Lennon v. McCartney

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Introduction

The emotions evoked through a piece of music are largely determined by its harmonies—pitches that occur together. Chord progressions describe the movements of these harmonies throughout the piece; thus, the chord progressions used are fundamental in determining the mood of the music and are worthy of analysis. Given the large influence that The Beatles have had on modern music, it is of interest to gain insight into the chord progressions used in their songs. It is already known that The Beatles' music contains a large variety of chords and chord progressions (Johansson, 1999). Some of this variation can be attributed to which band member was the primary composer of a song. Differences in melodies have been noted between songs written by John Lennon and those written by Paul McCartney; Lennon's have been known to stay within a smaller range of pitch compared to McCartney's (Glickman, Brown, and Song, 2019). Presumably, if there are differences in melody, differences in chord progressions could be present as well. This analysis was performed to investigate this possibility. To accomplish this goal, Markov chains were fit to different Beatles songs. An initial analysis revealed that, of a sample of randomly selected songs from each artist, most chord progressions yielded regular Markov chains. No discernable patterns were observed within the group of McCartney's songs or within the group of Lennon's, and no categorizable differences were found between the two artists. Because of this, this report will focus on two songs (one from each artist) that produced Markov chains which deviated from the regular structure: "Norwegian Wood" and "Good Day Sunshine". The state spaces for these Markov chains were the chords utilized in the respective songs, and transition matrices were created from the chord transitions present in the songs.

Music Theory

- **Chord:** A group of notes played together – usually considered three or more.
    - Chords are denoted by roman numerals
- **Tonic chord:** The chord based on the first note of the scale, denoted "I". This is considered the "home chord" and gives a sense of resolution.
- **Cadence:** A two-chord progression that ends a phrase of music.

Results and Discussion

Norwegian Wood

"Norwegian Wood" is a 1965 Beatles song written primarily by John Lennon. The chords utilized in this song are the tonic (I), flat 7^{th} (bVII), minor 1^{st} (i), subdominant major (IV), minor supertonic 7^{th} (ii^7), and dominant 7^{th} (V^7). Thus, the state space for this Markov Chain is:

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S_1 = {I, i, ii^7, IV, V^7, bVII}.

The transition matrix (P_1) and Markov chain plot are shown in Table 1 and Figure 1, respectively:

Table 1. Transition matrix for "Norwegian Wood" chord progressions (P_1).

From	To I	i	ii^7	IV	V^7	bVII
I	0	0.2	0	0	0	0.8
i	0	0	0.5	0.5	0	0
ii^7	0	0	0	0	1	0
IV	0	1	0	0	0	0
V^7	1	0	0	0	0	0
bVII	1	0	0	0	0	0

