Bounce Back from Vocal Injuries," *People,* last modified November 11, 2019, accessed October 12, 2020, https://people.com/music/celebrities-who-had-vocal-injuries/?slide=7308069#7308069.

Appendix

The proceeding figures are the raw data collected during this research. Therefore, some explanation of its organization is in order.

The page immediately after this explanatory page is the one that I used to collect the information on the song that was easily accessible online or simply by listening to the song, such as the artist, year released, tempo, and the chart position, as well as where I compiled my range data and calculated the Range Score. These are all labeled above their respective columns.

The second figure is slightly more in depth; this is where I compiled the output data of Midi-Master. The song title is again on the far left, followed by the year released, Range Score, and tempo, all copied from the first spreadsheet. Range Scores above 6 are highlighted in green. The bulk of this sheet, however, is the frequency of appearance of each note in each song's MIDI file. If the cell is blank, the note did not appear in the song. If the cell is highlighted, that indicates it was one of the top three most frequent (or common) notes in the file. (If four are highlighted that indicates there was a tie.) The far right of the sheet sums the total number of notes below the passaggio range versus in and above the passaggio range, and the final column is how many notes were in the transcribed MIDI file in total.

The third and final appendix is the source code of Midi-Master. I ran it through the command line, so there is no user interface unique to the software.

Song Title	Artist	Decade Chart	Year Released	Chart Position	Tempo	Range	Highest Note Midi	Lowest Note Midi	Range Score
Shadow Dancing	Andy Gibb	1970	1978	10	102	G3-D#4	63	55	-4
Night Fever	Bee Gees	1970	1977	8	109	E4-D5	74	64	-2
Another One Bite	Queen	1980	1980	7	110	F3-F4	65	53	0
Call Me	Blondie	1980	1980	9	143	D4-D5	74	62	0
Bette Davis Eyes	Kim Carnes	1980	1981	2	116	C4-C5	72	60	0
Centerfold	The J. Geils Band	1980	1981	11	114	E3-E4	64	52	0
Eye Of The Tiger	Survivor	1980	1982	4	109	C4-C5	72	60	0
Macarena (Baysi	Los Del Rio	1990	1995	2	103	D#3-D#4	63	51	0
Truly Madly Deep	Savage Garden	1990	1997	9	84	G3-G4	67	55	0
Let Me Love You	Mario	2000	2004	8	94	F3-F4	65	53	0
Yeah!	Usher feat. Lil Jon & Luc	2000	2004	2	105	A#3-A#4	70	58	0
Gold Digger	Kanye West feat. Jamie	2000	2005	9	92	C4-C5	72	60	0
Party Rock Anthe	LMFAO feat. Lauren Ber	2010	2011	2	130	D#2-D#3	51	39	0
Rolling in the Dee	Adele	2010	2011	10	105	C4-C5	72	60	0
We Found Love	Rihanna feat. Calvin Har	2010	2011	6	128	C#4-C#5	73	61	0
Girls Like You	Maroon 5 feat. Cardi B	2010	2017	5	125	G3-G4	67	55	0
Too Close	Next	1990	1997	7	100	F#3-G4	67	54	1
Le Freak	Chic	1970	1978	3	118	G3-A4	69	55	2
Every Breath You	The Police	1980	1983	5	117	G#3-A#4	70	56	2
Flashdance...Wha	Irene Cara	1980	1983	6	124	A#3-C5	72	58	2
No One	Alicia Keys	2000	2007	6	90	B3-C#5	73	59	2
Uptown Funk	Mark Ronson feat. Brunc	2010	2014	1	115	C4-D5	74	60	2
Tie A Yellow Ribb	Dawn feat. Tony Orlandc	1970	1973	9	87	D3-F4	65	50	3
Say Say Say	Paul McCartney & Micha	1980	1983	8	118	A#3-C#5	73	58	3
(Everything I Do)	Bryan Adams	1990	1991	5	66	F4-G#5	80	65	3
How You Remind	Nickelback	2000	2001	5	85	G3-A#4	70	55	3
Low	Flo Rida feat. T-Pain	2000	2008	3	127	D#3-F#4	66	51	3
I Gotta Feeling	The Black Eyed Peas	2000	2009	4	128	E3-G4	67	52	3
Shape of You	Ed Sheeran	2010	2017	3	96	G#2-B3	59	44	3
Foolish Games/Y	Jewel	1990	1995	4	65	F#3-A#4	70	54	4
Candle In The Wi	Elton John	1990	1997	10	61	B2-D#4	63	47	4
Tonight's The Nig	Rod Stewart	1970	1976	2	91	F#3-B4	71	54	5
You Light Up My I	Debby Boone	1970	1977	1	78	F#3-B4	71	54	5
Lady	Kenny Rogers	1980	1980	10	68	C#3-F#4	66	49	5
Boom Boom Pow	The Black Eyed Peas	2000	2009	7	130	D2-G4	67	50	5
Despacito	Luis Fonsi & Daddy Yanl	2010	2019	9	89	F#3-B4	71	54	5
Silly Love Songs	Wings	1970	1976	6	124	C3-G4	67	48	7
I Just Wanna Be '	Andy Gibb	1970	1977	5	97	E3-B4	71	52	7
I'll Make Love To '	Boyz II Men	1990	1994	6	48	D3-A4	69	50	7
Un-Break My Hea	Toni Braxton	1990	1996	3	56	D3-A4	69	50	7
Apologize	Timbaland feat. OneRep	2000	2007	10	59	D#3-A#4	70	51	7
Old Town Road	Lil Nas X feat. Billy Ray	2010	2019	7	68	G#2-D#4	63	44	7
How Deep Is You	Bee Gees	1970	1977	4	105	A#2-G4	67	46	9
One Sweet Day	Mariah Carey & Boyz II I	1990	1995	8	64	D#3-C#5	73	51	10
Dilemma	Nelly feat. Kelly Rowlanc	2000	2002	11	84	C3-C5	72	48	12
Somebody That I	Gotye feat. Kimbra	2010	2011	8	65	C3-C5	72	48	12
Closer	The Chainsmokers feat.	2010	2016	4	95	D#2-D#4	62	38	12
Let's Get It On	Marvin Gaye	1970	1973	7	81	C3-D#5	75	48	15
Endless Love	Diana Ross & Lionel Ric	1980	1981	3	94	A#2-D5	74	46	16
End Of The Road	Boyz II Men	1990	1991	11	50	D#3-G#5	80	51	17

