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MUSIC IS NOT A LANGUAGE

Re-interpreting empirical evidence of musical 'syntax'

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The emergence of local expectations in listeners of music has been occasionally explained by assuming a sort of musical syntax or grammar. While sharing some superficial qualities, music and language structures are working differently: language syntax is organized in a hierarchical system, working only context-sensitively (the applicability of syntactical rules is influenced by the context), whereas musical structures, especially harmonic progressions, emerge mainly out of constructive, context-dependent processes (the context is able to establish completely new structural principles). Collected examples from musical literature of western tonal music across styles and epochs show five main principles of musical structure-building that distinguish musical models from syntactical rules: Constructivity, mappability, contextuality, individuality and contingence. The main influence of frame and context on musical expectations can be especially demonstrated by means of a harmonic progression frequently used in empirical studies as assumed syntactical violation: the neapolitan sixth chord succeeding the dominant. As a consequence, a re-interpretation of the empirical data should consider the specific context of the observed effects: they might be more a result of the introduction of the listener to a redundant stylistic model instead of the application of syntactical rules proper. According to the provided examples, structural expectations of listeners appear to be rather combinations of general familiarity to styles and composition principles, individual preferences and local framing. Based on these historical and systematic arguments, the structure of music seems to be flexible and integrative, and not bound to a syntax system.

Key words

music syntax; music structure; harmony; harmonic expectation; music perception

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1. Introduction

Every piece of music owns a specific repertoire of sounds and structures, thus sharing stylistic characteristics with others. This individual fingerprint of a musical expression is often recognizable intuitively. Additionally, music history shows a broad variety of tonal music styles and cultures. The assumption that musical harmonic structures might share a language-like grammar arose in the 1980s (cf. e.g. Bharucha and Krumhansl, 1983; Baroni et al., 1983). Since then, several studies in the field of cognitive neuroscience of music investigated the structural similarities and differences of languages and musical styles, or even whole musical systems like the harmonic system of 18th to 19th century European major/minor functional tonality, often labeled as „western tonal music". Based on the observation of the existence of several musical styles with rather strict and hierarchical harmonic rules, one hypothesis in this research field claims, that this harmonic system works much like the syntax of a language. From a music theoretical point of view, this claim has to deal with some difficulties: at first, the extension of its validity is very difficult to draw, because various musical styles employing the same harmonic system do not necessarily follow the same rules of harmonic structure building. At least the term 'western tonal' applies to far more styles and harmonic systems than functional ones. Secondly, even within a defined musical style, a composer of a piece of music is more or less free to install new structural principles, to which listeners might adapt their expectations after a while of listening, not necessarily leaving the impression of stylistic appropriateness. Additionally, for any example of a stylistic 'rulebreake' it is possible to generate a piece of music – stylistically different but still within the same harmonic system – using this deviation as a structural rule, so that the former 'standard' combination appears then as the 'deviant'. And finally, other dimensions or parameters of music than harmony are as well comparably powerful in building musical structures: especially melody (voice leading), articulation (phrasing), rhythm, and timbre (coulour). In this respect it is generally hard to conceive of a musical syntax based on harmony alone. Additionally, complex musical parameters like harmony itself are sui generis combinations of horizontal (time) and vertical (frequency) processes: "Counterpoint cannot be purely linear, just as harmony cannot be reduced to a vertical dimension." (Poulin-Charronnat et al., 2005; see also Huron, 2001). Therefore also harmonic developments themselves can hardly be reduced to chord progressions only, without carefully considering voicing, register, tempo, timbre and other structural characteristics (cf. Bregman 1990).

In order to broaden the discourse between cognitive neuroscience and music theory, these music theoretical arguments shall be collected and elaborated in this article for possible applications in cognitive neuroscience of music.

Most theoretic approaches presupposing a "syntax of western tonal music" are aiming at the standard model of the functional cadence - either according to the function theory ('Funktionstheorie') after Riemann and Maler (see Maler, 1931/1984) or Schenker's fundamental voicing ('Ursatz': see Schenker, 1906/1978; cf. Lerdahl and Jackendoff, 1983; Beach, 1989). Additionally, generative grammar algorithms are able to emulate hierarchical harmonic functionality (see Steedman, 1996; Mazzola, 2002; Hamanaka et al., 2006; Katz and Pesetzky, 2009; Rohrmeier, 2007; de Haas et al., 2009; Rohrmeier, 2011).

The different concepts of musical syntax use two major constructions: induction and deduction. Meyer, 1956, for example, defines "the syntactical nature of different musical styles" as "the organization of sound terms into a system of probability relationships" or "the limitations imposed upon the combining of sounds" (p. 62). This inductive construction of syntax uses the observation of absolute frequency and chain probabilities of musical events in a definite corpus of music. The deductive construction instead assumes a set of rules or a generative grammar to differentiate between regular and irregular, i.e. syntactical and asyntactical structures. Both approaches are able to sufficiently describe many well-defined musical styles, but of course not 'western tonal music' as a whole: in the first case (the observation of occurrence probabilities) music history shows that a piece of tonal music can indeed use other than established, frequently occurring structures, especially being able to define an individual set of probabilities and expectations. Therefore, the results of the inductive construction of music syntax are of course dependent on the corpus they are based on, and cannot be too broadly extrapolated. The second case (the assumption of a musical generative grammar) implies a difference of "right" and "wrong" compositions, of fulfillment or violation of syntactic rules, which does equally apply to some definite musical styles, but not to all existing possibilities of western tonal music. But even a clear validity of a hierarchical syntax within a certain style does not imply that other harmonic styles are constructed similarly. Moreover, some recent empirical studies in the neuroscience of music tend to choose musical structures creating impressions like inappropriateness or irregularity in a specially intended way (see examples below). Therefore the evidence of the participant's syntactical

processing might appear more as a result of the experimental design and not of the functionality of tonal music in general. If complementary musical stimuli were chosen, and the musical context was composed accordingly, the relation of ‚syntactical' and ‚asyntactical' could well have occurred just vice-versa. The reason for this observation lies in the fact, that, in functional music, chords and tones gain their function out of redundant processes – especially they are not given by descriptive dimensions like the degree of the root alone. This means that the observed syntax might be valid within a special set of musical events employed by the composer, occasionally even within a whole music style, but not in tonal music in general. This generalization has to be questioned and the empirical results have to be re-interpreted on the background of the main difference between language syntax and musical harmonics: the harmonic structure of a musical piece might work with a hierarchical principle, but this structure, i.e. the syntax itself, is definable by the individual piece or its style, and not by a larger context comparable to languages. Described from the listener's point of view, we are able to acquire musical harmonic principles rapidly within the first bars of an unknown musical piece, and are able to extrapolate this harmonic ‚fingerprint' experience immediately (see examples in the next chapters). Therefore, tonal music harmonics might be compared better to the syntax of poetry in invented languages: the various pieces might share principles and build styles, but if they don't, they just implement a new set of structures instead of violating a given syntax. A composer can easily 'break a rule' in setting up another rule for his piece of music demanding complementary 'fulfillments'. The only difference for the listener is a result in another stylistic impression, but might not lead to the detection of irregularities. Therefore, a more proper term for the observed empirical effects of unexpected events would be 'change of style', and not 'violation of syntax rules'. Meyer (1956) describes, how the overall tendency of historical composers to change stylistic rules consequently leads into more long-term developments of new styles and music systems. Furthermore, it has been suggested that existing phenomena of syntactic processing in certain musical styles could be explained by employing more basic and general psychoacoustic accounts (Bigand, Tillmann & Poulin-Charronat, 2006).

