X-bar Theory in 17th-18th Century Western Tonal Music

Réka Köcsky

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Abstract

It has been proposed that musical syntax and musical universals can be examined using linguistic tools and concepts. The goal of the paper is to support the claim that "music contains a syntactic component in which headed structures are built". This paper makes an attempt to do this by showing that the structure of cadences in 17th-18th c. Western tonal music obeys principles of X-bar theory and the Projection Principle. I carried out a rating experiment, using a 5-point Likert scale, to address the following question: Can we identify heads, and distinguish between complement and adjunct modifiers in the syntax of cadences, in terms of obligatoriness/optionality, variability and order? The task was to judge the melodies on a 5-point Likert scale from the viewpoint of how harmonic (pleasant to hear) they found them. It is argued that the ratings provided by the musically untrained participants can for the most part be interpreted in terms of an X-bar theoretic structure. Cadences are analyzed as including heads, adjuncts, and selected complements.

1 Introduction

It has been a topic of discussion occasionally that music has a system of syntax similar to language and that language and music share universals. Such universal is for example the levels of language. On one level language combines meaningless units into meaningful ones, and on the next level, the combination of meaningful units creates bigger meaningful units. Another universal is what Katz & Pesetsky (2011) claims, namely that constituent structure can be traced in musical syntax. The aim of the paper is to provide evidence that hierarchical phrase structure indeed can be found in music, doing so by presenting the results of an experiment carried out. The experiment was designed to map the rules governing the harmonies of cadences by defining the structure of cadences in 17th-18th century Western tonal music. I chose this type of music for two reasons. Firstly because it has a rather strict set of rules of composition and it is easier to start with this style than with a more flexible genre

or style of music. Secondly, this style of music has been studied before, for instance by Lehrdal & Jackendoff (1996), Katz & Pesetsky (2011). If the result of the experiment confirms the presence of phrase structure in cadences, this would support the hypothesis that language and music are governed by analogous principles of constituent structure.

Because of the nature of the topic, it would be very difficult to the readers to understand the hypothesis of the paper without some introduction to musical notions. Therefore first a short description of musical terms needs to be provided. The paper is structured in the following way. First there will be a short overview of the literature of musical syntax, and of the musical theory of cadences. Afterwards the theory of phrase structure used will be discussed briefly, followed by the hypothesis. Chapter three will demonstrate the material and the method used for collecting empirical data. In the fourth section the results of the experiment will be presented and the discussion of its consequences and implications, followed by a conclusion.

2 Background and a Short Theory of Cadences

2.1 Literature on Musical Syntax

Bernstein (1976) was one of the earliest works on the topic of analyzing music as a system similar to language, doing so from a linguistic point of view. This attempt was groundbreaking, because it was one of the first works that looked at music from a viewpoint that resembles linguistics. Bernstein attempted to find universals in music and features of syntax that are relevant to musical analysis. Looking for universals was a significant step because it helps us to get a deeper insight into human cognition (Jackendoff 1977, 884).

A Generative Theory of Tonal Music (henceforth GTTM, Lerdahl & Jackendoff 1996) is among the first papers that uses generative tools and is the foundation of a comprehensive basis for recent theories using hierarchical structures in tonal music. The paper asks a very interesting question: how is it possible that when people hear the same piece of music in different performances (for example orchestra or a solo instrument), different states of mind and environment, they still say that they heard the same piece of music, let us say the second movement of Beethoven's 7th symphony? One can never hear the very same sentence again (the same sound waves) when it comes to language, obviously this holds for music as well. Adding these facts up, Lerdahl & Jackendoff says there must be something more behind simply the physical form of music (1996, 2). GTTM also presents the notion of Prolongational Reduction as a component that has headed binary-branching hierarchical structures, thus matching the representation of linguistic syntax.

An even more recent and thorough study is *The Identity Thesis for Language and Music* (henceforth ITLM), in which Katz & Pesetsky (2011) review the GTTM's suggestions and it revises them according to the current linguistic theories. This revision results in a new theory of musical syntax. The underlying thought in the ITLM is that "what language and music have in common is not their building blocks (which are different), but *what they do with them*" (Katz & Pesetsky 2011, 3).[1] They put emphasis on the fact that while the building blocks of the syntax of language are lexical items, the things that function as building blocks in music are pitch-class and chord quality. Building blocks from one system cannot be paired with one from the other system (one will never find parts of speech in music, there are no verbs or nouns or adjectives), similarly, the result of their combinations is different as well.

