In search of the optimal hit record

composer: *Dicky Gilbers*

Abstract: In this paper, linguistic insights will be used to determine the optimal hit record. Especially Optimality Theory (Prince & Smolensky, 1993/2002/2004) seems to be an ideal framework to describe song structure and text. Optimal singing requires optimal accuracy and rate of the muscles of the relevant articulators, maintenance of voicing and maximal contrast between constriction and release in syllables, whereas optimal music requires a minimum of harmonic tension and a predictable song structure.

1. Intro of the ultimate hit record (15 seconds): Start! (Weller, 1980)

We could start this paper with "that" chord on a 12-string electric Gretsch guitar, sets two through five: A2 A3 D3 D4 G3 G4 C4 C4 with simultaneously a Dsus4 on a 6-string electric Rickenbacker guitar and D9sus4 on piano (D5 G5 E6 with D3 F3 in the bass) and a D on a Höfner bass (Brown, 2004), and we would be way back in 1964. Bands such as The Beatles were breaking the rules by starting "A hard day's night" (Lennon/McCartney, 1964) with the abovementioned chord and ending "She loves you" (Lennon/McCartney, 1963) with a 6-chord. Alternatively, we could start with a linguistic remark such as the following: according to Chomsky, Optimality Theory (Prince & Smolensky, 1993/2002/2004), predicts that all lexical inputs yield a single phonetic output, the optimal syllable: "perhaps /ba/" (Chomsky, 1995: 380). Chomsky is wrong; it should be /da/, at least in singing that is.[1]

Both remarks are meant to draw attention to our mission: discovering the ultimate hit record. Nevertheless, one way or the other, one can imagine (Lennon, 1971) that the intended audience for this paper will already be partly lost after the first paragraph. Research on music and research on language seem to involve different disciplines with their own terminology and methodology. These cognitive studies, however, have more in common than people might expect at first glance. Therefore, in order to warrant the use of linguistic insights in the analysis of music, we will start with a short overview of their similarities before we start our quest for the optimal song. "Are you all sitty comftybold two-square on your botty? Then we'll begin" (Stanley Unwin/Small Faces, 1968).

[1] Chomsky's assertion about Optimality Theory also fails to acknowledge the influence of faithfulness or correspondence constraints which ensure diversity in language (McCarthy, 1997).

2. First verse (30 seconds): Language and music - We belong together (Jones, 1981)

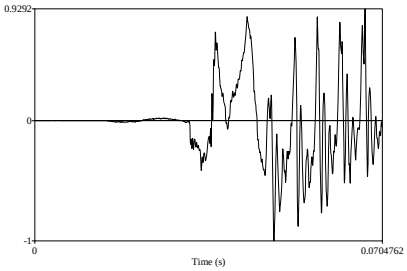
Language and music differ from each other. With a musical instrument you cannot communicate a sentence like “Frans Zwarts likes simple Rock ‘n’ Roll tunes such as Elvis’ “Mystery train”, whereas his wife Sharon Parry prefers more complicated music such as Miles Davis’ version of “My Funny Valentine”, but a closer look reveals that both songs do not differ that much harmonically”. “Music lacks the specificity of language in terms of semantic meaning” (Patel, 2008: 4). There are no nouns and verbs in music. Furthermore, different parts of the brain seem to be involved in the processing of language and music. After brain damage people may suffer from amusia without affecting their linguistic capabilities or from aphasia without affecting their musical capabilities.[2]

Nevertheless, there are also striking similarities. According to Patel (2008), language and music both involve complex and meaningful sound sequences and they define us as human. Especially if we consider the structure of language and music, the grammar, these disciplines reveal their similarities (Jackendoff & Lerdahl, 1980, Lerdahl & Jackendoff, 1983, Gilbers, 1987, Gilbers & Schreuder, 2000, 2002, Schreuder, 2006). “Music and language are ‘particulate’ sound systems, in which a set of discrete elements of little inherent meaning (such as tones or phonemes) are combined to form structures with a great diversity of meanings.” In holistic sound systems, used by many animals, each sound is associated with a particular meaning, but sounds are not recombined to form new meanings (Patel, 2008: 10).

Let us compare these discrete elements or building blocks in language and music. In language the biggest contrast in speech sounds is “mouth closed” versus “mouth open”. The sound wave in Figure 1 shows part of the closure and release burst of [p] followed by the beginning of a periodically repeating pattern of a full vowel [a]. No language in the world lacks the contrast of voiceless plosives and full vowels. Jakobson (1960) already explains why the lexicons of so many languages exhibit the words *papa* and *mama* by referring to the easy and maximal contrast of mouth closed – mouth open.

[2] The general idea is that language is processed in the logical left hemisphere of the brain and music in the intuitive, holistic right hemisphere (Levy, Nebes & Sperry, 1971, Kuyper, 2005, Nicolay, 2009, Chudles, 2011). However, the prosodic parts of language and also pragmatic aspects seem to be processed in the right hemisphere, whereas musical grammar seems to be located in the Broca area in the left hemisphere (Sperry, 1964, Pulvermüller, 2002, Bastiaanse, 2010, Bruinsma, 2012). Obviously, the distinction is not as clear as often assumed. Furthermore, all incoming auditory information is processed in Heschl’s gyrus in the primary auditory cortex, whether it concerns speech sounds or music (Peng, 2005, Bastiaanse, 2010).

Figure 1. sound wave of [pa]



Languages need to be more complex in order to be an adequate vehicle of communication. Diversity in meaning can be achieved in different ways, e.g. by adding classes of segments between the extreme plosives and vowels in the segment inventory, such as, for example, the liquids /l/ and /r/. Not every language, however, exhibits a phonemic contrast between the phones [l] and [r]. In Japanese, [l] and [r] are variants of the same segment category, whereas they are contrastive in European languages.[3]

In music, the building blocks consist of notes, tones. The musical universal is the octave, a doubling of frequencies between tones. Comparable to the way in which languages divide the scale between plosives and full vowels into categories of segments differently, the way in which the octave is divided into different steps is also culture-specific. In Western music the octave is divided into 12 equal-sized pitch intervals, whereas e.g. Javanese Gamelan music divides the octave into 7 pitch intervals (Perlman & Krumhansl, 1996, Patel, 2008). Just as it was difficult for a Japanese to discriminate between /l/ and /r/ in a Western language, it may be difficult for a Javanese to discriminate between e.g. a minor and a major third in a Western European song, because in his/her own musical system these tones are variants of the same tone category.