Music theory in general distinguishes between the harmonic expectance of a listener (which can be fulfilled or disappointed) and the chord progressions as such, which cannot be right or wrong, but only redundantly confirmed or more or less deviated by following events. Even in hierarchical harmonic systems like the Riemann-Maler (major-minor-tonal) functionality, all combinations of chords are possible and can sound plausible in the case they are composed 'convincingly' (according the individual listener's background), and any chord combinations can happen to appear inappropriate to a listener while sounding in special contexts or environments (cf. Müller et al. 2011).

Of course, music shows indeed structural categories across styles. Colour, for example, is somehow universal and categorical: we can recognize the sound of known musical instruments, mostly regardless of what they are playing. Pitch and intervals, just like phonemes in language, depend on the used musical tuning system but then build stable categories across musical styles. The musical 'lexicon' consists out of motives (e.g., "5-5-5-3" as the beginning of Beethoven's fifth symphony), themes (e.g., national anthems), other citations (e.g., jingles) and signals (e.g., the rhythm of "SOS"): among accordingly competent listeners they get quasi-semantic meanings (Dowling and Harwood, 1986, therefore discuss the term 'musical syntax' on the background of these kinds of symbolization in a Peirceian meaning). But music in general does not show an organizational time structure that has to be followed for successful communication. By this definition, musical syntax does not exist. In fact, many music theorists "consider the metaphor of music being a language as prescientific, or to grant it a similar significance as the saying of the 'language of flowers'" (de la Motte-Haber, 2005). Or as Huron (2006) states: "Many purported patterns of organization are not borne out by careful examination of musical scores or sounds. And several of the patterns purportedly observed about musical organization actually describe the listener's experience instead" (p. 371). The reason for composition traditions all over the world being extensively concerned with the organization of harmonic structures might lie in the fact that exactly this dimension is much less predefined in general, and therefore available for artistic creation.

2. Structure-Building in Western Tonal (Functional and Non-Functional) Harmony

2.1 Western Tonal Harmonic Systems and Theories: Overview

Some musical structural models like the authentic cadence (dominant-tonic) have been used by western composers over epochs. This fact seems to support assumptions like: *"The chord progression I–I6–IV–V–I thus reflects a structural rule which can be viewed as an instance of syntax in musical grammar"* (Loui et al., 2005). But several musical models do not employ structural rules that can be called 'syntactic' in the sense that single incidents can be categorized as 'fulfillments' or 'violations' of syntactical rules. Instead they are building redundancies in confirming the harmonic fingerprint of an individual musical piece or section.

Most of the historical music styles show distinct borders of accepted and not-accepted individuations. But assuming a common harmonic 'grammar' in all styles of 'western tonal music' would need a more integrative concept of syntax that allows the building of new structural rules out of a context. In this sense, the concept of 'rule violation' is in a way fundamentally strange to the much more dynamic perception of music from a general point of view (cf. Ockelford, 2004). On the contrary, western tonal music appears to allow more possibilities of composition practice and music theory than those that are covered by major/minor functionality, generative grammar algorithms or other subordinating hierarchies of the harmonic system, not yet considered other structural parameters of music.

In general, music theory distinguishes between descriptive harmonic systems like the general bass denotation or the scale degree system, and interpretative systems that consider a listening perspective like the fundamental bass theory after Rameau or the functional theory after Riemann and Maler. Pure descriptive systems offer the advantage to deliver an objective algorithm to describe the harmonic events at hand. In case of the general bass, the most objective denotation in case of scale-based tonal music, the bass note is declared as the root of a harmonic chord, regardless of its harmonic function. The scale degree system employs already a very little amount of interpretation in the search for a virtual root of a possibly inverted triad – this root is then denoted as the degree. Interpretative systems offer the advantage to describe more the sensual acoustic impressions, together with the consequence of the introduction of subjective listening perspectives that have to be referenced more carefully. Rameau's fundamental bass theory claims the root relationship of directly succeeding chords, e.g. denominating fifth relations by "dominante" (roots in falling fifths) or "sous-dominante" (roots in rising fifths). Riemann-Maler's functional theory installs a more complex system of harmonic relationships by claiming one (apparently virtual) tonic for a whole piece. This distinction between purely descriptive and more or less interpreting harmonic systems should be considered while employing their denotations and interpretations as variables in neuroscientific analysises. Especially premature mixtures between the rather objective, descriptive and denotating degree system ("I – II – III – IV – V – VI – VII") and the much more subjective, interpretative system of functionality ("tonic, dominant, subdominant") bears the danger of incorrect or too subjectively dependent categorizations and therefore of a misleading analysis and interpretation of empirical data.

2.2 The General Bass

The General Bass is a script to denote the performance of a chord by a given bass tone. The General Bass is ignorant of harmonic events, functions, or progressions – it only denotes the keys that have to be pressed on the keyboard in addition to the bass. This scripture is therefore the most objective and non-interpreting system in western tonal harmonic systems. Basic examples are given in the following table.

no indication	add 3^{rd} and 5^{th} (all notes according to accidentals of the set)
6	add 3^{rd} and 6^{th}
b	add flattened 3^{rd} and 5^{th}
#	add raised 3^{rd} and 5^{th}
7	add 3^{rd}, 5^{th}, and 7^{th}

2.3 The Degree System

In the 18th century, a triad chord could also be described as an inversion of the triad on a scale degree root. The scale degrees are mostly written with roman letters: I – II – III – IV – V – VI – VII. This system is still quite objective, while already bearing some situations of competing interpretations. For example, the sixth chord on the IInd degree is an often-employed chord in cadences of Renaissance and Baroque pieces. The question, if this ought to interpret as an alteration of the IInd degree, or an inverted VIIth degree regular triad, is generally ambiguous and has to be analyzed contextually (in addition to that, the later functional theory by Riemann and Maler in the late 19th and early 20th century claims that this chord should be interpreted as an abbreviated, incomplete dominant seventh chord).

2.4 Fundamental Bass

The fundamental bass, formulated by Rameau in the 18th century (e.g. Rameau 1722), was the first attempt to interpret not only the structure of harmonic chords, but also their relationships. The main idea of the fundamental bass consists of the progression of virtual roots of the harmonic chords, and therefore not necessarily rendering the real bass melody like in the case of General Bass. In addition to the degree system, the theory of a fundamental bass analyses the intervals of this virtual roots. When they show a fifth relation, Rameau denotes this interval as “dominante” *d* when falling, and “sous-dominante” *s* when rising to the virtual target chord root. Whenever the first degree of the accidental scale is involved, he indicates this case as “dominante-tonique” *dt* or “sous-dominante-tonique” *st*. This system is based on the relationship of a single chord only to its immediately preceding and the successive chord. In this meaning, every chord that is followed by a chord in a fifth relationship is either a dominant (followed by a falling fifth in the fundamental bass) or a subdominant (followed by a rising fifth). In Rameau’s nomenclature these terms do not denote a special scale degree. In contrast to the later functional theory, the fundamental bass concept analyses only the hierarchies between immediately successive chords, and not a hierarchy between overall functions. Outside the direct relationships between successive chords the fundamental bass installs a coordinating instead of the subordinating principle. This crucial difference is the reason why Rameau’s fundamental bass is in general more adequate in analyzing and describing Baroque compositions than the functional theory: many baroque compositions do not have a clear tonic, but are constantly floating through the circle of fifth. In those cases, the functional theory is often forced to state an ongoing modulation (which is kind of an inner contradiction to the functional claim of a global tonic), whereas the fundamental bass correctly describes a local hierarchy together with a global homogeneity.