Besides the previously mentioned milestones, a large number of neurological and psychological experiments have been carried out in order to see the similarities and differences between the activated areas of the brain while processing language and music.

A. D. Patel and his colleagues carried out research that proved that "language and music can be studied in parallel to address questions of neural specificity in cognitive processing" (Patel et al. 1998, 717). In their experiment they used the P600 event-related brain potential (ERP), which comes out as a result when the examined person hears strings of words that are difficult to parse because of the garden path effect. The P600 always occurs when the difficult part is reached by the listener, therefore it was suggested that it is the sign of re-analysis of structure. The semantic counterpart of P600 is N400, a "negative-going wave" that is triggered by phenomena in semantic integration processes (Patel et al. 1998, 718).

Burkhard Maess et al. (2001) described a MEG experiment that suggests that musical syntax is processed in Broca's area as well, not only the incoming auditory human language (Maess et al. 2001, 540). They based their hypothesis on the results of the Patel et al. (1998) study about the P600 ERP in addition to another EEG study, and in their own test they used the same experimental protocol. They presented a sequence of five chords to non-musician participants. Some of the sequences contained harmonically unexpected chords in different positions. As it turned out, even non-musicians have expectations of what chord should follow a certain chord in a given musical context. For example a Neapolitan chord, which is a possible variation of a subdominant chord, triggered a stronger magnetic effect in the position where a tonic chord should be, than in a position of a real subdominant.

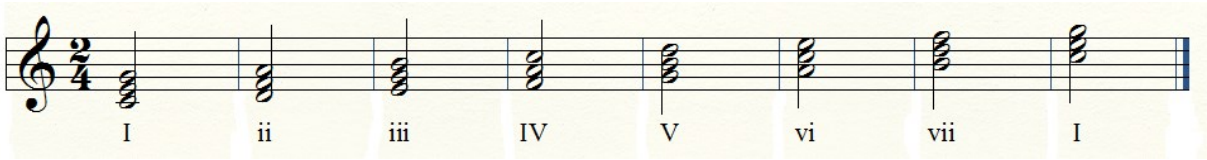
[1] The italization is present in the original text as well.

2.2 Basic Musical Terminology

In this subsection I will explain the required terms from musical analysis so that they are clear for readers of the paper who are untrained in musical theory, and because some terms in musicology are used ambiguously. First a basic theory about chords will be provided and then the discussion will turn to cadences.

A very simple definition of chords is: "three or more notes sounded simultaneously" Harnum (2001, 246). Chords are named with Roman numerals showing on which scale the chord is built. In Western tonal music a scale is a sequence of eight sounds. It does not matter now what the rules are for constructing a scale. The first sound of the scale will get the I number, pronounced as *first degree*, the second sound will be II, *second degree*, and so on. The construction of a chord has strict rules as well but I will not go into details about that. However, an important detail is that the harmonic function of a V chord (a fifth degree chord, its base note is the fifth sound in the key's scale) is called *dominant* and the harmonic function of a I chord is *tonic.* Every sound in a scale has a harmonic function, basically it is their structural role (Patel 2008, 265-266). Tonic means that it is an element that has the first sound of the scale as its base sound. Dominant means that its base sound is the fifth sound of the scale. These terms will be often significant in the later sections. In (1) you can see a C-major scale with chords. The chords that are important in cadences are named with capital Roman numbers.

(1) C-major scale with chords



Cadences are sequences of chords (or sequences of sounds which can be put together as chords) that have a special function. They indicate that a musical section or the whole piece of music is ending. In 17th-18th century Western tonal music there are several subtypes of cadences. There are full and perfect cadences and variations of a perfect cadence.

At the very end of a composition, most of the time one will hear a *perfect cadence*, which is a V to I or a IV to I sequence after an optional I to IV sequence. The first one is also called an *authentic cadence,* while the latter of the two is called a *plagal cadence* or *church cadence*. When a cadence is not at the end of a piece of music, instead of a I chord the continuation of the piece can be found. However, the continuation then has to start with tonic elements. Note that the dominant chord before the tonic one can be a V^7 chord as well, which

is not much different from the normal V chord, but it is used by composers slightly more often. The difference is that one of the sounds in the chord is the seventh on the scale. Normally that sound is a different one. (2) illustrates these cadences:

(2) a. (I - IV -) V/ V^7 - I perfect/authentic cadence
b. V/ V^7 - I perfect/authentic cadence
c. IV - I plagal/church cadence

The extension of a full perfect cadence is very limited. Only certain chords are allowed to be used and the local restrictions are strict as well. When one tries to extend a cadence, the rules are independent from chord progression, what matters is the harmonic function. Only a dominant chord can extend the dominant V/ V^7 while only a tonic chord can extend the tonic I degree chord. Therefore the candidates for the extension of V/ V^7 are: i) another V chord, ii) a chord called $I^{6,4}$. The name is misleading, it is not a tonic chord, its base sound is a dominant element. These two chords always come before the V/V^7 chord and their order is interchangeable. The possible extensions of the tonic I is either a VI chord or a IV^6. However, there can only be one of these, and always before I. One might think that VI or IV^6 is the extension of V/V^7 but that is not possible. We know that those chords cannot belong to V/V^7 as its extension, because their harmonic functions do not match. To sum it up, a fully extended perfect cadence looks like (3):

(3) I – IV– $I^{6,4}$ – v – V^7 – IV^6/VI - I

2.3 Complements and Adjuncts in Language

This section provides a brief overview of the syntactic position and behaviour of adjuncts and complements within the theoretical framework of X-bar theory and the Projection Principle. For that I use Carnie's (2006) syntax textbook and his (2010) *Constituent Structure*. The theory states that every phrase includes one head, and the semantic argument selected by the head is in the sister position of the head. The arguments that are not selected appear via adjunction, as sister of an intermediate projection $(X')^2$. The left daughter of XP is the specifier position. The above described structure can be seen with rewrite rules in (4) and as a tree diagram in (5).

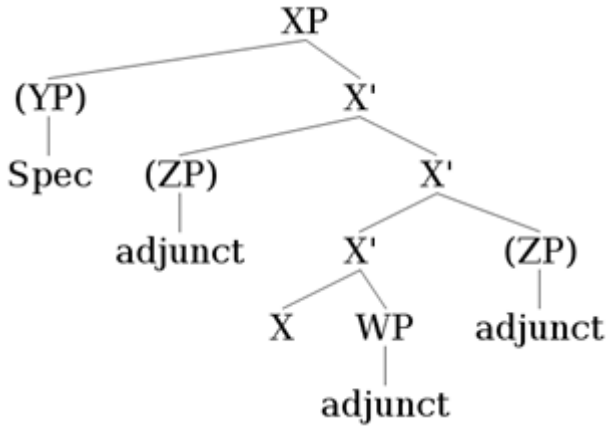
[2] One might assume that the non-selected arguments adjoin to the phrase or to both the phrase and the intermediate projection but that is not important in the analysis of cadences.

(4) XP → (YP) X'

X' → (ZP) X'/ X' (ZP) (this rule is recursive and can be built in both orders)

X' → X (WP) (this rule can be reordered as well)

(5) Tree diagram of X-bar scheme



Complements are selected by the head of the phrase, that is, the head requires certain elements that can be optionally or obligatorily present in the phrase. Their category, their number and their thematic roles are prescribed by the head as well. Adjuncts are always optional, and they are not selected, while complements are either optional (for example *read a book* vs *read*) or compulsory (*love Mary*).

The selectional restrictions can be divided into two main subtypes, s-selection (semantic selection) and c-selection (category selection). C-selection is a restriction on the syntactic category of the phrase that the head selects. For instance, the verb *put* selects an obligatory object complement, which is an NP, and *put* also selects a PP.

S-selection is the selection of thematic roles and relations. A thematic role (agent, experiencer, theme, patient, instrument, etc.) is assigned to all arguments. Some predicates can only assign certain roles to their arguments and even if c-selection would allow a phrase to fill the place of the argument, the sentence might be still ungrammatical if the thematic roles are not approved by s-selection. S-selection seems to be relevant to cadences when the harmonic functions play a role in the importance and grouping of chords in a cadence, namely which extensions and possible heads belong together, and which chords can follow another one. For example, in a cadence a third degree chord cannot follow a fifth degree cord, that would be considered disharmonic in 17th-18th century Western tonal music because the harmonic functions do not match. In the beginning of a cadence a tonic element (first degree chord: I) should be followed by a subdominant one (fourth degree chord: IV), then a dominant one (fifth degree or its variants: V), which can be repeated a couple of times, and then at the

end another tonic element (a first degree chord optionally preceded by a tonic variant) has to finish the cadence. These restrictions can be compared to semantic selection because it is not the actual chord that matters but its role in harmony. The table below collects the characteristics of complements and adjuncts.