The similarities between language and music can be found especially in the way the building blocks are part of bigger units. A sequence of tones establishes a motif in music and motifs together form themes, themes form phrases, phrases together form a section such as a verse or a chorus, and sections are part of a song (Lerdahl and

[3] Diversity can also be achieved by means of syllable complexity. Languages such as Dutch allow for complex consonant clusters in syllable structures, as exemplified in the syllables in *angstschreeuw* 'cry of fear' or *herfststorm* 'autumnal storm'. Some dialects of Berber even allow for syllables that consist of consonants only: *txznt* 'you stored'. Hawaiian, on the other hand, is a language with simple syllable structures without consonant clusters and also with a relatively small segment inventory. In this language, diversity in meaning is achieved by coining occasionally very long words, e.g. *humuhumunukunukuapua'a* 'the Hawaiian State fish'. When a language constrains syllable structure, diversity can also be achieved by means of tonal variation, as in Mandarin.

Jackendoff, 1983, Gilbers & Schreuder, 2000, 2002, Schreuder, 2006). In language, segments establish syllables, syllables in their turn are part of feet, feet are part of prosodic words and prosodic words are part of phonological phrases that in turn are part of intonational phrases that are part of an utterance (Nespor and Vogel, 1986, Selkirk, 1984). In this way, both objects of research are structured hierarchically in a similar way. For example, in each prosodic word, one foot is the most important – the head – and in each foot one syllable is the head. In a musical theme, one motif is the head, and in that motif one note is the most prominent one. By recognizing some notes as more important than others, people are able to understand music. If they cannot recognize what is essential and what is ornamental, they will lose contact with the piece, and it will become a meaningless sequence of unrelated sounds to them. The point of losing contact will be different for individual listeners. In a similar way, people cannot understand speech by listening to a sequence of different sounds without noticing (mostly unconsciously) how all these sounds are related to each other.

3. First chorus (after 45 seconds): Done this one before (Lane, 1973)

3.1 Language and music - Still the same (Seeger, 1978)

Jackendoff & Lerdahl (1980) point at the similarities between music and language, and in their generative theory of tonal music, they describe musical intuition using methods from linguistics (Lerdahl & Jackendoff, 1983). Gilbers (1987), on the other hand, uses insights from music theory in an account of rhythmic variability in phonological phrases in language. Liberman (1975) already claimed every form of temporally ordered behavior to be structured the same way.[4]

Gilbers & Schreuder (2000, 2002) and Schreuder (2006) elaborate on the similarities in methodology in both disciplines by providing a linguistic, more specifically an optimality theoretic account (Prince and Smolensky, 1993/2000/2002) of the way listeners construct connections between the sounds they perceive in music. As mentioned above, mostly unconsciously, the listener is capable of recognizing the construction of a piece of music by considering some notes/chords as more prominent than others. The object of research is structured into domains, and in each of these domains the prominent constituent, i.e. the head, is to be assigned by means of a coherent set of well-formedness conditions (called “preference rules” in the general theory of tonal music (Lerdahl and Jackendoff, 1983) and “constraints” in Optimality Theory. The possible candidates for an

[4] Lasher (1978) describes patterns in ballet in a similar way.

output form, i.e. interpretation of a piece in music or e.g. a realization in language, are evaluated by the whole of these well-formedness conditions. The evaluation indicates what is grammatical in a language and which mode of perception is optimal in music.

In Optimality Theory and Tonal Music Theory, well-formedness conditions are soft and potentially conflicting. They can lay down opposite requirements on the output structure or interpretation to be preferred. Conflicts are solved by assuming differences in the weight between the different conditions. The whole of a set of hierarchically ranked conditions determine the optimal realization of phonological forms or the optimal interpretation of a piece of music (Gilbers & Schreuder, 2002).

3.2 Comparison of well-formedness conditions

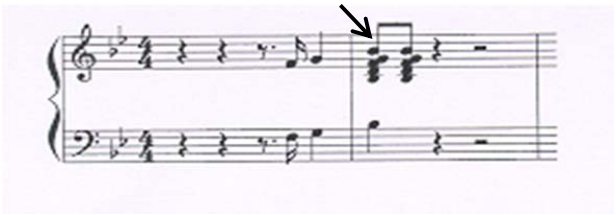
3.2.1 Optimality Theory: Lonely at the top (Newman, 1971)

In this section, we will give examples of well-formedness conditions and compare them in music and language. (1) is an example of a preference rule adapted from Lerdahl and Jackendoff's generative theory of tonal music (1983).

(1) Preference rule 1: choose as the head of a domain the chord (or the note) which is in a relatively strong metrical position.

An example of a strong metrical position in music theory is the first position in the measure. Figure 2 shows a motif from the jazz traditional "Tuxedo Junction" by the Glenn Miller Orchestra (Hawkins, Johnson, Dash, Feyne, 1941). The first B flat 6 chord of the second measure in Figure 2, indicated by the arrow, is the head of the domain, the most prominent chord, since it is in the strong position of the measure. It outranks the same chord following it, which is in a less important position. The preceding notes in the motif are perceived by the listener as ornamental upbeats.

Figure 2 Motif from Tuxedo Junction



One could imagine another preference rule choosing the first note of the melody as the head. In Optimality Theory (Prince & Smolensky, 1993/200/2002) terms, such a preference rule would be dominated by the rule in (1).

This kind of positional markedness can also be found in language. In order to find out what the prominent syllable is in a foot, first language acquisition data suggest that Dutch children prefer an initial stressed syllable. At the age of (1;6), child Steven has no problem realizing a world such as *áppel* "apple", which starts with a stressed syllable. However, *banáan* "banana" which starts with an unstressed syllable is problematic and is realized as [ˈba:m]. At the age of (2;5), the names of his favorite Jungle Book characters *Balóu* and *Baghéera,* both with an unstressed first syllable*,* are realized as, respectively, [ˈbɑlu] and [ˈχe:ʀa:]. Regardless of which kind of truncation or rhythmical metathesis operation is used, the optimal output at this stage of acquisition is a foot with an initial stressed syllable, the head. More evidence for this default trochaic pattern in Dutch can be found in the adaptation of French loan words in Dutch: *narcís* "daffodil" is often realized as *nárcis* and *parfúm* "perfume" as *párfum* by many Dutch speakers.