2.5 Functionality

The functional theory by Riemann and Maler was especially fruitful in Europe for the analysis of classical music of the late 18th and early 19th century. In contrast to the degree system with seven degrees of the scale, functionality claims only three main functions: tonic (I: T/t), dominant (V: D) and subdominant (-V, ergo IV: S/s). The symbols are written in majuscules in case of a major triad and in minuscule for minor. The derivates of the main functions, parallels (P/p) and counterparallels (C/c), are triads built on the degrees a third lower (p) and higher (c) in the case of a major scale, and a third higher (P) and lower (C) in a minor scale. These derivates can serve as substitutes for the main functions, and they can be borrowed from the homonymous scale of the opposite gender. Within this system, every harmonic progression should in principal be reducible to either the plagal (T-S-T) or the authentic cadence (T-D-T). Every function can be represented by a substitute chord (e.g. its parallel or counterparallel), and every chord can be accompanied by its own dominant (called secondary dominant). As a corollary, these principles deliver the implication that every chord can be interpreted in a number of ways of relationships according to its harmonic context, which makes the theory surpassingly powerful in describing the sensory impression of the harmonic events. For example: the triad on the first degree (I), mostly appearing as tonic, can occasionally also be interpreted as the dominant chord of the subdominant, and the subdominant can occasionally be interpreted as the counterparallel of the tonic parallel (if the harmonic impression appears to suggest this interpretation): $I = T = [D]^{\rightarrow S} = [D]^{\rightarrow TpC}$. The first degree triad can also appear as the incomplete diminished seventh ninth triple dominant to the tonic parallel: $I = [\cancel{DDD}^{5>79}]^{\rightarrow Tp}$ - these two chords share the identical three notes but with different functions. This means, that the degree I is not always representing the tonic, and the tonic can be represented by another degree. Additionally, this example shows that even the role of a note of a triad in terms of being a consonant or dissonant tone depends on the deployment and the solution. The functional theory is also capable of describing divergent impressions of multiple

listeners, or of situations of multivalent harmonic functions like in modulations. Therefore the projection on the scale degrees is not injective: every degree triad can appear in a whole set of possible functions, in addition of the enharmonic cases. Another implication is the fact that a special chord gains its harmonic function out of the context, i.e. out of the redundancy that is built by the preceding and succeeding events. For example, after a modulation, the new target tonic has to be confirmed by additional functions in order to install this new tonal centre properly with redundant harmonic relationships. A function is therefore a relative categorization, showing weaker or stronger relations, depending on the context. This means, a triad or a chord can appear to be *more or less* the tonic, or *more or less* the subdominant, or even both at the same time – depending on the harmonic circumstances (like the D major chord in bar 1 and bar 5 of Brahms' Intermezzo A major op. 118 No. 2, see Fig. 3d). And a function can well be revised, wiped or faded in the case when the harmonic progression does not confirm the established function with further redundancy. Shortly formulated, functionality is a dynamic, highly context-sensitive process.

In some literature, a mixed nomenclature of the functional and degree system is used (e.g. in Justus and Bharucha, 2002, p. 472, see also Patel, 2003). The correspondence of functions is given in this table, showing the main shortcuts of functions provided by the Riemann-Maler system:

Degree	**Interval to Tonic**	**Function following Justus and Bharucha**	**Main (frequently used) functions of the degree's triads after Riemann and Maler**		
			Name	**Major**	**Minor**
I	prime (unison)	tonic	tonic / secondary dominant to subdominant	T / $[D]^{\rightarrow S}$	t
II>	minor second	(flattened) supertonic	minor subdominant counterparallel	sC	sc
II<	major second	(raised) supertonic	double dominant / major subdominant parallel	DD	Sp
III>	minor third	(flattened) mediant	minor tonic parallel / minor dominant counterparallel	tP / dC	tp / dc
III<	major third	(raised) mediant	dominant to tonic parallel / major dominant parallel / major tonic counterparallel	$[D]^{\rightarrow Tp}$ / DP / TC	Dp / Tc
IV	fourth	subdominant	Subdominant / incomplete diminished double dominant ninth to tonic parallel	S / $[\text{~~DD~~}^{5>79}]^{\rightarrow Tp}$	s
T	tritone	-	(as major triad:) imcomplete diminished dominant ninth to subdominant / (as diminished triad:) incomplete double dominant seventh	$[\text{~~D~~}^{5>79}]^{\rightarrow S}$	~~DD~~^{7}
V	fifth	dominant	Dominant / minored dominant / counterparallel of minor tonic parallel	D	d / tPc
VI>	minor sixth	(flattened) submediant	Minor Tonic Counterparallel / or Minor Subdominant Parallel	tC or sP	tp or sp
VI<	major sixth	(raised) submediant	Dominant to Subdominant Parallel / Triple Dominant / Major Tonic Parallel / Major Subdominant Counterparallel	$[D]^{\rightarrow Sp}$ / DDD / TP / SC	Tp / Sc
VII>	minor seventh	subtonic	Double Subdominant	SS	ss

VII<	major seventh	triad on leading tone	Double Dominant to Tonic parallel / (as diminished triad:) incomplete dominant seventh	$[DD]^{\rightarrow Tp}$	$\not{D}^{7}$

A comparison of the two systems of analysis (degree-based and functional) shall be demonstrated using an example from Bigand et al. (2003) and Poulin-Charronnat et al. (2006): while the degree-based system reports the information about the position of the triads on the key scale, in this case *a minor* (Poulin-Charronnat et al., 2006, however report the degrees of the parallel *C major* scale instead), the functional analysis provides information about the relationships between the chords and their functional ambiguity (Fig. 3e). The example starts with a minor triad, which is then affirmed as tonic by the following four chords: the second chord is the minored dominant sixth chord, followed by the subdominant's sixth chord and the dominant parallel. The *a minor* key is then finally installed, at the latest, with the cadence dominant parallel – tonic in the fifth chord of the sequence. Then again confirmed by the subdominant and the tonic parallel. The latter progression is because of its plagal cadential quality leaving the *a minor* key towards the parallel key *C major*, so that at this point the latter four chords gain a possible second interpretation as dominant, tonic parallel, and subdominant parallel in *C major*. Finally, the new tonic *C major* is at the same time affirmed and blurred by the last chord of the sequence: this chord can be heard as the tonic counterparallel of the old tonic a minor or as the subdominant of the new tonic *C major*, but because of the fifth relation and the bass voicing of the progression (F – C – F), this *F major* chord itself is now claiming for the tonic part. If the sequence would be continued, the composer would have to decide which of the three now in parallel established and sensorial present tonics were to be affirmed or if this floating between the three should go on. This is an excellent example for a typical situation where several functional interpretations are present simultaneously, and where every new chord is able to strengthen or weaken one of them, or to remain in a plurivalent equilibrium: The function of the tonic is constantly revised by redundant confirmation or concurrent deviation of other added chords. The impression of "tonicality" and any other functionality is highly context-sensitive, and the strength or weakness of this impression is a result of a dynamic process.

2.6 Non-functional western tonal music

Not every historical and systematically possible style of western tonal music has subordinating, hierarchical harmonic principles. Systematically argued, what in one tonal piece counts as 'regular', could appear as 'irregular' within another piece. And more general, for every compositional rule in a given tonal style, a complementary tonal style can be generated with a complementary regularity.

In two major styles chord progressions and functional, subordinating hierarchies build the clear main harmonic structure principle in an architectural or syntactic sense: Classical tonal jazz and the First Viennese School style. Harmonic chord progressions in the functional sense are results of long-term developments in the different styles of counterpoint. In various other western and non-western tonal styles, harmony is highly entangled with or even more a result of other principles like melody (Gregorian chant, Indian raga, pentatonics), voicing (Renaissance, early Baroque, free tonality), colour (expressionism, impressionism, percussion music), or rhythm (Gamelan, minimal music, African folk music, electronic dance music). Romanticism and late 20th century tonal music tended to integrate all these dimensions of western and non-western tonality. Compared to the functional cadence, only very little research has been addressed on other forms of western tonal music (exceptions can be found, e.g., Huron, 2006; Krumhansl et al., 1987; Krumhansl et al., 2000; Rohrmeier and Cross, 2009).