(6) Characteristics of complements and adjuncts

COMPLEMENTS	ADJUNCTS
Obligatory or optional.	Optional.
Selected by the head.	Not selected.
Possible number: 0,1,2 (e.g.give)	Any number (recursive rule)
In a basic structure it must be closer to the head than adjuncts.	In a basic structure it must be further away from the head than complements.

The Projection Principle states that the features (such as semantic roles) and the subcategorization frame of a lexical item must be satisfied in syntactic representations. In particular, all the selectional restrictions of heads must be satisfied by their complements (i.e., sisters), and conversely, all complements must be selected by the head. That is why selected arguments end up in the complement position and non-selected arguments cannot be there.
Heads may place semantic restrictions on their adjuncts as well, even though the appearance of adjuncts is generally optional. For instance, the verb 'reach' in a sentence like *I reached the top for two hours* is semantically incongruent with the temporal adjunct 'for two hours'. In short, semantic restrictions may be imposed by heads not only on complements but also on adjuncts.

A theory by Ernst (2002) will also be important in the analysis of chords. This theory introduces a semantic approach to adverbials, where syntax refines the set of possible adverbials after semantic constraints limit them. Such limited adjuncts are for example sentence and VP adverbials (e.g. *probably* and *carefully*, respectively), since semantic requirements must be fulfilled first.

2.4 Proposal for Phrase Structure in Cadences

I decided to study the structure of cadences because their structure seems to be constructed according to strict selection. What needs to be examined are the following subhypotheses:

1. Both V/V^7 and I have to be present in a cadence, therefore it is worth examining whether any of them is the head of the whole cadence.

2. Both V/V^7 and I have extensions. It is clear which ones belong together (because of their harmonic function), but it is not obvious yet whether they are adjuncts or complements:

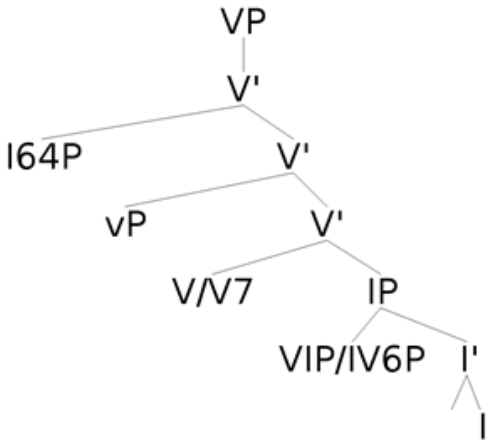
(i) The extensions of V/V^7 are optional, interchangeable, and their harmonic function is restricted, which seems to resemble s-selection, therefore they can be adjuncts.

(ii) I suggest that the extension of I is in the specifier position of the phrase. The reason for that is that the occurrence of the extension is rare, and there is always only one present. The fact that the two options can be there only as alternatives to each other suggests that there is only one position present. This is a characteristic of specifiers. Moreover, if it was a complement, it would interfere with the head-complement relation between V/V^7 and I. It is not contradictory to believe that the extensions of the dominant chord are adjuncts, such a strict limitation of possible elements for adjuncts is not unknown in linguistics either. It is possible that the semantic constraints narrow down the possible set of chords with the help of a harmonic functional criterion. It is possible that the same thing happens here in music, the set of chords is narrowed down by a harmonic functional criterion.

The most important parts of a cadence are the chord with the dominant function and the following chord with the tonic function. I analyze the whole cadence as a phrase consisting of other phrases. One of these is a phrase that contains the dominant chord, and another one contains the tonic chord. I propose that the dominant chord is the head of the most important phrase of the cadence and it selects the phrase with the tonic chord as its complement. The other parts of the cadence are adjuncts of the dominant chord, and one of them is the specifier of the tonic chord.

I propose that the V/V^7 chord is the head of a VP phrase (here V means *fifth degree chord* just like earlier, not to be mistaken for *Verb Phrase*), and its complement is I, which is the head of a IP phrase (here I means *first degree chord,* NOT *Inflectional Phrase*). The other extensions are in the adjunct position of the VP and the tonic extension in the specifier position of IP. In (7) I present a tentative tree diagram for the phrase of cadences. I labelled the extension V chord's phrase as 'vP' so as to make a clear distinction between that chord and the V head. I used VP as the label of the dominant chord's phrase, I64P and vP for the chords that I claim to be the adjuncts of the V/V^7 head. IP is the tonic chord's label, while IV6P and VIP are IP's specifier (and they are in complementary distribution). IP is the complement of the V/V^7 head.