3.2.2 The Weight (Robertson, 1968)

Another well-formedness condition refers to the differences in weight between syllables in language and between chords in music. In language, syllables may differ in weight, which may be an important cue in order to find out which syllable is the stressed one, i.e. the prominent one in a word. For example, in Hindi, the strongest syllable available in the word is stressed (Hayes, 1995). Only in cases of a tie, the penult syllable will be stressed. In this language, syllables that end with a long vowel and a consonant (VVC) or with a short vowel followed by two consonants (VCC) are considered to be super heavy; syllables ending with a long vowel (VV) or a short vowel plus a consonant (VC) as heavy and syllables ending with a short vowel (V) as light. In Table 1, *dhar* in *kidhar* is heavy and *ki* is light and hence, *dhar* will be stressed; in *asbaab*, *baab* is super heavy and *as* is heavy, hence *baab* will be stressed; in *reezgarii*, *reez* is super heavy, *ga* is light and *rii* is heavy, hence *reez* will be stressed. In the last two examples in Table 1 ties arise. In *samiti* all syllables are light and in *aasmaanjaah* all syllables are super heavy. In both cases the penult syllables are stressed. In an optimality theoretic account, the constraint peak prominence (stress falls on the heaviest available syllable) dominates the constraints Non-Finality (stress does not fall on the final syllable) and Align Right (stress coincides with the syllable at the right edge of the word) (Prince & Smolensky, 1993/2002/2004).

Table 1. Stress assignment in Hindi

	Peak Prominence	Non-Finality	Align Right
kí dhar	*!		*
☞ ki dhár		*	
ás baab	*!		*
☞ as báab		*	
☞ réez ga rii			*
reez gá rii	*!		*
reez ga ríi	*!	*	
sá mi ti	vac		**!
☞ sa mí ti	vac		*
sa mi tí	vac	*!	
áas maan jaah	vac		**!
☞ aas máan jaah	vac		*
aas maan jáah	vac	*!	

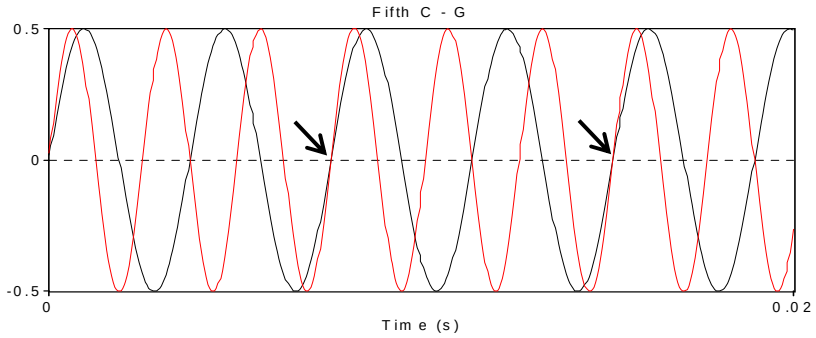
Like syllables in language, chords in music can also be ranked according to differences in weight. The preference rule in (2) is connected to a hierarchy of chords based on harmonic stability. A triad tonic-tierce-fifth (c-e-g) is more stable than a seventh chord (c-e-g-b^b), while a seventh chord in its turn is more stable than for example a suspended chord: Csus4 (c-f-g) or a diminished chord: C^0 (c-e^b-g^b). The latter two chords are to be used ornamentally as transitions from one prominent chord to another.

(2) Preference rule 2: choose as the head of a domain the chord (or the note) which is relatively harmonically consonant.

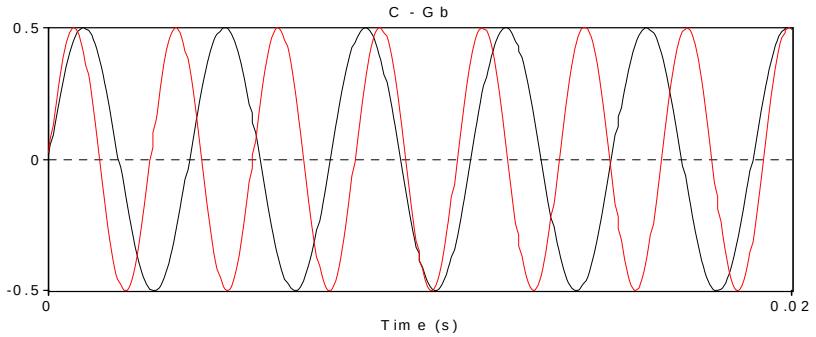
Preference rule 2 indicates that a chord C is preferred to for example C^0 as the head of a domain. Just compare the notes c and g in a tonic-fifth combination of a triad tonic-(tierce-)fifth to the combination of c and g flat in a diminished chord C^0 (c-(e^b-)g^b). Fig. 3a shows that two cycles of the sound wave c have the same duration as three cycles of the sound wave g. At the point indicated by the arrow the pattern repeats itself. In other words, these waves harmonize perfectly. The combination is easy to process for us. Fig. 3b shows that the waves of c and g flat never coincide in a periodic pattern: tension remains and needs to be solved for us listeners in a combination of waves that harmonize better. A diminished chord is perceived as a chord building up tension as a transition chord. This is not a matter of taste: c and g belong together, just as a and e, etc. Our brain prefers a combination of frequencies as in Fig. 3a to a combination of frequencies as in Fig. 3b.

Figure 3 Sound waves

a. c plus g



b. c plus g^b



3.2.3 Between alpha and omega (Lux/de Queljoe, 1970)

As a final example of well-formedness conditions, boundary marking effects can be observed in both language and music. Van Zonneveld (1983) describes this phenomenon as the Rhythmic Hammock, Hayes (1995) calls it the Phrasal Rule. To mark the domain boundaries, secondary stress is shifted toward the edges in (3). Prosodic cues such as intonation contours, pitch accents, pauses and rhythm patterns help us to detect the structure, to understand where a domain begins and ends. In OT, alignment constraints account for this effect of boundary marking.