The functional theory by Riemann and Maler proved to be especially powerful in explaining the harmonic structure of Viennese School music and many compositions of the romantic era, but shows its limitations already with Baroque and 19th century styles without a clear tonic, and appears not to be applicable successfully to most of the even older or younger idioms of western tonality like modal chords, pentatonic scales, Renaissance cadences, fourth harmonics, pluritonality, Liszt style atonality, whole tone scale, expanded tonality (beginning with Beethoven's String Quartets), chromatic modulations in 19th century music, free leading notes, free tonality, minimal music or alternative tuning modes to the equal temperament. In the following section, we try to give a brief overview of the historical development of western tonal music, together with some few examples of non-functional western tonality.

2.7 The origin of western tonal harmonics

The western tonal scale system has its origin in the medieval hexachord, roughly said a scale 'without' the later VIIth degree (Guido of Arezzo, 1025; cf. Hoppin, 1978). The origins of harmony in a polyphonic (i.e. not purely melodic) sense as a dimension of musical structure arouse in western tonal music from the 13th to the 15th century. In former epochs, melodic principles were ruling for centuries. Harmonic thinking in this sense arouse first within modal styles that created harmony in a fundamentally different way to the 18-19th century functionality (e.g. the polyphony in the Notre Dame School in the 13th century, or the harmonics in secular music by Guillaume de Machaut in the 14th century). In music history, the concept of counterpoint and thus the model of clausulae as precedents of the authentic cadence developed only very slowly (see Davison and Apel, 1946). At the same time, languages were used to build hierarchic syntactical structures at least since the antiquity. Since then, up to the Baroque era, voice leading was clearly the main compositional tool to build harmonic structures. Rameau (1722) introduced the concept of the fundamental bass (i.e. virtual chord roots, see above), and hence the idea of chord progressions as a form of harmonic analysis and composition. Composers and theoreticians of the Baroque era searched for the ideal combination of traditional counterpoint and the contemporary fundamental bass (cf. Fux, 1725; Marpurg, 1759; Kirnberger, 1771; Schulz, 1773). Therefore, the Baroque style system could be considered as an era of equilibrium of harmony and voicing.

Besides the historical development, there are also systematic demands for a more careful analysis of harmony beyond pure chord progressions or functional hierarchies. Poulin-Charronnat et al. (2005) investigated the influence of voice leading, and Boltz (1989) of the rhythmic structure on tonality and harmonic impressions. Eberlein (1994) has pointed out, that harmonic structures, in general, work mainly as whole models, including voice leading and rhythm, than as pure combinations of chords or chord progressions. For example, the two chords in the second beat of the first bar in J. S. Bach's arrangement of "Ein feste Burg ist unser Gott" (BWV 302, Fig. 1f) can only be analyzed by considering the applied advanced voice leading tools: a dissonant chord (a b d' d'') is followed by an even more dissonant one (g c#' e' d''). If we try to analyze only the chord progressions, then these two chords appear as a mixture of tonical, subdominantal and dominant functions, where a strict functional analysis falls short; but looking at the voicing this passage turns out as a very elegant combination of different counterpoint rules. Huron (2001) gives a systematic set of rules deduced from perceptual demands for an effective voice leading. Not surprisingly, most of these perceptual rules are consistent with most of the historic counterpoint principles.

2.8 Some selected examples of non-functional western tonal music

The question, which of all possible examples may count for a basic corpus of „western tonal music" is of course a matter of definition. In music history, a clear border between western and non-western music is hardly definable, and also between tonal and non-tonal music. Meyer (1956) proposes a differentiation within the culture of western tonal music in epochs, style systems, and styles. Most of the examples used in neuroscientific literature investigating musical syntax employ a rather abstract, academic, exercise-like, functional, four-voiced and homophonic style, together with simple harmonic schemes that can be found in certain European (i.e., Middle European, especially German) folk songs and folkloric pop. The crucial discussion concerning these empirical findings is, to what extent their evidence might be effectively applied – in other words, how far a generalization is reasonable. At least, the field of western tonal music seems to be apparently too wide to be represented only by hierarchical functional cadences. The following list of examples is not comprehensive, but shall indicate the variety of harmonic systems within the historical development of western tonality that are not or only partly covered by the authentic/plagal cadence system.

2.8.1 Modality

Modality is a system of western tonality working differently than the functional system with its major and minor scales. The Greek and central European medieval modal scales survived through the centuries in popular songs and dance music all over Europe, and build the harmonic material of several major Jazz styles and other popular music until the 21st century. The modal scales don't own a dominant in a functional sense, but for example a minor triad on the Vth degree instead.

2.8.2 Renaissance clausulae

The concept of a cadence arouse in the form of contrapuntal ending models during early polyphony up to the Renaissance clausulae. These clausulae consist in the standard version of a discant clause with the penultimate modal scale tone 7 and the ultimate 8, an altus clause with the penultimate 5 and the ultimate 5, a tenor clause with penultimate 2 and ultimate 1, and a bass clause with penultimate 5 and ultimate 1. These schemata arouse at first from contrapuntal requirements, long before founding the later thinking in harmonic chord progressions.

2.8.3 The circle progression

The perhaps most frequently used harmonic model in the Baroque era is the circle progression (I-IV-vii-iii-vi-ii-V-I), or its dissonant derivate, the “seventh chord chain”, consisting of the seventh chords on these degrees. This harmonic model proves to be difficult to integrate in the functional system. Generally, the functional theory can hardly describe the harmonic relationships of the viith degree correctly, because it does not serve as a functional root. The functional theory claims instead that this triad should be interpreted as an incomplete seventh chord on the virtual Vth degree root, and not as the diminished minor secondary dominant to the dominant parallel, which would appear to be a better description of the acoustic impression: [d$^{5>}$]$^{\rightarrow Dp}$. In the circle progression, the 2nd, 3rd and 4th chords are obviously changing in their harmonic function, but the 3rd chord is mostly functionally categorized either together with its precedent or following chord (either as T-S-~~D~~^{7}-Dp-Tp-Sp-D-T with double dominant or as T-S-~~D~~^{7}-Tg-Tp-Sp-D-T with double tonic: both interpretations do not accompany the sensory impression, cf. Daniel 2004). This model is an example where Rameau’s fundamental bass theory delivers a more adequate analysis in comparison to the Riemann-Maler functionality because of its weaker hierarchy (Rameau analyses the vii chord correctly as a dominant to the following chord iii: the fundamental analysis reads “dominante(d) – d – d – d – d – d – dominante-tonique – tonique”, which appears as a much more correct representation of the sensory impression).

2.8.4 Pentatonics

The pentatonic scale in the western variation is based on a five-tone-scale consisting out of two major second steps, then a minor third step, and another major second step, leading into the octave by a last minor third step. Based on a fundamental note, this scale can also be described as the fundamental, major second, major third, fifth, and major sixth. On a piano keyboard, the black keys resemble the pentatonic scale. This scale is able to have a double tonic at the same time (a major and a minor one, e.g. the triads on d# and F#). It has no full dominant, and is therefore non-functional. Various children’s songs employ the pentatonic scale, and also many jazz, rock and pop pieces (e.g. “Papa was a rollin’ stone” by Whitfield and Strong, 1971).