(7) Tree diagram of the hypothesized structure of cadences



3 Materials and Methods

This section will cover the methodology of the experiment I carried out as well as information about the participants of the experiment. The experiment was planned with the help of methods used in linguistics to identify constituency structure. Since a phrase has obligatory elements, and a strict structure, violating those expectations will trigger less acceptable or completely ill-formed cadences. If musically untrained people are sensitive to those manipulations of the cadences that are not allowed by the theory, then they adapt the rules of human language syntax to these musical constructions. That would suggest that the same rules apply to music as to human language as far as X-bar Theory and Projection Principle are concerned. To find out whether this hypothesis is true or not, I asked people to judge sound samples, whether they find them pleasant or unpleasant within the style of classical music.

Altogether forty-four people participated in the experiment, they had little or no musical education, and thirty-eight of them were secondary school students aged from 15 to 19, males and females, all native speakers of Hungarian. The experiment was done with this group because I could only find that many test subjects who would participate in a high school. In addition to the students, six adults participated as well. Four participants had to be excluded because they graded perfectly well-formed, standard cadences with unreasonably bad grades. Excluding participants with the help of controlling sentences is used in linguistic experiments as well, that is why such perfect cadences were used as control here as well.

The forty sound files were put in random playlist and the listeners had to forward to the next one after they had listened to an item. They were allowed to listen to each item only once, and then they had to grade each one on a scale of five grades (1 is the lowest, 5 is the highest). They were asked to grade a chord sequence 1 if they found it absolutely unpleasant to hear and 5 if they found it perfectly fine, using the rest of the scale for the ones that they

find to be in-between. Trying to make sure the participants understand the task, first eight sample files were shown to them as an illustration of what a well-formed and ill-formed cadence sounds like. The ill-formed cadences were such that I put random chords in the place of dominant and tonic elements. I did not use this method in the sound files of the experiment, because that would have made the list of possible combinations too long for a participant to go through. For each examined stimuli I would have had to include another sequence of chords with randomly put chords, which would have multiplied the list of stimuli eventually. The sound files were created with the help of a music notation software[3] and they were verified by a professional musician. There were thirty cadences consisting of chords only and ten taken out of a piano piece[4]. From the piano piece there were original ones and manipulated cadences as well.

The results of the experiment are expected to support the claim that cadences are constructed according to the rules of X-bar theory, because the deletion of the dominant head is supposed to trigger worse judgements by listeners than the deletion of tonic heads. Furthermore, I wish to establish the heads of the phrases of a cadence and which parts of a cadence are complements and which are adjuncts.

There were thirteen pairs of stimuli tested for significance with paired samples t-tests on the Z-scores. The rest of the sound files were fillers. Eight out of the pairs were from the cadences I made, the rest from the piano piece. Calculated *p*-values were subjected to Holm-Bonferroni correction.[5]

As the three points of the hypothesis in 2.4 (1, 2(i) and 2(ii)) shows, there were three main tests in the design of the experiment. The list of stimuli with explanation about what each of them focuses on can be found in the appendix.

One of the three tests focused on finding what the most needed element is in a cadence. Therefore cadences with missing V heads and I heads were created, with and without continuation. If V is the most important head of the cadence, the judgements of the listeners will be the worst when it is missing. I expected the judgements to be worse when I is missing as well, but no decrease when there is continuation. That is because the continuation always starts with a tonic element by rule, therefore the requirement of the cadence being followed by a tonic element is fulfilled. The pairs of cadences testing this were: Pair 1, Pair 7.

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[3] Finale 2011 by MakeMusic, Inc.

[4] Andante movement of Sonatina in D-major by Ignaz Pleyel.

[5] This correction orders the *p*-values of comparisons in ascending order, assigns ranks to them and then the *p*-values are multiplied by the specific rank number and this will be the new corrected *p*-value. The correction of *p*-values is necessary for reducing the likelihood of false positives.