(3)	*Mississìppi Délta*	→	*Mìssissippi Délta*	
	Speciàle áanbieding	→	*Spèciale áanbieding*	*“special offer”*
	Fótotòestel	→	*Fótotoestèl*	*“photo camera”*
	Hándenàrbeid	→	*Hándenarbèid*	*“manual labor”*

In music, not all chords are suitable for domain boundary marking. Just as there is a hierarchy in strength of chords, as we have seen in the previous section, not all chord combinations are equal; a logical sequence of chords is predictable. Usually, the optimal chord is the final chord, a chord which generally is built on the tonic, preceded by a dominant chord. In the key of C, the dominant chord is G. This chord is suitable for a cadence; it creates a kind of tension in music that has to be solved by a subsequent tonic chord. The cadence chord often concludes a phrase or section. In a default progression of chords, the G "belongs to" the C. Listeners, mostly unconsciously, know what the next chord will be in a sequence. Pachelbel's canon, which is based on a sequence of cadences, is exemplary for this predictability of the next chord. Just like the notes c and g belong together in Figure 3a, the consonancy between the chords C and G is much higher than, for example, the consonancy between the chords C and B. This preference for a harmonically more consonant chord in the chord sequence marking the boundary of a domain is stated below (= preference rule #7 in Lerdahl and Jackendoff, 1983).

(4) Preference rule 3: choose as the head of the domain the chord which emphasizes the end of a group as a cadence

Preference rule 3 states that, given the tonality of the piece, all chords are harmonically unequal in their strength. As in Optimality Theory, the set of preference rules in music theory is hierarchical: preference rule 3 overweighs preference rules 1 and 2.[5]

4. Second verse: "One chord is fine. Two chords is pushing it. Three chords and you're into jazz." (Lou Reed)

The first three positions in the harmonic hierarchy are occupied by the tonic, the dominant, and the subdominant (F in the key of C), respectively. These three chords together are harmonically consonant and do not create much tension for the listener. A lot of simple songs, such as Folk songs, Blues songs, and Protest songs make use of these

[5] Lehrdal and Jackendoff (1983) give only one ranking of well-formedness rules, while in OT different rankings of the constraints are made for every language. Although Lerdahl and Jackendoff only offer one ranking for tonal music, one can imagine that, for example, prolongation of a melodic line is more important in Eastern music than in Western music, while possibly in Western music relatively more weight is attributed to the harmonic consonance of a piece. Gilbers and Schreuder (2000, 2002) suggest that differences in musical styles can be accounted for in the same optimality theoretic way as differences between languages.

chords. The combination dominant-tonic solves all tension. However, classical music by, for example, Beethoven or Mozart can also be reduced to these simple patterns of tonics and dominants when all adornment is left out and the pieces are reduced to their essential parts. This is exactly how our musical intuition works; by reducing the stream of notes to the essence, the listener gets to the foundation of the construction of a piece. It also enables him/her to compare various improvisations on one theme and to relate them to the original theme. As an example, Lerdahl and Jackendoff (1983) (cf. Schreuder and Gilbers, 2000/2002 and Schreuder, 2006) hierarchically structure Mozart's Piano sonate no. 11 K.331 into domains and apply the preference rules to determine the heads and dependents in each domain. Reduction in the smallest domains leads to simplified tunes; reduction in the higher domains just leaves the dominant and the tonic and ultimately the most important chord of the piece: the tonic. The result of the step-by-step reduction can be depicted in a tree diagram, as familiar in linguistic methodology, in which the dependency relations between all notes and chords are described. In other words, even more complex tonal music can be reduced to the essential progression of chords: subdominant-dominant-tonic.

Of course, composers who want to challenge their audience may, for example, use unfamiliar chord sequences, additional chords between the dominant and the tonic, which will be experienced by the listener as delay of the resolution, being ornamental, less important for the essence of the piece. Comparing simple Folk or Rock 'n' Roll songs with the music of, for example, Max Bruch makes it safe to say that the latter can be considered as requiring more musical experience to understand, because it builds up more tension in the chord progression. However, Bruch is easy in comparison with Alban Berg's music, in which the listener is not certain whether or not the tension is solved.

The listener will relate the unexpected sequences to the dominant-tonic solutions. A deviating note in a Miles Davis solo is perceived as strange because our musical intuition expects a harmonic note. In other words, subconsciously, Sharon Parry applies the same strategies when listening to Miles Davis as Frans Zwarts does when listening to Elvis Presley. Whether one considers a certain kind of music as being too dull, too simple, too complicated, or too peculiar is listener-specific. Whether one appreciates the deviations from the default patterns is a matter of taste, and it is a matter of taste whether one drops out when listening to Miles Davis or Alban Berg. It is not a matter of taste that a dominant and a tonic harmonize best, since it follows from physical principles.

Not only markedness conditions play a role in music and language. Diversity is also required, otherwise all songs would be the same and with respect to language, nobody would leave the babbling stage. However, things might be different if we consider hit records. Probably, the audience for Alban Berg will be much smaller than the audience for

Max Bruch, who in his turn had fewer hit records than Elvis Presley. If a record company wants to reach the largest possible audience for the music they release, they have to keep it simple. Originality sounds good in a slogan, but it is not what record companies are really looking for. For example, director Berry Gordy of the Detroit-based record company Tamla Motown demanded from his composers team Brian Holland, Lamont Dozier and Bernie Holland that every hit single would be the blueprint for their next composition. Only follow-ups that slightly altered the elements of the previous hit were allowed by Motown's so-called "quality control" (McEwen and Miller, 1992). Only if a successive release was no longer a big hit, the composers got the opportunity to try something different. That is why "Quicksand" (Holland/Dozier/Holland, 1963) by Martha Reeves and the Vandellas is an exact copy of their top 5 hit record "Heatwave" (Holland/Dozier/ Holland, 1963) and since "Quicksand" was also a top 10 hit, the third single in row, "Live wire" (Holland/Dozier/Holland, 1964), had the same structure and Charleston rhythm as well. According to the Motown policy, you had to give the public the idea that they could recognize a hit, which was easier for them if they were already familiar with the song. Tongue-in-cheek, the composers team called the follow-up to the hit record "I can't help myself" (Holland/Dozier/Holland, 1965) by the Four Tops, "It's the same old song" (Holland/Dozier/Holland, 1965).[6] Indeed with the same song structure, similar intro drum roll and opening riff, same rhythm, 4/4 beat with tambourines, and a booming bass, and the song became a hit record as well. Clearly, diversity is not very important for a hit song. Therefore, in our quest for the optimal hit record, we will rely on markedness constraints in the remaining of this paper.