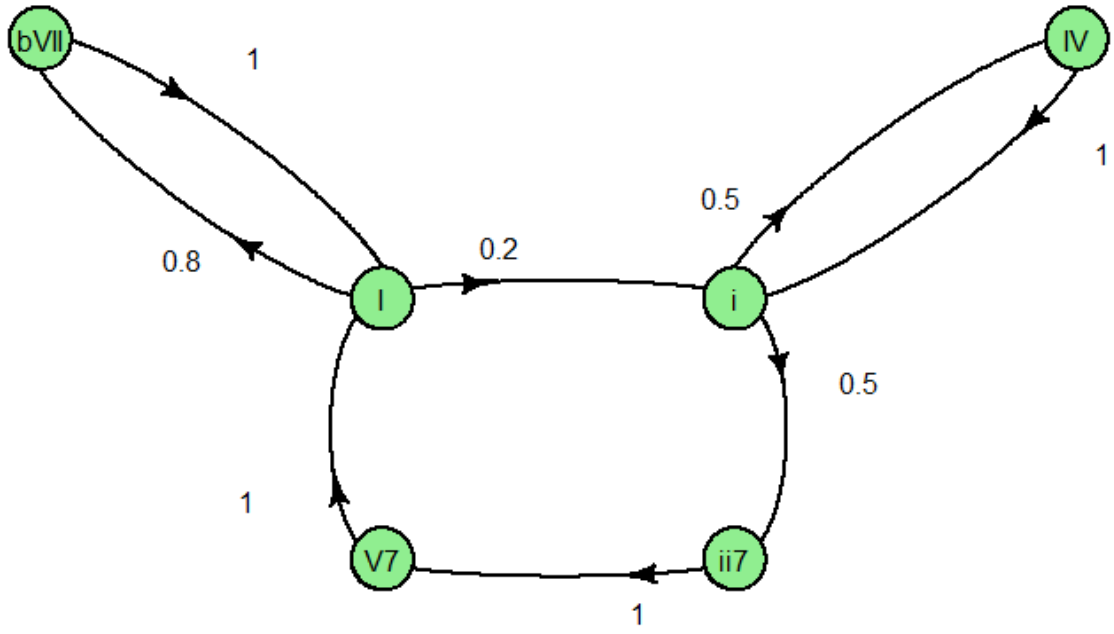

Figure 1. Markov chain plot with transition probabilities for "Norwegian Wood" chord progressions.

This is an irreducible, periodic Markov chain with period 2, which leads to two cyclic subclasses: C_0 = {I, IV, ii^7} and C_1 = {i, bVII, V^7}. It is not surprising that the I chord and V^7 chord belong to adjacent cyclic classes; chords built on the fifth note of the scale (such as V^7) are often immediately followed by the tonic chord (I) to form a cadence (Benward and Saker, 2009). As this progression gives the listener a sense of resolution, it is not unexpected that Lennon chose to use it in this song. More interesting is the use of the flat 7^{th} (bVII). It is an unusual chord, but the Beatles took preference to it, so much so that part of the increasing popularity of this chord in the 1960s has been attributed to the Beatles' success (Pinter, 2019). Despite the uniqueness of this chord at the time, Lennon's employment of it within his chord progressions was typical; this chord was most often used as a replacement for a chord based on the dominant of the scale (such as the V^7) (Pinter, 2019). Since V^7 and bVII fell into the same cyclic subclass, it is quite plausible that Lennon was using this technique in "Norwegian Wood".

Table 2 shows the fundamental matrix (Z_1) for this Markov chain. Using this, the matrix of mean recurrence times (M_1) can be found, as shown in Table 3.

Table 2. Fundamental matrix for "Norwegian Wood" chord progressions (Z_1).

	To					
From	I	i	ii^7	IV	V^7	bVII
I	0.944	-0.051	-0.097	-0.097	-0.168	0.469
i	-0.842	1.235	0.546	0.546	0.474	-0.959
ii^7	0.230	-0.337	0.760	-0.240	0.689	-0.102
IV	-1.199	1.092	0.474	1.474	0.403	0.474
V^7	0.587	-0.194	-0.168	-0.168	0.760	0.184
bVII	0.587	-0.194	-0.168	-0.168	-0.240	1.184

Table 3. Matrix of mean recurrence times for "Norwegian Wood" chord progressions (M_1).

From	To I	i	ii^7	IV	V^7	bVII
I	2.8	9	12	22	13	2.5
i	5	7	3	13	4	7.5
ii^7	2	11	14	24	1	4.5
IV	6	1	4	14	5	8.5
V^7	1	10	13	23	14	3.5
bVII	1	10	13	23	14	3.5

Given that the tonic chord is considered the "home base" of the song, a natural question to ask is how long it should take to return to the tonic after leaving? In this case, the value in question is the $(1,1)^{th}$ entry of matrix M_1: 2.8. Thus, the expected number of steps taken to return from the tonic to the tonic is 2.8.

Good Day Sunshine

"Good Day Sunshine" was written in 1966 primarily by McCartney. It includes the chords tonic (I), supertonic major (II), major supertonic 7^{th} (II^7), dominant 7^{th} (V^7), submediant major (VI), submediant 7^{th} (VI^7), submediant 9^{th} (VI^9), and subdominant minor 7^{th} (vi^7). The state space for the Markov chain is then:

$S_2 = \{I, II, II^7, V^7, VI, VI^7, VI^9, vi^7\}$.

Clearly, this state space differs greatly from that of "Norwegian Wood". It has eight states instead of six, and the intersection of the two is only $\{I, V^7\}$. It should be noted that although McCartney's song has more chords overall, two of them are both based on the second note of the scale (II and II^7), and four of them are all based on the sixth note of the scale (VI, VI^7, VI^9, and vi^7). Thus, all chords are based on either the first, second, fifth, or sixth note. In contrast, the chords in Lennon's song are all based on either the first, second, fourth, fifth, or seventh notes. The transition matrix (P_2) and Markov chain plot for "Good Day Sunshine" are displayed in Table 4 and Figure 2, respectively.