For the second test, to see whether the extensions of V are indeed adjuncts, I tried reordering them and deleting them, expecting no change in terms of grading. Similarly, the absence of the extension of I should have no consequence either. If I delete the I head, and leave the supposed specifier there, the cadence should be judged as an ill-formed one, because if the head is missing, the specifier cannot be present either. The latter generalization can be overridden in language if the head is phonologically zero, for instance, it is deleted or it is filled by a phonologically zero element (like a null preposition, or a null subordinating complementizer). Pair 2, Pair 4, Pair 5, Pair 10 , and Pair 13 tested the extensions relations.

The third test was to see in what relation the I and V/V7 chords are. If I and V prove to be in head-complement relation, the extension of I can only be either an adjunct or a specifier. According to the X-bar theory rules the expectation is that if the I chord a complement, the deletion of I is expected to trigger better judgements from the participants than the deletion of V/V7. The pairs testing this question were: Pair 3, Pair 6, Pair 8, Pair 9, Pair 11, Pair 12.

4 Results, Discussion and Implications

4.1 Results

The raw scores were transformed into Z-scores, in order to reduce interparticipant error-variance. The results showed that although the judgments are somewhat diverse, the rating of the key variants were rather unanimous. The table in (8) below presents the corrected *p*-values. The 1st and 2nd part labels refer to the chord progression part and the cadences from the piano piece, respectively. The rank shows the order made by the Holm-Bonferroni correction. The full list of stimuli and the pairs can be found in the appendices. I highlighted the pairs that have a significant *p*-value (Pair 7 from the first group and pair 9, 11, 12, and 13 from the second group).

(8) Table of corrected *p*-values[6]

		T	*df*	*p*	rank	Holm-Bonferroni corrected *p*
1st part						
Pair 7	V25_z - V27_z	2.318	38	.026	1	0.026
Pair 5	V10_z - V14_z	1.801	38	.080	2	0.159
Pair 1	V7_z - V30_z	-1.058	38	.297	3	0.890
Pair 6	V18_z - V20_z	1.047	38	.301	4	1.206

[6] The 1st part refers to the stimuli with chord sequences constructed by me, and the 2nd part contains the stimuli used from the Pleyel piano piece.

Pair 3	V8_z - V27_z	.875	38	.387	5	1.935
Pair 2	V8_z - V12_z	-.400	38	.691	6	4.147
Pair 8	V27_z - V29_z	.379	38	.707	7	4.947
Pair 4	V10_z - V28_z	-.121	38	.905	8	7.238
						2nd part
Pair 13	V41_z - V43_z	3.339	38	.002	1	0.002
Pair 9	V37_z - V38_z	3.310	38	.002	1	0.002
Pair 11	V38_z - V39_z	-3.076	38	.004	2	0.008
Pair 12	V41_z - V42_z	2.822	38	.008	3	0.023
Pair 10	V37_z - V39_z	.371	38	.713	4	2.852

4.2 Discussion and Implications

Pair 7, which triggered a significant *p*-value consisted of a cadence without the specifier of I (9a) and one with the specifier but without the I head (9b). Note, that as it was mentioned before (in 2.2), the I - IV sequence at the beginning of the cadence is optional. They were put in the sample files so that the cadences are less sudden.

(9) a. I - IV - $I^{6,4}$ - v - V^7 – I
b. I - IV - $I^{6,4}$ - v - V^7 – IV^6

The significant difference in judgements confirms the prediction that while the absence of the I head results in worse judgments, absence of I's extension causes less decrease in judgments of harmony. The latter one is also shown by Pair 5, because there is no significant *p*-value. Here there was a perfect cadence without IV^6 (10a) and one with IV^6 (10b).

(10) a. I - IV - V^7 – I
b. I - IV - V^7 – IV^6 - I

The prediction that continuation is allowed after the I chord was borne out by the lack of significant *p*-value in Pair 1, which compared a fully extended cadence (11a) and the same one with continuation (11b).

(11) a. I - IV - $I^{6,4}$ - v - V^7 - VI –I
b. I - IV - $I^{6,4}$ - v - V^7 - VI - I - continuation

I expected Pair 6 to have a significant *p*-value, because in one of them the V head is missing (12b), therefore it should be less acceptable. However, this is not what the judgments show.