Satisfaction of all linguistic markedness constraints leads to the optimal syllable in language, satisfaction of all well-formedness conditions, i.e. preference rules, in tonal music theory leads to the optimal chord: the tonic. However, hit songs with just one chord are hard to find in the pop charts. Funk and dance are genres in which sometimes a groove is based on just one chord, as in "Shotgun" by Jr. Walker & the All Stars (Walker, Gordy, Horn, 1965) or "Thank you (falettinme be mice elf agin)" by Sly & The Family Stone (Stewart, 1969). Other one chord hit songs with a verse-chorus structure are rare: "Coconut" by Harry Nilsson (Nilsson, 1971), Chain of fools by Aretha Franklin (Covay, 1967), "The beat goes on" by Sonny & Cher (Bono, 1967) and (actually a b-side) "Run through the jungle" by Creedence Clearwater Revival (Fogerty, 1970) are songs that come to mind. Hit songs should be catchy and, therefore, structurally and harmonically simple in

[6] "I can't help myself" was also the blueprint for Madonna's hit record "Like a Virgin" (Steinberg/Kelly, 1984), albeit written by different composers.

order to reach the largest possible audience. Obviously, just one chord is too dull, the largest possible audience needs a bit more tension, but not too much.

Like one chord songs, two chord songs are also very rare. The well-formedness conditions predict the second chord to be the dominant. “Jambalaya” by Hank Williams (Williams, 1952) and “Mendocino” by Sir Douglas Quintet (Sahm, 1968) are examples. Typical groove songs of two chords are “Paperback writer” (if we skip the a capella intro) by The Beatles (Lennon/McCartney, 1966) and “Feelin’ Alright” by Traffic (Mason, 1968) and Sly delivered “Everyday people” (Stewart, 1968) using only the chords C and G.[7]

The optimal combination of chords extends the tonic and dominant sequence with a sub-dominant building up the required tension for a hit song, but most importantly these three chords provide the chord progression that was already familiar for most listeners. In the key of C, F is added to the tonic C and the dominant G. Especially in the 1950s and 1960s, the combination of tonic, dominant and subdominant warranted a song catchy enough for the largest possible audience.

5. Second chorus: Moving waves (Van Leer/Inayat Khan, 1971)

Pop music started in the 1950s with Rock ‘n’ Roll. Young people emancipated as a social group. Because of post-war prosperity and consequently a higher standard of life, the youth in the 50s became more independent. They became a new “audience” and they developed their own subculture with their own clothes and music. Every time when a new audience emerges in history, this is accompanied by a new kind of music. The emancipation of Christians brought forth Gregorian music, the rise of nobility in the 10th and 11th century went together with secular music by troubadours, the rise of the upper middle class in the 16th and 17th century was accompanied by concerts and opera, the rise of the lower middle class in the early 19th century went along with light music and songs, and after the industrial revolution in the 19th century, the rise of the working class in the early 20th century went together with the emergence of Jazz. New music should be simple, rebellious and exciting (van der Plas, 2003), but different enough to be peculiar to the group. It should be music made by the same kind of people: simple, spontaneous adolescents enjoying life (Willemze, 1975). In the early 50s, Jazz, just like classical music, had developed too far; the artistic level was too high for a large audience. And the traditional music of the 50s by artists such as Doris Day or Frank Sinatra was seen as

[7] “A horse with no name” by America (Bunnell, 1972) is an a-typical two chord song, because it deviates from the dominant-tonic sequence. With its Em and D6/9 chord with an F# bass it cannot be seen as a harmonically simple two chord song, such as e.g. “Jambalaya”.

boring, commercial music for the parents. In sum, the "new" audience was ready for new music: Rock 'n' Roll.

However, Rock 'n' Roll could not be seen as entirely new music. The sources of Rock 'n' Roll include Ragtime music with its characteristic syncopic piano playing and classical harmonies, Gospel with its question-answer singing, which can also be observed in 50s doo-wop, Blues with its characteristic three chords, 12 bars and AAB structured lyrics, and Folk, stories on rhyme carried over from generation to generation with simple accompaniment. Rock 'n' Roll allegedly developed from black Rhythm & Blues and white Country & Western, but that is a simplification. "Rock and Roll was an inevitable outgrowth of the social and musical interactions between blacks and whites in the South and Southwest (of the United States of America). Its roots are a complex tangle." (Palmer, 1992). Gospel influenced Blues, Blues influenced Folk, etc. New music always starts as simple, rebellious and exciting music. In that sense, there is no fundamental difference between Rock 'n' Roll in the 50s and Jazz in the first decade of the 20st century in New Orleans. However, music develops; Jazz developed from simple New Orleans Jazz via Chicago Jazz to higher artistic levels, such as the musical virtuosity of Bebop. As soon as a music genre develops "too far", it gets too serious and too complicated for a large audience. In a similar way, the simple pop music of the 50s developed in the 60s, but it was getting too complicated in e.g. the 70s symphonic rock. When music gets too complicated, the audience is getting smaller and it will become music for the happy few: a breeding ground for new developments for a large audience that is in need of new exciting music, which could be e.g. Punk/New wave or Hiphop. And again, the new music starts simple, rebellious and energetic.

In sum, the optimal hit record cannot be found in a genre that has developed too far. If the audience should be as large as possible, markedness constraints prevail and we should look at a song in a genre that is undeveloped as yet. For example, 1910s New Orleans jazz, 50s Rock 'n' Roll, 70s English Punk, early 80s New Wave, 90s Dutch Gabber, etc. Numerous hits in the 50s and 60s were built on three chords: most 50s Rock 'n' Roll songs, such as "Tutti Frutti" (Penniman, 1955) by Little Richard, "Mystery train" (Parker/Phillips, 1955) by Elvis Presley, and most 60s garage songs, such as "Louie Louie" (Berry, 1963) by The Kingsmen.[8] We conclude that the optimal chord progression consists of the tonic, the dominant and the subdominant. "All you need to write a country song is three chords and the truth." (Harlan Howard)

[8] In later decades also four chord songs became popular. In these songs, a parallel chord of the tonic is added to the sequence of tonic-dominant-subdominant, Am in the key of C.