2.8.6 Fourth harmonics

Fourth harmonic systems base on the fourth as the constructive interval, instead of the same role of the fifth in functional systems. While within functionality it is possible to generate characteristic dissonances in adding thirds on top of each other before reaching the root again (3-5-7-9-11-13-15=^{15ma}1=^{8va}(^{8va}1)), fourth harmonics does the same with fourths (4-7-10-13-16-19- 22=^{8va}(^{8va}(^{8va}1)). The result is a very delicate and floating harmonic system, much employed by late romantic as well as early impressionistic composers, up to many jazz standards and rock titles in the 20th century.

2.8.7 Whole tone scale

The whole tone scale consists out of six major second steps (or whole tone intervals) and is therefore equally balanced, without a possible root (which can be only composed melodically). There are two possible transpositions: F# G# A# c d e, and F G A B c# d#. This scale was introduced to European tonal music in the late 19th century. It was especially used by Claude Debussy to emulate south-east Asian tuning systems like those of the Gamelan orchestra, which consists actually only out of five and not out of six intervals. Nevertheless, the whole tone scale became very famous among various composers in aiming for a floating and non-centralized harmonic impression.

2.8.8 Parallel / Bypassed Functionality: Jazz

Also in Jazz there have been parallel developments of different harmonic systems. Beginning already from the classical Jazz (e.g. Gospel and Spiritual, New Orleans / Dixieland, Ragtime) in the early 20th century, Jazz styles employ other tonal systems, especially pentatonics, modality and chromatics – and of course, the Blues scales. The harmonic Blues scheme, widely used and varied, became also the foundation of later styles like Rock 'n' Roll: this scheme I – IV – I – V – IV – I reads in its functional description as T – S – T – D – S – T, but especially in its Rock 'n' Roll version with unsolved seventh chords on each position, this architecture works quite differently. The IVth degree does not appear functionally, neither as a secondary dominant (to double subdominant), nor as a proper subdominant, and the Vth degree sensorically does not really appear as dominant, but more like an emphatically "raised IVth degree", or if properly functionally described, as a double subdominant substitute: T – S – T – SSP – S – T. Compared with the scheme of various folk songs I – V – I – IV (– I) – V – I, the IVth and Vth degree in the Blues scheme somehow seem to have exchanged their functional roles – just as if the fifth relations were turned simply "upside down". But the most obvious difference to the Riemann functionality of Blues and Classical Jazz is the existence and employment of the Blues scales and the melodic "blue" notes between the semitones of the tempered chromatic scale. Nevertheless, while being non- (or para-) functional, Blues and Classical Jazz harmony is organized hierarchically and can therefore correctly be described as a syntactical harmonic system.

2.8.9 Minimal Music, Hiphop et al.

The harmony of Minimal Music, Hiphop and various late 20th and 21st century electronic dance music mostly works through shifts and other equivalent, coordinating transpositions to all degrees of the chromatic total. Within the various styles, there exist preferences for mediantal, diatonic, enharmonic or chromatic relations, but the common principle is an equal status of progressions through the (mostly) root positions of chromatic chords. Of course, due to the explanatory flexibility of the Riemann functional system, even an often used and highly chromatic and enharmonic Hiphop chord combination like f# minor – g minor – f# minor – g minor can be interpreted functionally, but the necessary theoretical effort does not at all relate to the sensory impression and the much simpler hypothesis of a semitone shift.

2.9 Summary: A contradiction?

Western tonal music consists of various epochs, styles and developments (cf. Meyer, 1956). Far from all of them show a hierarchically organized harmony, and some can even not be described by the functional system or by the terms 'tonic – subdominant – dominant' in general. In contrast to this, recent neuroscientific research on cognitive processing of tonal music claims to deliver evidence for a common syntactical structure of western tonal styles. This superficial contradiction might be taken as a hint to a conceptual or a methodological problem, or perhaps also both. Therefore more empirical research with several musical styles would form an urgent desiderate, together with a more interdisciplinary approach to the theoretical concepts of harmonic structure between musical and neuroscientific competence.

3. Five Major Principles of Structures in Western Tonal Music

For the purpose of investigating the underlying reasons for this contradiction, we have collected examples of harmonic structures used in different styles and epochs of western tonality and analyzed stimuli used in selected empirical studies addressing harmonic "syntax" (i.e.: Bod, 2002; Creel et al., 2004; Dienes and Longuet-Hingins, 2004; Fedorenko et al., 2009; Koelsch, 2009; Koelsch and Jentschke 2008; Koelsch and Siebel, 2005; Koelsch et al., 2005; Krumhansl et al., 2000; Large and Palmer, 2002; Leino et al., 2007; Loui and Wessel, 2007; Loui et al., 2005; Maess et al., 2001; McMurray et al., 2008; Miranda and Ullman, 2007; Patel, 2003; Patel et al., 1998; Poulin-Charronnat et al., 2006; Slevc et al., 2009; Steinbeis and Koelsch, 2008; Tillmann, 2008).

Our historical and systematic analysis revealed several peculiarities and modes of functioning of harmony that contradict, or at least do not support, the assumption of a syntactic structure of tonal music in general. In particular, hierarchical forms of organizing harmony are only one possibility

among many others. These examples can be categorized in five major principles; a) constructivity, b) mappability, c) contextuality, d) individuality, and e) contingence. These five principles are elaborated in the following sections.

3.1 Constructivity

Music pieces in general can build individual rules of harmonic structures, combinations, models and progressions. In that sense, music is constructive. Music pieces are not necessarily based upon fixed, learned or already known structures. On the contrary, listeners of music are able to rapidly acquire new musical systems (see Jonaitis and Saffran, 2009; Tillmann, 2008; Smith and Melara, 1990; Kuhn and Dienes, 2005; Loui and Wessel, 2008; Loui et al., 2009; Rohrmeier and Cross, 2009).

In the following section we will discuss examples of constructivity in four senses: Music pieces are able to overrule existing familiarities (see 3.1.1), individual models are applied additionally or in parallel to other established principles (3.1.2), the models superficially fit to some known principles while aiming at a different structural idea (3.1.3), or they are able to introduce radical new forms of thinking about musical structures (3.1.4).