(12) a. I - IV - $I^{6,4}$ - V^7 - IV^6 –I
b. I - IV - $I^{6,4}$ - IV^6 –I

The same comparison in the second part examined by Pairs 9, 11, and 12 show significant *p*-values. My suggestion is that it is easier for the listener to recognise an ill-formed cadence in the case of a real composition than in the case of a simple chord progression. Additionally, the adjunct of the missing V/V^7 has a dominant function, and maybe that is enough for the listeners to build up the tension-relaxation relation in the cadence. That tension-relaxation relation is needed for the closure of the piece of music. The same thing might play a role in Pairs 3 (13a-b) and 8 (14a-b) as well, where the missing I head did not result in a significant *p*-value.

(13) a. I - IV - $I^{6,4}$ - v - V^7 - IV^6 - I
b. I - IV - $I^{6,4}$ - v - V^7 - IV^6

(14) a. I - IV - $I^{6,4}$ - v - V^7 - IV^6
b. I - IV - $I^{6,4}$ - v - V^7 - IV^6 - continuation

Pair 2 compares cadences that include reordered extensions of the V head (15b). Since the *p*-value of the Z-scores is not significant, it seems to be confirmed that the extensions of V are adjuncts. What also supports this hypothesis is the insignificant *p*-value in Pair 4, where a perfect cadence is compared to one with only one of the possible adjuncts of V. Additionally, in Pair 10, the adjunct of V was deleted, and it did not result in a significant difference.

(15) a. I - IV - $I^{6,4}$ - v - V^7 - IV^6 - I
b. I - IV - v - $I^{6,4}$ - V^7 - IV^6 - I

All in all, the comparisons mostly strengthened the hypothesis that (i) V/V7 and I behave like heads and V/V7 seems to be the head of the whole cadence, (ii) the extensions of V/V7, according to the X-bar scheme, resembles adjuncts and the behaviour of the extension of I is of a specifier. For those occurrences when the data does not seem to support the theory, there can be other reasons, for example the semantic selection discussed in section 2.3. The adjuncts carrying the needed harmonic functions can be one explanation for why the heads can be deleted. That is possible because the required dominant function is still present, therefore the tension-relaxation relationship between the dominant and tonic elements is fulfilled. This suggestion, based on the musical functions of elements, however, raises the broader question of the precise licensing conditions of an assumed "phonological" deletion in music. This intriguing issue is left for future research.

5 Conclusion

This paper introduced a new type of analysis of musical structure. I made an attempt to analyse cadences of 17th-18th century Western tonal music, with the help of notions used in linguistics. My proposal was that there is a VP in the cadence with a V/V^7 head and this head has a IP complement and two possible adjuncts (there can be more than two occurrences, but only two types, V and $I^{6,4}$). Additionally, the IP phrase has a I head and two possible specifiers (VI and IV^6).

Besides presenting a theoretical argumentation I also carried out an experiment, thus I was able to support the theoretical claims with data gained from the experiment. The extensions of V proved to be adjuncts. The extension of I cannot easily be examined, because deletion does not decide whether it is an adjunct, a complement or a specifier, and it cannot be reordered with anything, because there is always only one extension, which seems to share characteristics with specifiers.

To sum it up, the importance of this experiment is to show that people, even with little or no musical education, are indeed sensitive to some of the structural rules in music that are present in human languages as well, namely X-bar Theory and the Projection Principle, although they are not aware of the rules of constructing cadences. This is exciting because it implies that language and music might share other universals as well.

6 Appendix

In the following table one can see all the chords used in the experiment. The participants listened to them in a random order, not in the one presented in the table. The disharmonic ones are starred in the first column. The question mark shows that the judgement of those cadences is not obvious since the missing element is preceded by a very similar one. The third column describes what the stimuli wished to examine.

(16) Table of stimuli

	Chord progression	Explanation
	I - IV - I6,4 - v - V7 - VI -I	If all possible extensions are accepted.
	I - IV - I6,4 - v - V7 - IV6 -I	If all possible extensions are accepted.
	I - IV - V - I	Authentic cadence, used as control.
	I - IV - V7 - I	Authentic cadence, used as control.
	I - IV - v - I6,4 - V7 - VI -I	If the dominant extensions can be reordered.