6. Middle 8: Plagiarism – Sorry, she's mine (Lynch, 1966)

The possibilities to structure songs are unlimited; even if the number of chords is theoretically finite, you can always lengthen a song, change the tempo in various ways, etc. However, not only the chord progression, but also the structure of hit songs, i.e. songs that appeal to the largest possible group of listeners, seems to be limited. Most of the best-selling pop songs do not exceed three minutes.[9] Eurovision Song Contest candidate songs are not allowed to exceed this duration. "Hit factories", such as Don Kirshner's Brill Building, with composers such as Goffin & King, Neil Sedaka, Neil Diamond, Leiber & Stoller, and Bacharach & David, made use of hit song templates.[10] One of the most used templates starts with an intro of 15 seconds, during which a disc jockey can announce the song on the radio, followed by a verse. Within 45 seconds the chorus should follow, for otherwise the largest possible audience will already lose interest and drop out. The chorus should contain a catchy hook and catchy lyrics that are easy to be memorized or easy to sing. Then a second verse followed by a repetition of the chorus follows after which the song needs a short interruption in a solo or a middle 8. This volta of built up tension should not last too long for the listeners. Instead, the tension should be solved in a return of the chorus and a repetition of that chorus. That is all. Preferably, in a 4/4 time and at the most popular rate of 120 beats per minute. An alternative is to start with the chorus, a convention often used in dance music. Another alternative is a sequence of verse-bridge-verse, which can be repeated two or three times.[11]

Given the optimal chord progression and the optimal structure and duration of a song, one can imagine that a lot of songs sound alike. The tonic-subdominant-dominant scheme of "Hang on Sloopy" (Russell & Farrell, 1964) by The McCoys is exactly the same as the scheme in "Get off of my cloud" (Jagger & Richard, 1966) by The Rolling Stones, as is the intro of the 50s pastiche "Summer nights" (Jacobs & Casey, 1978) from the soundtrack

[9] In many BBC afternoon radio shows, songs exceeding three minutes were not broadcasted. That is why the duration of "Tin soldier" (Marriott/Lane, 1967) by the Small Faces was 2 minutes and 76 seconds according to the label on the single. The disc jockeys did not notice and played the record.

[10] The composers in the Brill Building had day jobs writing songs in small rooms "with just enough room for a piano (…) and maybe a chair for the lyricist if you were lucky. You'd sit there and write and you could hear someone in the next cubby hole composing a song exactly like yours." (Carole King quoted in Frith, 1978).

[11] There are hardly any deviations from this formula in the evergreen hit songs of the last 60 years. While "Yesterday" (Lennon/McCartney, 1965) has an AABABA-structure and "White Christmas" (Berlin, 1941) and "I left my heart in San Francisco" (Cory/Cross, 1962) can be seen as an intro plus one long chorus, most songs have a verse-chorus-verse-chorus-middle8-chorus structure.

of the musical Grease, and the scheme of "Second choice" (Gregson, 1980) by New Wave band Any Trouble, to name just a few three-chord songs.

If we extend the scheme to four chords, most songs exhibit the addition of the parallel chord to the tonic-dominant-subdominant sequence and again many four chord songs sound similar, as brilliantly shown by the Australian comic group Axis of Awesome.[12] All of these songs use similar harmonic progressions. However, it is hardly possible to compose a simple, harmonic song without making use of these chords. Just as most vowel systems of languages of the world at least exhibit /a,i,u/, songs need to be built on the combination of these chords. Vowel systems can be extended with, for example, /e,o/ and music progressions with a parallel chord (A minor (Am) in the key of C), but rarely without, respectively, /a,i,u/ in the vowel inventory and C, F, G in the chord progression. In other words, these similar progressions are not a case of plagiarism. Even in songs with a little more complex, but completely similar chord progression –as in "We used to know" (Anderson, 1969) by Jethro Tull and "Hotel California" (Henley, Frey, Felder, 1977) by The Eagles– one cannot speak of plagiarism. The harmonies are self-evident; nobody owns the rights to progressions such as C-F-G, or C-Am-F-G or C-G-B^b-F or C-G-Am-Em-F-C-Dm-G, etc. There is no copyright on these chord sequences, as there is no copyright on 3/4 or 4/4 beats and rhythm patterns. Otherwise Bo Diddley would have been a rich man, because his jungle rhythm has been copied by countless acts including The Rolling Stones, The Pretty Things, The Who and Iggy Pop. Only when the melody of a song is copied, can one speak of plagiarism. Therefore, "Child in time" (Lord/Blackmore/Glover/Paice/Gillan, 1970) by Deep Purple can be accused of plagiarizing "Bombay calling" (LaFlamme/ LaFlamme/Wallace, 1968) by It's a Beautiful Day, because it borrowed the melody of the latter song, whereas "Stand!" (Buck/Stipe/Mills/Berry, 1989) by R.E.M. cannot be accused of plagiarizing "Sometimes good guys don't wear white" (Cobb, 1966) by The Standells, even if these latter two songs with the same riff and chord progression sound more alike. In the next section, we will discuss the optimal lyrics of the optimal pop song.

7. Third chorus: Done this one before (Lane, 1973) as well

Clements (1990) claims that the optimal syllable structure consists of a maximal rise in sonority at the beginning of a syllable in combination with a minimal (or preferably no) decrease in sonority at the end of the syllable. In this way of reasoning, /pa/ is the optimal syllable in language, which is in line with the abovementioned simple mouth closed -

[12] Axis of Awesome – 4 chords (Raskopoulos/Naimo/Davis, 2011).
www.youtube.com/watch?v=5pidokakU4I

mouth open syllable of Jakobson (1960). Van Eerten, Gilbers and Lowie (ms.) account for the optimal syllable structure in improvised singing. In their experiment, musicians had to improvise on melodies without using lyrics. The results showed that the optimal syllable in singing depends on the interaction of the following influences: maximal contrast between constriction and release, accuracy and rate of the muscles of the relevant articulators and maintenance of voicing. The syllable /da/ was the most used syllable by the participants and turned out to have the preferred syllable structure in improvised singing.

The difference between optimal syllables in speech and singing can be described in an optimality theoretic framework (Prince & Smolensky, 1993/2002/2004) as a difference in ranking of the constraints on syllable structure. In language, the dominant constraints are CV (a syllable consists of a vowel preceded by a consonant), Max Contrast (there is a maximal contrast in sonority between the segment in the onset and the segment in the nucleus of the syllable) and Articular Ease. Although universally, coronal sounds are more frequent than labials (Maddieson, 1984), /pa/ is easier than /ta/ or /da/ from an articulatory point of view. Hudgins & Stetson (1937) show that labial consonants are physically easier to produce than coronals, because the production of a labial mainly requires the contraction of one large muscle. This muscle, however, is slower than those used for production of a coronal; out of all articulators, the tongue tip can make the most precise movements by small intrinsic muscles. In other words, from the viewpoint of Articular Accuracy, /ta/ is more optimal than /pa/. The muscle needed for articulation of /t/ or /d/ is faster, which is more important in singing.