3.1.1 Overruling principles

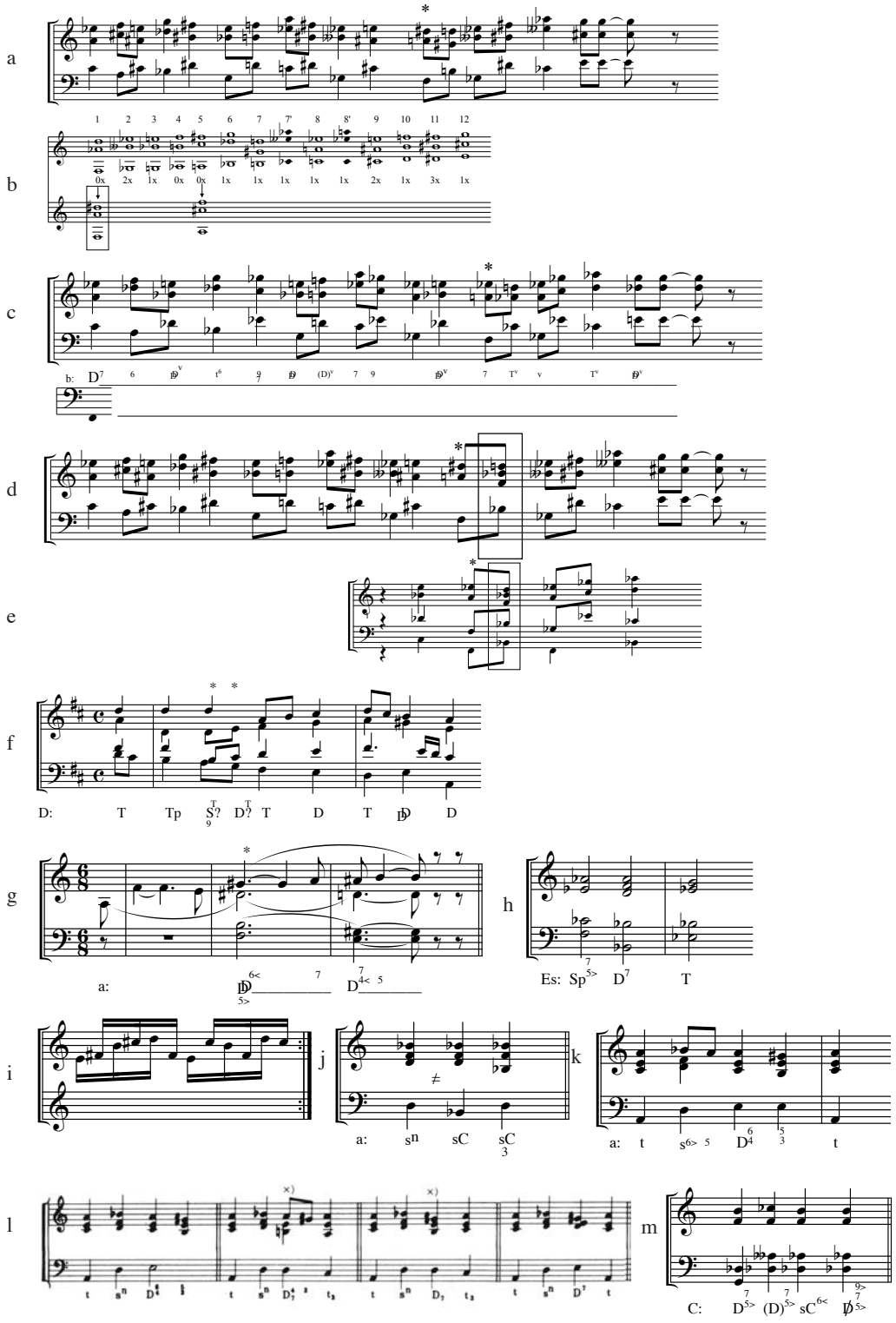
One instantiation of constructivity is constituted by the use of overruling principles. Kuhn and Dienes (2006) showed, that comparably new, yet unknown melodic composition principles could be implicitly learned within 15 minutes, and explicitly explored within 45 minutes. Rohrmeier and Cross (2009) were able to implement a non-functional harmonic system by an artificial grammar algorithm, which could be learned by musicians and non-musicians in about 25 minutes of attendance. Loui and Wessel (2008, cf. Loui et al., 2009) were able to train participants in judging melodies in a by then unknown scale within 30 minutes. As Saffran et al. (1999) reported, listeners were able to build a statistical prediction in familiarity of melodic motifs after an exposure of 20 minutes of six template samples. Peretz et al. (1998) investigated the influence of short exposure to new melodies on the liking and recognition.

Within real compositions, the acquisition of piece-specific structure principles appears to work even much faster (see Krumhansl, 2010; Bigand et al., 2011). We propose to analyze an example from the peripheral area of western tonality (the piece obviously doesn't count to the repertoire of functionality, but it is a good example for a piece from the edges but within the western system of tonalities), because it shows very well how harmonic structures are able to introduce themselves already after a few events: “Vexations”, a piano piece by Erik Satie (composed 1893; Fig. 1a). The composition uses almost only diminished triads. The possible interpretation of diminished triads as the VIIth degree of a diatonic scale (or even a functional dominant) is overruled by a strong coordinated (instead of subordinated) organization of nearly the full chromatic set of diminished triads. This concept becomes evident already after the first few chords (cf. Orledge, 1998): A bass melody consisting of 18 notes using 11 different pitches of the chromatic totality (see analysis: only A flat is missing) is played alternately solo and harmonized by diminished sixth chords, alternating in octave and fifth position of the discant voice.

This alternation could also be considered as a kind of the ‘syntax’ of this piece: whenever the alternation of octave and fifth position was not followed or disturbed, for example by repeating a position, an accordingly sensible listener should immediately be able to detect a violation of this ‘syntax’. Nevertheless, there is hardly an analogy in language. At least, a series of coordinated single words will not build a syntax in the core definition of the term, but a series of coordinated chords can easily build a new harmonic system for a piece of western tonal music.

One chord (Fig. 1b, no. 5) in “Vexations” is replaced by an augmented triad, and one chord (Fig. 1b, no. 1) is replaced by an augmented sixth chord that could be enharmonically reinterpreted as major seventh chord without the fifth (Fig 1a, marked with an asterisk *). The latter chord usage shows impressively the constructivity of harmonic structures: here this alleged dominant-like chord loses fully its functional characteristics, gaining a new role within a set of non-hierarchical structured sounds.

Figure 1



a) Extract from “Vexations” by E. Satie with marked (*) exceptional chord; b) analysis of used triads; c) possible functional interpretation; d) a dominant-tonic combination as violation of harmonic principles; e) alternative context, where the impression of an inappropriate progression is soothed; f) J.S. Bach’s choral “Ein feste Burg ist unser Gott”, BWV 302; g) R. Wagner’s Tristan chord, original use in the beginning of the prelude of the opera “Tristan und Isolde”; h) standard solution of its enharmonic subdominantal correspondent; i) initial pattern from S. Reich, “piano phase”, with para-functional tonality; j) neapolitan sixth chord s^{n}, subdominant counterparallel sC and sixth chord position of sC; Mozart’s tritone substitution compared with enharmonically equivalent D and sC derivates; k) initial context of the neapolitan sixth in the 17th century; l) the Neapolitan chord forces a directly following dominant to a resulting cross-relation x); m) tritone substitution principle, used a.o. by W.A. Mozart.

3.1.2 Structural functions established in parallel

Many compositions of the Romantic epoch liked to blur hierarchic functions of tonality (see Kelley, 2006), often by avoiding the tonic chord for a rather long time. For example, in the prelude of Richard Wagner's opera "Tristan und Isolde" the tonic appears only extremely late, and the harmonic processes beforehand are comparably complex. The "Tristan chord" (Fig 1g, marked by an asterisk *) uses a somehow sophisticated enharmonic solution of a chord, known from other contexts enharmonically as half diminished subdominant parallel (Fig. 1h). Especially the actually dissonant augmented sixth (g sharp) does not really appear as a dissonance. This example shows, that a piece of music is able to establish a special way of listening and interpreting the musical events immediately. According to the demands of the functional theory, the Tristan chord would have to proceed into the solution given by Fig. 1h. But the listener, even as novice, gets very soon (i.e. after few repetitions of this solution in the first bars) very familiar with the 'Tristan' solution given by Fig. 1g, in contradiction to the system of functionality. In contrast to the seventh chord in "Vexations", this chord does not lose fully its tonal functions, but it is introduced with an individual progression, that soon becomes very familiar while listening further (see Rothgeb, 1995). From a structural point of view, and according to the interpretation currently leading in music theory, this progression is considered not as a combination of chord functions, but as a chromatic version of a derivate of the ancient phrygian clausulae, as the discant clausula ascends with a major second into the ultima (but here into the fifth instead of the octave), and the bass clausula descends with a minor second into the ultima, the root. This analysis again demonstrates the existence of styles with possible primacy of voice leading principles over chord progressions (cf. Poulin-Charronnat et al., 2005).