Table 4. Transition matrix for "Good Day Sunshine" chord progressions (P_2).

From	To I	II	II^7	V^7	VI	VI^7	VI^9	vi^7
I	0	0.25	0	0.25	0	0	0	0.5
II	0	0	0	0	0.889	0	0.111	0
II^7	0	0	0	1	0	0	0	0
V^7	1	0	0	0	0	0	0	0
VI	0	0.625	0	0.375	0	0	0	0
VI^7	0	0	0	0	0	1	0	0
VI^9	0	0	0	0	0	1	0	0
vi^7	0	0	1	0	0	0	0	0

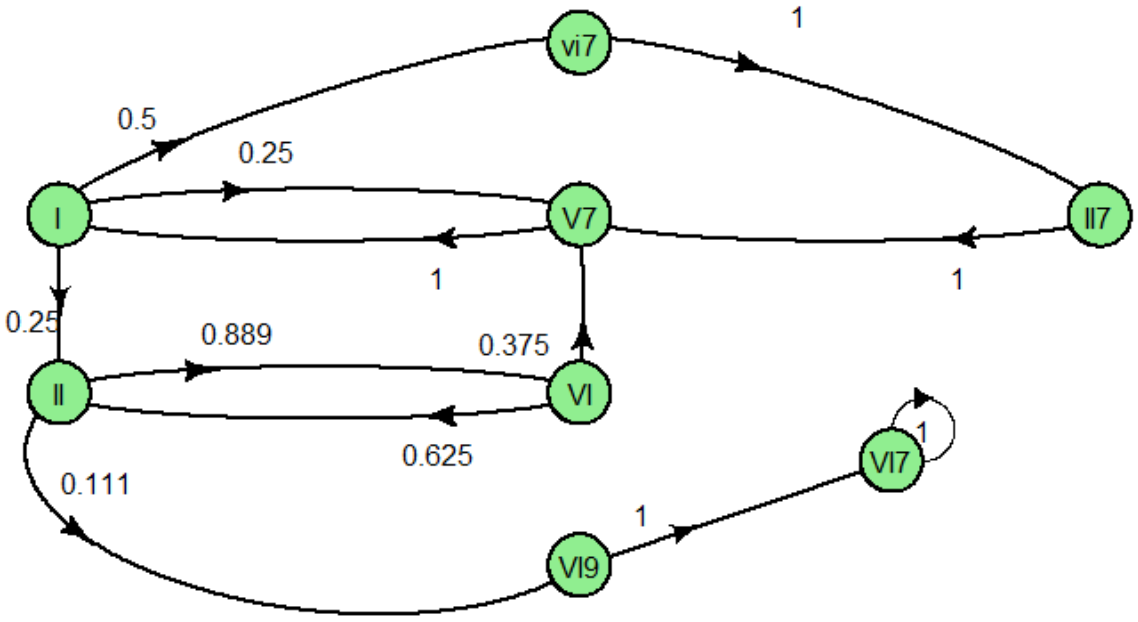

Figure 2. Markov chain plot with transition probabilities for “Good Day Sunshine” chord progressions.

This Markov chain is reducible. This is because McCartney used the same six chords throughout the majority of the song, and then introduced two new chords (VI^9 and VI^7) to end the piece. This results in two classes of states. The first consists of the six chords used throughout the bulk of the song: I, II, II^7, V^7, VI, and vi7, all of which communicate with each other. The second contains only the last chord, VI^7, which is absorbing. VI^9 does not belong to a class, as it was only used once, to lead into the last chord. It leads into the absorbing state with probability 1 and thus does not communicate with itself or any other states. This Markov chain has transient states I, II, II^7, V^7, VI, vi^7, and VI^9, and recurrent state VI^7. The fundamental matrix for this Markov chain (N) is presented in Table 5.

Table 5. Fundamental matrix for “Good Day Sunshine” chord progressions (N).