Therefore, as Van Eerten et al. (ms.) show, prototypical syllable sequences like *tralala*, *lalala* and *shoobeedoo*, often used as typical examples of a singing sequence, actually do not seem to be optimal for singing. Consonant clusters are marked from an articulatory point of view and these patterns occurred only sporadically in the improvisations in the experiment in Van Eerten et al. Phonetically and phonologically, /la/, just like /na/, is less optimal than a plosive-vowel combination, as the contrast between a plosive and a vowel is bigger than between a liquid or nasal and a vowel. The greater constriction in the onset, the more rhythmical precision is made possible. With regard to the optimal syllable, the difference between speech and singing can also be found in the voicing of the coronal. As pitch is an essential component of singing, voiced speech sounds are inherently of major importance for singing. Vocal fold vibration is essential for an optimal sequence in singing, which makes the voiced coronal more optimal for singing than its voiceless counterpart.

Table 2b shows the constraint ranking in singing. The constraints Voiced and Articular Accuracy are more important than Max Contrast and Articular Ease, whereas it is the other way around in speech (Table 2a).

Table 2a. The optimal syllable in speech

	CV	*Max. Contrast*	*Articular Ease*	*Voiced (singable)*	*Articular Accuracy*	*Sonorant*
[la]		**!*	*			
[da]		**!*	*			*
[ta]			**!*	*		*
[na]		**!*	*			
[di]		**!*	*			*
[do]		**!*	*			*
[fa]		**!*	*	*	*	*
☞ *[pa]*				*	*	*
[ba]		**!*	*		*	*
[ga]		**!*	*		*	*

2b. The optimal syllable in singing

	CV	*Voiced (singable)*	*Articular Accuracy*	*Max. Contrast*	*Articular Ease*	*Sonorant*
[la]				**!*	*	
☞ *[da]*				*	*	*
[ta]		**!*			*	*
[na]				**!*	*	
[di]				**!*	*	*
[do]				**!*	*	*
[fa]		**!*	*	*	*	*
[pa]		**!*	*			*
[ba]			**!*	*	*	*
[ga]			**!*	*	*	*

8. Last chorus: The ultimate song

Now, let us skip that dull third verse, as the template for hit songs prescribes, and join together in the last chorus immediately. If the optimal chord progression consists of the tonic, the dominant and subdominant, and if the optimal syllable for singing is /da/, then it must be easy to find out what the ultimate hit record is. Not the Small Faces' "Sha la la

la lee" (Lynch/Shuman, 1966), not The Shoes' "na-Na-na" (Versteegen/Van Es, 1967) and not Otis Redding's "Fa-fa-fa-fa-fa" (Cropper/Redding, 1966): the ultimate hit record was written by the Neue Deutsche Welle Gruppe "Trio": "Da da da" (Remmler/Kralle, 1982).[13]

9. Fade-out: Acknowledgements

Thanks to Steven Gilbers and Jack Hoeksema for comments on content and style.

10. Bibliography

Bastiaanse, Y.R.M. (2010). *Afasie*. Houten: Bohn Stafleu van Loghum.

Brown, J. I. (2004). *Mathematics, Physics and A Hard Day's Night*. Ms. Dalhousie University.

Bruinsma, A. (2012). Taal *en muziek in de hersenen.* BA-thesis University of Groningen.

Chomsky (1995). *The Minimalist Program*. Cambridge, MA: The MIT Press.

Chudler, E.H. (2011). *One brain …. Or two?* faculty.washington.edu/chudler/split.html

Eerten, L. van, Gilbers, D. and Lowie, W. (submitted). Fa-fa-fa-fa, De do do do de da da da, Na-na-na, Sha la la la lee: What is the optimal syllable in improvised singing?

Frith, S. (1978). The Sociology of Rock. London : Constable.

Gilbers, D. (1987). Ritmische Structuur. *Glot* 10: 271–292.

Gilbers, D. and Schreuder, M. (2000). Taal en muziek in Optimaliteitstheorie, in *TABU* 30.1-2: 1-26.

Gilbers, D. and Schreuder, M. (2002). Language and music in Optimality Theory. Ms. ROA 571-0103.

Hayes, B. (1995) *Metrical Stress Theory: Principles and Case studies*. Chicago: The Chicago University Press.

Hudgins, C.V. and Stetson, R.H. (1937). Relative speed of articulatory movements. *Archives néerlandaises de phonétique experimentale* 13: 85-94.

Jackendoff, R. and F. Lerdahl (1980). *A deep parallel between music and language*, Ms. Indiana University Linguistic Club.

Jakobson, R. (1960). Why 'mama' and 'papa'? In: B. Kaplan and S Wapner (eds.). *Perspectives in Psychological Theory, Essays in Honor of Heinz Werner*.

[13] There is one remaining issue. Several times, the composer of this paper has been asked the following question: "If you know it all so well, why didn't you write a hit song yourself?" We will leave this question for future research.