	Chord progression	Explanation
	I - IV - v - I6,4 - V7 - IV6 -I	If the dominant extensions can be reordered.
	I - IV - V7 - VI - I	If both of the dominant extensions can be freely left out.
	I - IV - V7 - IV6 - I	If both of the dominant extensions can be freely left out.
	I - IV - v - V7 - VI -I	If any of the dominant extensions can be freely left out.
	I - IV - v - V7 - IV6 -I	If any of the dominant extensions can be freely left out.
	I - IV - I6,4 - V7 - VI - I	If any of the dominant extensions can be freely left out.
	I - IV - I6,4 - V7 - IV6 - I	If any of the dominant extensions can be freely left out.
*	I - IV - I6,4 - VI - I	If the hypothesized dominant head can be left out.
*	I - IV - I6,4 - IV6 - I	If the hypothesized dominant head can be left out.
?	I - IV - I6,4 - v - VI -I	If the hypothesized dominant head can be left out.
?	I - IV - I6,4 - v - IV6 -I	If the hypothesized dominant head can be left out.
?	I - IV - v - VI - I	If the hypothesized dominant head can be left out.
?	I - IV - v - IV6 - I	If the hypothesized dominant head can be left out.
	I - IV - I6,4 - v - V7 - I	If the specifier of the tonic head can be left out.
*	I - IV - I6,4 - v - V7 - VI	If the tonic head can be left out.
*	I - IV - I6,4 - v - V7 - IV6	If the tonic head can be left out.
	I - IV - I6,4 - V7 - I	If the specifier of the tonic head can be left out.
	I - IV - I6,4 - v - V7 - I	If the specifier of the tonic head can be left out.
	I - IV - I6,4 - v - V7 - IV6 - I - cont.	Used as control.
	I - IV - I6,4 - v - V7 - VI - I - cont.	Used as control.
	I - IV - I6,4 - v - V7 - VI - cont.	If the tonic head can be left out, followed by continuation with a tonic start.
	I - IV - I6,4 - v - V7 - IV6 - cont.	If the tonic head can be left out, followed by continuation with a tonic start.
	I-III - I6,4 - V7 - cont.	If the tonic head can be left out, followed by continuation with a tonic start.
	I - I6,4 - V7 - cont.	If the tonic head can be left out, followed by continuation with a tonic start.
*	I - III - VI - I - cont.	If the dominant head can be left out.
*	I - III - IV6 - I - cont.	If the dominant head can be left out.

	Chord progression	Explanation
	I - V - I - cont.	Used as control
*	I - I6 - IV - I	If the dominant head can be left out.
*	I - I6 - IV - I - cont.	If the dominant head can be left out.
	I - I6 - IV - V - I	If the specifier of the tonic head can be left out.
	I - I6 - IV - V - I - cont.	If the specifier of the tonic head can be left out.
	I - I6 - IV - V - cont.	If the tonic head can be left out followed by continuation starting with a tonic element.
	I - I6 - V - I	Used as control.
	I - I6 - V - I - cont.	Used as control.
	I - I6 - IV - V7 - cont.	If the tonic head can be left out followed by continuation starting with a tonic element.

The pairs of stimuli compared can be found in this table. The highlighted one was judged better. The one that is typed in bold letters are the ones expected to be judged better in terms of harmony.

(17) Table of stimuli compared

Pair	Cadence 1	Cadence 2
Pair 1	I-IV-$I^{6,4}$-v-V^7-VI-I	I-IV-$I^{6,4}$-v-V^7-VI-I-continuation
Pair 2	I-IV-$I^{6,4}$-v-V^7-IV^6-I	I-IV-v-$I^{6,4}$-V^7-IV^6-I
Pair 3	I-IV-$I^{6,4}$-v-V^7-IV^6-I	I-IV-$I^{6,4}$-v-V^7-IV^6
Pair 4	I-IV-V^7- I	I-IV-$I^{6,4}$-V^7-I
Pair 5	I-IV-V^7-I	I-IV-V^7-IV^6-I
Pair 6	I-IV-$I^{6,4}$-V^7-IV^6-I	I-IV-$I^{6,4}$-IV^6-I
Pair 7	I-IV-$I^{6,4}$-v-V^7-I	I-IV-$I^{6,4}$-v-V^7-IV^6
Pair 8	I-IV-$I^{6,4}$-v-V^7-IV^6	I-IV-$I^{6,4}$-v-V-IV^6
Pair 9	I-$I^{6,4}$-V-continuation	I-$I^{6,4}$-continuation
Pair 10	I-$I^{6,4}$-V-continuation	I-V-continuation
Pair 11	I-$I^{6,4}$-continuation	I-V-continuation
Pair 12	I-$I^{6,4}$-V^7-I	I-$I^{6,4}$-I
Pair 13	I-$I^{6,4}$-V^7-I	I-$I^{6,4}$-V^7-IV^6-I

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