3.1.3 Use of structures for other purposes

Steve Reich's "piano phase" (Fig. 1i) uses a superficially tonal motif to launch a structural process in another dimension. Two pianists are playing the same monophonic pattern, and by increasing slightly the tempo for a specific time, the second pianist gets ahead one note after the other. As a result, the two patterns form various rhythmic, melodic and harmonic "interior" motifs that invite the listener to submerge deeply into the sound. This composition technique does not use chord "progressions" (every section is based more or less on one single harmony), especially not syntactical hierarchies of chords, and thereby initiates very rich and complex structure-building processes (see Epstein, 1986). This example shows the existence of tonal music where the concept of a 'syntax' consisting out of chord progressions appears not to be applicable on a basic level. Although this example appears to be somehow trivial, this kind of multi-layer structuring is a frequently used principle in experimental tonal compositions.

3.1.4 Introduction of new forms of structure building

The hierarchical, subordinating harmonic system of tonal functionality is only one among various possibilities of building harmonic structures within western tonal music – not even considering non-western and non-tonal types of music. Historically, composers in all epochs were in general very creative in inventing new forms of harmonic organization. From time to time they broke with their contemporary traditions and invented a completely new form of harmonic structures, within or beyond tonality: for example free tonality, timbre melody, musique concrète, aleatorics, chance operations or minimal music.

3.2 Mappability

Composition principles can be borrowed from any other structure, and are therefore particularly able to import and represent syntactic rules, independent of their recognisability. For the purpose of discussing "musical syntax" it may be interesting to analyze mapped syntactical language structures by musical means, as they are conducted in the composition principle of "instrumental speech", where instrumental parts are sampling spoken text (cf. e.g. Segnini, 2004).

An often-used composition principle is the mapping of foreign structures onto musical events. This strategy can be found not only in serial compositions. An early occurrence of this concept is the mapping of text by representing the letters with corresponding note names (for example the combination of the word B-A-C-H by the motif B flat – A – C – B natural). A more recent example is the

work of Conlon Nancarrow, who implemented canons representing ratios of mathematical meaningful numbers like *pi* or *e* (Euler's number).

Not surprisingly, grammar-generated composition algorithms are able to emulate existing hierarchical musical styles like Blues (Chemillier, 2004; Steedman, 1996), classical periodicity (Hamanaka et al., 2006), pieces which are formally reducible to Schenker's 'Ursatz'/'Urlinie' like Mozart's Theme of the Sonata A major KV 331 or Bach's Prelude I in C major of the Well-Tempered Clavier (Katz and Pesetzky, 2009), and baroque chorals (Rohrmeier, 2007). On the other hand, musical harmony, and music in general, is able to reproduce *any* syntax, regardless of being generated by grammar algorithms or by other tools (cf. Nauert, 2003). That means, to a given set of structural rules, it is possible to compose music which is structured according to the intended architecture. That is, chosen and set rules can be implemented in music. If this is sufficiently well done, even desired effects in the listener can be achieved. This is the approach often taken when designing and composing musical stimuli for empirical research.

3.3 Contextuality

Musical structure is inherently context-dependent. Therefore, any "violation" or "deviation" of listener's expectations can serve as a "standard", and vice versa, simply by defining the alleged violation as a composition principle for a musical piece. Also without installing an own musical idiom, individual pieces are able to set individual "standards", even if they are unusual or can hardly be found in other comparable pieces. The sequence "T–D–S–T" for example is, although not as often used as "T-S-D-T", not a syntactical violation of the authentic cadence, but rather an incidence of the plagal cadence "T – SSD – S – T", used for example by Felix Mendelssohn-Bartholdy in the beginning of his "Overture to a Midsummer Night's Dream" op. 21, or by the Blues Scheme used in several classical Jazz styles. The "Classical Symphony" op. 25 by Sergej Prokofieff establishes a characteristic but unusual cadence model in the second theme (T-VII-tC-DD), which becomes also very soon quite familiar to the novice listener.

Language syntax as well is context-sensitive in the meaning of contextual influence on the applicability of syntactical rules (cf. Levy, 2008), and is also able to build style-based expectations (as shown e.g. in Frazier et al., 2000). In comparison to the contextuality of musical structures, at least two fundamental differences should be considered: At first, language syntax, albeit being context-*sensitive* (in the sense that applicability of certain syntactical rules is controlled by the context), is not itself context-*dependent* (in the sense of being able to install totally new syntactical rules or reject existing ones depending on the context). In general, the context of a sentence only defines if a syntactical rule is applicable, and is not able to build new rules or reject common rules instantaneously. If a novel would be written completely out of asyntactical sentences, they still would remain asyntactical, albeit being expected after some reading. Musical pieces, on the contrary, can use "deviations" of expectations as motifs, thus being able to change their status into incidences of a style. Secondly, language syntax works through abstract categorization and is therefore much less affected by tempo, volume, timbre, register, voicing, discontinuities in contributing factors (e.g. changes of speaker), layers and streams, acoustical conditions, local particularities and personal preferences (we can *like* asyntactial sentences while they remain asyntactical) – whereas music hierarchical, subordinating "syntax", if involved at all, is highly interconnected with these dimensions.

Furthermore, in most musical styles, there exist elegant "deviations", unexpected "surprises", yet inexperienced "deceptions", or sophisticated breaks of counterpoint rules: e.g. parallel fifths in pieces of J.S. Bach like in the Choral of Cantata BWV 40 "Jesu, nimm dich deiner Glieder", or the choral "Ich will dich mit Fleiß bewahren" of his "Weihnachtsoratorium", or those passim in Mozart's work that gave their name to the "Mozart-fifths", that are highly appreciated through intelligent voice leadings. These "violations" represent rather compositional mastership than musical errors, and build a proper quality of musical allurement (cf. Gaver and Mandler, 1987; Daniel, 2004). It would be a great advantage to investigate also the perceptive processing of such paradoxical phenomena within well-defined styles.

3.3.1 Well-known combinations can appear as "violations"

Regardless of the fact that the chords in Erik Satie's "Vexations" are organized non-functionally, a possible functional analysis could be hypothetically delivered as shown in Figure 1c. By adding an imaginary fundamental root (F) for the whole passage, every chord could be interpreted as part of a dominant to the tonic B flat. In this interpretation, the previously differing chord (*) changes its role to

the functional basis. According to this (mis)-interpretation, if we replaced the 13th chord by this virtual tonic B flat, as shown in Figure 1d, we would get the impression of a rather inappropriate progression of the combination D^7-T (dominant seventh chord – tonic). On the other hand, removing the context and adding different chord roots to force the listener towards the functional interpretation could soothe this impression (as shown in Figure 1e).

Meyer (1956) gives another example for the occurrence of an authentic cadence as a violation: "There is a striking example of this in *Ein Heldenleben* by Strauss. Just before [the bar marked with the] number 77 [in the edition of] (Eulenberg, miniature score) there is a perfectly regular cadential progression, II-I_4^6 – V, in E-flat major, which in a piece written a hundred years earlier would lead us to expect the tonic chord. Here, however, it leads us to expect almost anything but the tonic; and when the tonic does come, it is definitely felt to be a deviant" (p. 66, see Fig. 3f). In order to experience this surprise, it is crucial to have gone through a passage, or better the whole 6 minutes of the fourth set before the bar at number 77.

3.3.2 The neapolitan sixth chord: origin and historical use

Several studies addressing "music syntax" take the neapolitan subdominant s^n as a reputed "violation" of the harmonic system when placed at the end of an authentic cadence instead of the tonic (e.g., Steinbeis et al., 2008; see also Maess et al., 2001; Slevc et al., 2009; Loui et al., 2005; Leino et al., 2007; Koelsch et al., 2005). Some studies however use the subdominant counterparallel sC instead of the neapolitan chord s^n. Because the neapolitan chord became somehow crucial in recent literature, we describe its historical and systematic functionalities here in more detail. To develop the main point of the argument (the exchangeability of violation and fulfillments by altering the introduction), it seems to be important and fruitful to consider the functional possibilities of this specific musical pattern in the interpretation of the purported evidence of a musical 'syntax'.