Song Title	year re	range	tempo	C#2	D2	D#2	E2	F2	F#2	G2	G#2	A2	A#2	B2	C3	C#3	D3	D#3	E3	F3	F#3	G3	G#3	A3	A#3	B3	C4	C#4	D4	D#4	E4	F4	F#4	G4	G#4	A4	A#4	B4	C5	C#5	D5	D#5	E5	below passaggio	in and above passa	Total
(Everything I Do)	1991	3	66																	1			5		3		2	11		17		14	13		4								39	31	70
Another One Bite	1980	0	110																	24		10	9		16		22	12		1		1											94	1	95
Apologize	2007	7	59															2		4		6			28		20				17		2		1			8					77	11	88
Bette Davis Eyes	1981	0	116																								2			13		1	36		11		20	1		6				15	75	90
Boom Boom Pow	2009	5	130		4			8				16					3			2				6						4			5		2								43	7	50
Call Me	1980	0	143																											12		9	14		13		8	2		4		8		12	58	70
Candle In The W	1997	4	61											2		5	1		18		12	23		9		32		15	2	3														122	0	122
Centerfold	1981	0	114																7			22		5		15			18		13														67	13	80
Closer	2016	12	95			2					10		10		13			16					59		46		17			3														176	0	176
Despacito	2019	5	89																		11	10		40		80		32	63		52		39	19		4		1					236	115	351
Dilemma	2002	12	84												27		5			84				7			8		4		6	29		22	1	15			5				135	78	213
End Of The Roa	1991	17	50															2		2		8	5	26			8		6	27		22		28	1								84	51	135
Endless Love	1981	16	94										1		4		7	5		7		3		4	5		8		5	4		5		2		6	10		4		2			53	29	82
Every Breath You	1983	2	117																				24		9		17	9		5		7		1	4		2							64	14	78
Eye Of The Tiger	1982	0	109																								2			29		42		28	15		5		4					31	94	125
Flashdance...Wh	1983	2	124																						11		25		17	10		20		10		6	21		6					63	63	126
Foolish Games/Y	1995	4	65																		5		10	26		23		8		9		24	37		23		5							81	89	170
Girls Like You	2017	0	125																			12		16		8	52		28		10			2										116	12	128
Gold Digger	2005	0	92																								1		3		7	2		3		5				1			4	18	22
How Deep Is You	1977	9	105										5		3		2	12	1	14		19	17		27	2	16	3	2	3		1		6									126	7	133
How You Remind	2001	3	85																			8		7	27		29		21	22		19					2						114	21	135
I Gotta Feeling	2009	3	128																42			34		28		47	38		28		10	2		11									217	23	240
I Just Wanna Be	1977	7	97																2		2			8		30		39	31		23		13		7	28		4					112	75	187
I'll Make Love To	1994	7	48														6		2		6	1		20		20		10	27		18		19	4		1							92	42	134
Lady	1980	5	68													1		8		4	11		13		25	6		10		5		5	2										83	7	90
Le Freak	1978	2	118																			6		28			9		16		4			1		5							59	10	69
Let Me Love You	2004	0	94																	19		25		3	61		53		41	8		2											210	2	212
Let's Get It On	1973	15	81												1			8		1		3			13		19		6	24		26	4	22	4		7		2			2	75	67	142
Low	2008	3	127															6		2	2		2		145	2				65			17										224	17	241
Macarena (Bays	1995	0	103															3		1			37		4		59			9													113	0	113
Night Fever	1977	-2	109																												2		8		20	4		41	1	8	1		0	85	85
No One	2007	2	90																							1				18		27		45	27		22		4			1	143	144
Old Town Road	2019	7	68								19		2	16		31					3		14		1	6		8		13													113	0	113
One Sweet Day	1995	10	64															2		1		8	12		8		4	2		7		6		15	35		25		13	3			44	97	141
Party Rock Anthe	2011	0	130			25					8		12		10	4		8																									67	0	67
Rolling in the De	2011	0	105																								32		4	44		20		50	3		13		5				80	91	171
Say Say Say	1983	3	118																						6			7		12		6	9	2	6		16		6	3			25	48	73
Shadow Dancing	1978	-4	102																			10		11	24		18		14	4													81	0	81
Shape of You	2017	3	96								3			2		52			66		84		48		8																			263	0	263
Silly Love Songs	1976	7	124													1							9		8		4	21		15		13	7		33								58	53	111
Somebody That	2011	12	65												2		14		14	14		41		22			18		20			19		28		26	5		8				145	86	231
Tie A Yellow Ribb	1973	3	87														1	1	2	11		10		24	14		30	6	16	2	1	5											117	6	123
Tonight's The Nig	1976	5	91																		1		7			7		15		33			12		6			5				63	23	86
Too Close	1997	1	100																		14			31		16		2	32		17		8	2									95	27	122
Truly Madly Deep	1997	0	84																			4		9		5	71		20		8			3									109	11	120
Un-Break My He	1996	7	56														8		10		8	4	1	14	1	28	2	13	16		15	15		4		1							105	35	140
Uptown Funk	2014	2	115																								47		29			72		11		8			6		1		76	98	174
We Found Love	2011	0	128																									1				4	27		13		29	7		4			1	84	85
Yeah!	2004	0	105																						3		12		90	11		23		69		14	2						116	108	224
You Light Up My	1977	5	78																		2	4		12	3	11	3	3	3	1	5		7	7		4		1					42	24	66