	To						
From	I	II	II^7	V^7	VI	VI^9	vi^7
I	16	9	8	15	8	1	8
II	12	9	6	12	8	1	6
II^7	16	9	9	16	8	1	8
V^7	16	9	8	16	8	1	8
VI	13.5	9	6.75	13.5	9	1	6.75
VI^9	0	0	0	0	0	1	0
vi^7	16	9	9	16	8	1	9

It should be noted that the interpretation of the fundamental matrix (the expected number of times that the chord in the column is played given that the song begins on the chord in the row) is not so applicable in this context. McCartney decided the initial chord and how many times each chord would be played, and then the transition matrix was built on that; the transition matrix was not used to generate the song. Similarly, concepts such as expected absorption times and absorption probabilities are not meaningful in this scenario. For this reason, those results will not be presented.

McCartney’s decision to alter the song right at the end is interesting and unexpected for the listener. It is then also of interest to analyze the patterns used throughout the rest of the piece, prior to the change. To do this, another Markov chain was fit excluding the last two chords. The state space reduced to:

$S_3 = \{I, II, II^7, V^7, VI, vi^7\}$,

and the new transition matrix (P_3) and plot are displayed in Table 6 and Figure 3, respectively.

Table 6. Transition matrix for “Good Day Sunshine” chord progressions, excluding the last two chords (P_3).

	To					
From	I	II	II^7	V^7	VI	vi^7
I	0	0.25	0	0.25	0	0.5
II	0	0	0	0	1	0
II^7	0	0	0	1	0	0
V^7	1	0	0	0	0	0
VI	0	0.571	0	0.429	0	0
vi^7	0	0	1	0	0	0

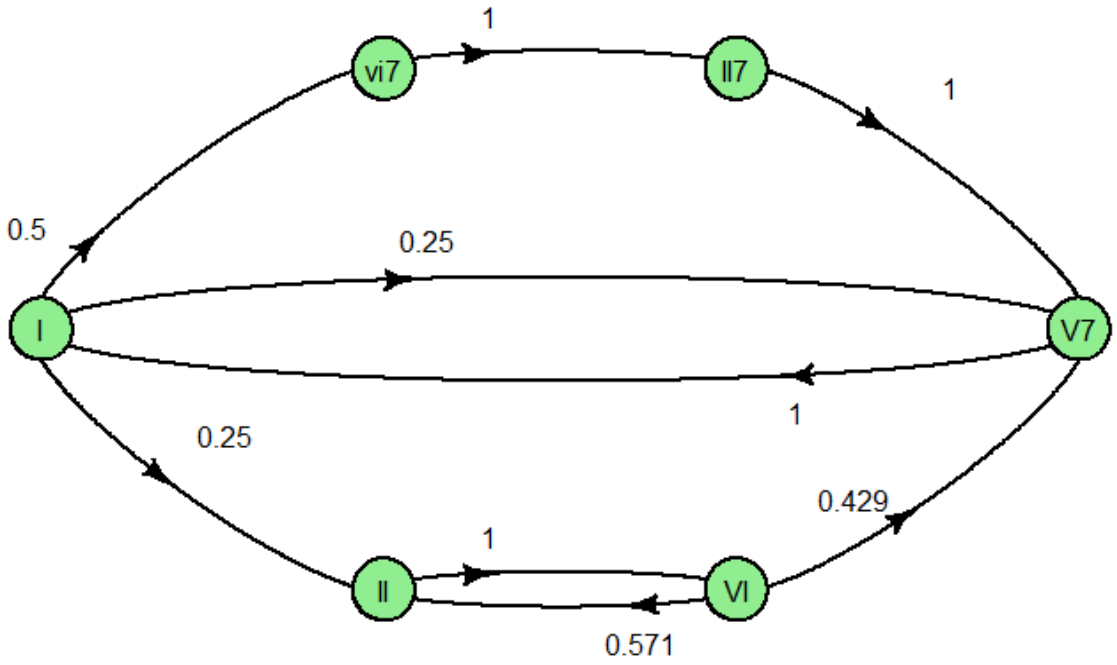

Figure 3. Markov chain plot with transition probabilities for "Good Day Sunshine" chord progressions, excluding the last two chords.

This new Markov chain is irreducible with period 2, and therefore—like "Norwegian Wood"—yields two cyclic subclasses: C0 = {I, II^7, VI} and C1 = {II, V^7, vi^7}. Once again, the tonic chord (I) is found in a different subclass than the dominant 7^{th} (V^7). Chords rooted in the dominant note of the key naturally build up an anticipation of resolution (Willimek and Willimek, 2013) and neither Lennon nor McCartney strayed from the standard practice of using the dominant 7^{th} to resolve back to the tonic chord.