New York.
Kuyper, A. (2005). *De functie van de linker en rechter hersenhelft*. www.synergy-at-work.nl/downloads/funct hersenhelften.pdf
Lasher, M. (1978). *A Study in the Cognitive Representation of Human Motion*. Ph.D. dissertation, Columbia University.
Lerdahl, F. and Jackendoff, R. (1983). *A Generative Theory of Tonal Music*, The MIT Press, Cambridge, Massachusetts, London, England.
Levy, J., Nebes, R.D. and Sperry, R.W. (1971). Expressive language in the surgically separated minor hemisphere. In: Cortex, 7 (1), 49-58.
Liberman, M. (1975). *The Intonational System of English*, Garland Publishing, Inc., New York & London.
Maddieson, I. (1984). *Patterns of Sounds*. Cambridge University Press, Cambridge.
McCarthy, J. (1986). OCP Effects: Gemination and antigemination. *Linguistic Inquiry* 17: 207-263.
McCarthy, J. (1997) Process-specific constraints in Optimality Theory. *Linguistic Inquiry* 28, 231-251.
McEwen, J. and Miller, J. (1992). Motown. In: A. DeCurtis, J. Henke, H. George-Warren, J. Miller (eds.). *The Rolling Stone Illustrated History of Rock & Roll.* Plexus London: 277-292.
Nespor, M. and Vogel, I., 1986. *Prosodic phonology*. Dordrecht: Foris.
Nicolay, K. (2009). Over magneten, fotonen en slimme chemicaliën. In: D. Bär, M. Evenblij, J. Jolles, K. Nicolay, F. van Oranje & S. Rombouts (eds.) *Brein in Beeld*. Den Haag: Stichting BWM, 13-25.
Palmer, R. (1992). Rock begins. In: A. DeCurtis, J. Henke, H. George-Warren, J. Miller (eds.). *The Rolling Stone Illustrated History of Rock & Roll.* Plexus London: 3-16.
Patel, A. (2008). *Music, language and the brain*. New York: Oxford University Press.
Peng, F.C.C. (2005). *Language in the brain: Critical assessments.* London: Continuum.
Perlman, M. and Krumhansl, C.L. (1996). An experimental study of internal interval standards in Javanese and Western musicians. *Music Perception* 14, 95-116.
Plas, J. van der, (2003). *Popmuziek van A tot Z*. Het Spectrum. Utrecht/Antwerpen.
Prince, A. and Smolensky, P. (1993/2002/2004). *Optimality theory: Constraint interaction in generative grammar.* Blackwell Publishers (2004) (2002). Technical Report, Rutgers University Center for Cognitive Science and Computer Science Department, University of Colorado at Boulder (1993).
Pulvermüller, F. (2002). *The neuroscience of language. On brain circuits of words and serial order.* Cambridge: Cambridge University Press.
Schreuder, M. (2006). *Prosodic processes in language and music*. PhD Dissertation. Grodil

Series 60, University of Groningen.
Selkirk, E., 1984. *Phonology and Syntax. The Relation between Sound and Structure*. Cambridge, MA: MIT Press.
Sperry, R.W. (1964). The great cerebral commissure. *Scientific American,* 210 (1), 42-52.
Willemze, Th. (1975). *Spectrum Muzieklexicon* 1-4. Het Spectrum. Utrecht/Antwerpen.
Zonneveld, R.M. Van (1983). *Affix Grammatica: een onderzoek naar woordvorming in het Nederlands.* Meppel: Krips Repro. Proefschrift Groningen.

11. Discography: The Soundtrack of this paper (in alphabetical order on artist's name)

America 1972 – A horse with no name (Bunnell)
Any Trouble 1980 – Second Choice (Gregson)
Axis of Awesome 2011 – Four chords (Raskopoulos/Naimo/Davis)
Band, The 1968 – The Weight (Robertson)
Beatles, The 1963 – She loves you (Lennon/McCartney)
Beatles, The 1964 – A hard day's night (Lennon/McCartney)
Beatles, The 1965 – Yesterday (Lennon/McCartney)
Beatles, The 1966 – Paperback writer (Lennon/McCartney)
Bennett, Tony 1962 – I left my heart in San Francisco (Cory/Cross)
Brainbox 1970 – Between alpha and omega (Lux/Queljoe de)
Creedence Clearwater Revival 1970 – Run through the jungle (Fogerty)
Crosby, Bing 1941 – White Christmas (Berlin)
Davis, Miles 1964 – My funny Valentine (Rodgers/Hart)
Deep Purple 1970 – Child in time (Lord/Blackmore/Glover/Paice/Gillan)
Eagles, The 1977 – Hotel California (Henley, Frey, Felder)
Focus 1971 – Moving waves (Moving waves (Van Leer/Inayat Khan)
Four Tops, The 1965 – I can't help myself (Holland/Dozier/Holland).
Four Tops, The 1965 – It's the same old song (Holland/Dozier/Holland).
Franklin, Aretha 1967 – Chain of fools (Covay)
Grease soundtrack 1978 – Summer Nights (Jacobs & Casey)
It's a beautiful day 1968 – Bombay calling (LaFlamme/LaFlamme/Wallace)
Jam, The 1980 – Start! (Weller)
Jethro Tull 1969 – We used to know (Anderson)
Jones, Rickie Lee 1981 – We belong together (Jones)
Kingsmen, The 1963 – Louie Louie (Berry)
Lane, Ronnie 1973 – Done this one before (Lane)
Lennon, John 1971 – Imagine (Lennon)

Little Richard 1955 – Tutti Frutti (Penniman)
Madonna 1984 – Like a Virgin (Steinberg/Kelly)
McCoys, The 1964 – Hang on Sloopy (Russell & Farrell)
Miller, Glenn 1941 – Tuxedo Junction (Hawkins, Johnson, Dash, Feyne)
Mozart, W.A. around 1783 – Piano Sonata No. 11 K.331
Newman, Randy 1971 – Lonely at the top (Newman)
Nilsson, Harry 1971 – Coconut (Nillson)
Pachelbel, J. around 1670 – Canon in D major
Presley, Elvis 1955 – Mystery train (Parker/Phillips)
Redding, Otis 1966 – Fa-fa-fa-fa-fa (sad song) (Cropper/Redding).
Reeves, Martha & The Vandellas 1963 – Heatwave (Holland/Dozier/Holland).
Reeves, Martha & The Vandellas 1963 – Quicksand (Holland/Dozier/Holland).
Reeves, Martha & The Vandellas 1964 – Live Wire (Holland/Dozier/Holland).
R.E.M. 1989 – Stand! (Buck, Stipe, Mills, Berry)
Rolling Stones, The 1966 – Get off of my cloud (Jagger/Richard)
Seeger, Bob & The Silver Bullet Band 1978 – Still the same (Seeger)
Shoes, The 1967 – na-Na-na (Versteegen/Van Es)
Sir Douglas Quintet 1968 – Mendocino (Sahm)
Sly & The Family Stone 1968 – Everyday people (Stewart)
Sly & The Family Stone 1969 – Thank you (Falettinme Be Mice Elf Agin) (Stewart)
Small Faces 1966 – Sha la la la lee (Lynch/Shuman)
Small Faces 1966 – Sorry, she's mine (Lynch)
Small Faces 1967 – Tin soldier (Marriott/Lane)
Small Faces/Stanley Unwin 1968 – Happiness Stan (Marriott/Lane)
Sonny & Cher 1967 – The beat goes on (Bono)
Standells, The 1966 – Sometimes good guys don't wear white (Cobb)
Traffic 1968 – Feelin' alright (Mason)
Trio 1982 – Da da da (Remmler/Kralle)
Walker, Junior & The All Stars 1965 – Shotgun (Walker/Gordy/Horn)
Williams, Hank 1952 – Jambalaya (Williams)