Midi-Master scripted by Oscar Ibanez

```
from mido import MidiFile

#midi number to piano key note

midi_to_key = {21: 'A0', 22: 'A#0/Bb0', 23: 'B0', 24: 'C1', 25: 'C#1/Db1', 26: 'D1', 27: 'D#1/Eb1',

28: 'E1',

29: 'F1', 30: 'F#1/Gb1', 31: 'G1', 32: 'G#1/Ab1', 33: 'A1', 34: 'A#1/Bb1', 35: 'B1', 36: 'C2', 37:

'C#2/Db2',

38: 'D2', 39: 'D#2/Eb2', 40: 'E2', 41: 'F2', 42: 'F#2/Gb2', 43: 'G2', 44: 'G#2/Ab2', 45: 'A2', 46:

'A#2/Bb2',

47: 'B2', 48: 'C3', 49: 'C#3/Db3', 50: 'D3', 51: 'D#3/Eb3', 52: 'E3', 53: 'F3', 54: 'F#3/Gb3', 55:

'G3', 56: 'G#3/Ab3',

57: 'A3', 58: 'A#3/Bb3', 59: 'B3', 60: 'C4(middle C)', 61: 'C#4/Db4', 62: 'D4', 63: 'D#4/Eb4', 64:

'E4', 65: 'F4',

66: 'F#4/Gb4', 67: 'G4', 68: 'G#4/Ab4', 69: 'A4 concert pitch', 70: 'A#4/Bb4', 71: 'B4', 72: 'C5',

73: 'C#5/Db5',

74: 'D5', 75: 'D#5/Eb5', 76: 'E5', 77: 'F5', 78: 'F#5/Gb5', 79: 'G5', 80: 'G#5/Ab5', 81: 'A5', 82:

'A#5/Bb5',

83: 'B5', 84: 'C6', 85: 'C#6/Db6', 86: 'D6', 87: 'D#6/Eb6', 88: 'E6', 89: 'F6', 90: 'F#6/Gb6', 91:

'G6', 92: 'G#6/Ab6',

93: 'A6', 94: 'A#6/Bb6', 95: 'B6', 96: 'C7', 97: 'C#7/Db7', 98: 'D7', 99: 'D#7/Eb7', 100: 'E7', 101:

'F7',

102: 'F#7/Gb7', 103: 'G7', 104: 'G#7/Ab7', 105: 'A7', 106: 'A#7/Bb7', 107: 'B7', 108: 'C8'

}
```

```
def getSongNotes():
    notes = {}
    try:
        midiFile = input('Type file name with extension: ')
        mid = MidiFile(midiFile)
        for i, track in enumerate(mid.tracks):
            print('Track {}: {}'.format(i, track.name))
            for msg in track:
                if msg.type == 'note_on':
                    notes[msg.note] = notes.get(msg.note, 0) + 1
        #print(len(notes))
        return notes
    except Exception as error:
        raise(error)
def printNotes():
    notes = getSongNotes()
    midi_piano = {}
    for key in notes:
        if(midi_to_key.get(key)):
            midi_piano[midi_to_key.get(key)] = notes.get(key)
    for key, value in midi_piano.items():
        print(str(key) + '  count:' + str(value), sep=' ')
    #print(len(midi_piano))
```

printNotes()

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