It is also interesting that II^7 fell into the same cyclic subclass as the tonic, while ii^7 fell into the same subclass as the tonic in Lennon's song. Furthermore, in both cases these chords led to the dominant 7^{th} with probability 1. Both II^7 and ii^7 are 7^{th} chords built upon the second note of the scale of the song's home key, but the former is a major chord while the latter is minor. The minor, ii^7, is more commonly used because it only uses notes contained within the tonic scale while the major does not. From this, it appears that Lennon and McCartney used similar patterns with respect to the tonic and supertonic 7^{th}, but McCartney added more variety by using the less common, major version of the latter chord. Tables 7 and 8 respectively show the new fundamental matrix (Z_2) and mean recurrence times (M_2).

Table 7. Fundamental matrix for "Good Day Sunshine" chord progressions, excluding the last two chords (Z_2).

From	To I	II	II^7	V^7	VI	vi^7
I	0.789	-0.053	0.154	0.029	-0.193	0.274
II	-0.571	1.487	-0.526	-0.331	1.347	-0.406
II^7	0.309	-0.333	0.914	0.549	-0.473	0.034
V^7	0.549	-0.193	0.034	0.789	-0.333	0.154
VI	-0.331	0.627	-0.406	-0.091	1.489	-0.286
vi^7	0.069	-0.473	0.794	0.309	-0.613	0.914

Table 8. Matrix of mean recurrence times for "Good Day Sunshine" chord progressions, excluding the last two chords (M_2).

From	To I	II	II^7	V^7	VI	vi^7
I	4.167	11	6.333	3.167	12	5.333
II	5.667	7.143	12	4.667	1	11
II^7	2	13	8.333	1	14	7.333
V^7	1	12	7.333	4.167	13	6.333
VI	4.667	6.143	11	3.667	7.143	10
vi^7	3	14	1	2	15	8.333

M_2 tells us that the expected number of steps taken to return from tonic to tonic is 4.17. This is close to 1.5 times larger than the expected tonic recurrence time for "Norwegian Wood"; McCartney appears to take longer to return to the tonic chord than Lennon. One can see from the listed chord progressions (Appendix) that Lennon frequently visits the second cyclic subclass only once before returning to the tonic in the first subclass, whereas McCartney often alternates between one and two visits to the second cyclic subclass before returning to the tonic chord.

Conclusion

Similar patterns were found between Lennon's "Norwegian Wood" and McCartney's "Good Day Sunshine" despite major differences in the chords that made up each state space. In general, however, McCartney's song had more variety in terms of the number of chords used and the paths taken between tonic chords. Unfortunately, since this study focused on only one song from each artist, the results cannot be generalized at all. However, it is interesting that some similarities were found in the way that both artists deviated from the regular Markov chain structure found in the other analyzed songs. It should be noted that there are some definite issues with this type of analysis. Modelling with Markov chains is an over-simplification in this case because the end of the chain is determined by the composer; the chain is not allowed to continue indefinitely (in the irreducible case) or to conclude by randomness leading to an absorbing state (in the reducible case). Despite this flaw, Markov chain modelling in this context can still lead to insightful discoveries regarding patterns used throughout a song, as was witnessed in the results of this study. In future studies, it would be of interest to look at a

different comparison. Specifically, different albums could be compared to identify any transitions in chord progressions due to time period or style of the album. Furthermore, chord progressions used by The Beatles could be compared to those used in popular music both prior to and after The Beatles' huge successes; this could provide valuable insight into the impact that The Beatles had in the shaping of popular music.

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Appendix

Chord Progressions

Norwegian Wood:

I, bVII, I, bVII, I, i, IV, i, ii7, V7, I, bVII, I, bVII, I

Good Day Sunshine:

II, VI, II, VI, V7, I, vi7, II7, V7, I, V7, I, vi7, II7, V7, I, II, VI, II, VI, V7, I, vi7, II7, V7, I, V7, I, vi7, II7, V7, I, II, VI, II, VI, V7, I, vi7, II7, V7, I,V7, I, vi7, II7, V7, I, II, VI, II, VI, II, VI9, VI7, VI7