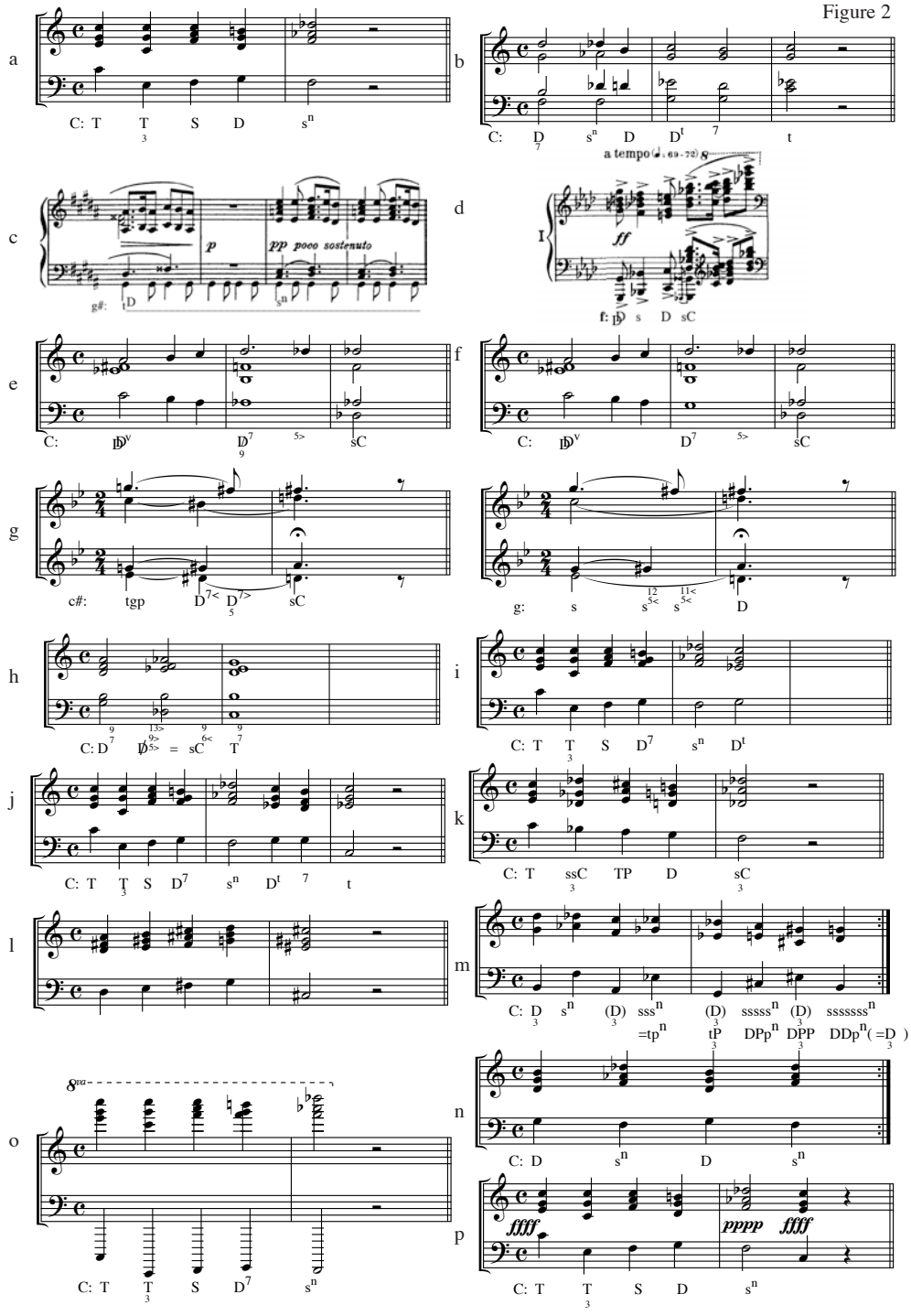
The neapolitan sixth chord is the minor subdominant with the fifth replaced by a minor sixth (s^n is the same as $s^{6>}$). Particularly, the neapolitan sixth chord is not an inversion of another chord. Historically, the neapolitan sixth chord is almost exclusively used in root position. Therefore, the neapolitan sixth chord can be distinguished from the minor subdominant's counterparallel sC (Fig. 1j). In English contexts the sC is occasionally called "flattened supertonic" – but the sC is functionally more a relative to the subdominant than to the tonic. Some other theorists named the sC also "independent neapolitan chord", but this nomenclature appears occasionally as a source of some confusion. The neapolitan sixth chord differs from the sixth position of the subdominant counterparallel in the doubling of the root and in its characteristic voicing. Figure 1k shows the origin of the Neapolitan chord in the 17th century out of a suspension ($s^{6> - 5}$), leading to the baroque voicing models of the Neapolitan chord in the 18th century as shown in Figure 1l.

Composers of the late 18th century frequently used the close relation of $D^{5> 7}$ in the opposite keys of the circle of fifths in a "tritone substitution": by only exchanging the interpretation of root and lowered fifth within a dominant seventh chord (and thus exchanging the roles of major third and enharmonic minor seventh) they modulated occasionally directly into the tritone key. This usage is specially interesting, while the $sC^{5> 7}$ appears to be enharmonically the same chord as $D^{5> 7}$ – that means, the sC is also very close related to the dominant through enharmonic equivalence and therefore is able to bridge subdominantal and dominantal functions (see Fig. 1m).

3.3.3 The combination dominant - neapolitan sixth chord is not incongruous as such

A number of empirical studies addressing musical "syntax" in cognitive neuroscience assume that the combination D – s^n is "syntactical inappropriate" or "incongruous". Generally they argue "only a tonic chord would be appropriate in that position" (e.g., Maess et al., 2001, p. 541; Fig. 2a). The initial underlying assumption that s^n cannot stand after D can be disproved by the example given in Figure 2b. Also historical examples exist for the use of the progression D – s^n (Fig. 2c) or D – sC (Fig. 2d). Also Antonín Dvorák begins the second set of his 9th Symphony op. 95 "From the New World" with the progression D – s^n (Fig. 3g). Examples given in Figures 2f and 2g show, that the s^n (or the sC) can even appear after the dominant at the end of a phrase. In tonal jazz, a frequently used coloration of the dominant is the addition or replacement by the sC with raised sixth and ninth (Fig. 2h). This use is following the tradition of the "tritone-substitution", because this chord is equivalent to the abridged dominant seventh chord with lowered fifth and added lowered ninth and lowered 13th.

Figure 2



a) supposed syntactical violation by D - s^n; b) appropriate appearance of the combination D - s^n; c) extract from M. Moussorgsky, Pictures at an Exhibition (Il vecchio castello); d) extract from M. Reger, Piano concerto f minor; e) appropriate appearance of the combination D - sC as ending of a phrase; f) works also well with the “clear” dominant; g) extract from E. Grieg, „Melancholy“, enharmonically modified to indicate the D - sC relationship of the last two chords; and a functional interpretation of the extract of „Melancholy“ in g minor (this motif shows certainly a case of free leading notes, transcending the functional system analysis, and yet another incidence where voice leading principles build the formal structure rather than chord progressions); h) jazz cadence with D - „sC“; i) healed “violation” by an added chord; j) even more “healed” with three chords added; k) modified introduction; l) nonfunctional version; m) turnaround with D - s^n progressions; n) nothing but ||: D - s^n :||; o) harmonic relations in extreme registers work differently; p) also the dynamics has a gradual influence on harmonic structure.

3.3.4 Reversing the deviation by modifying the context

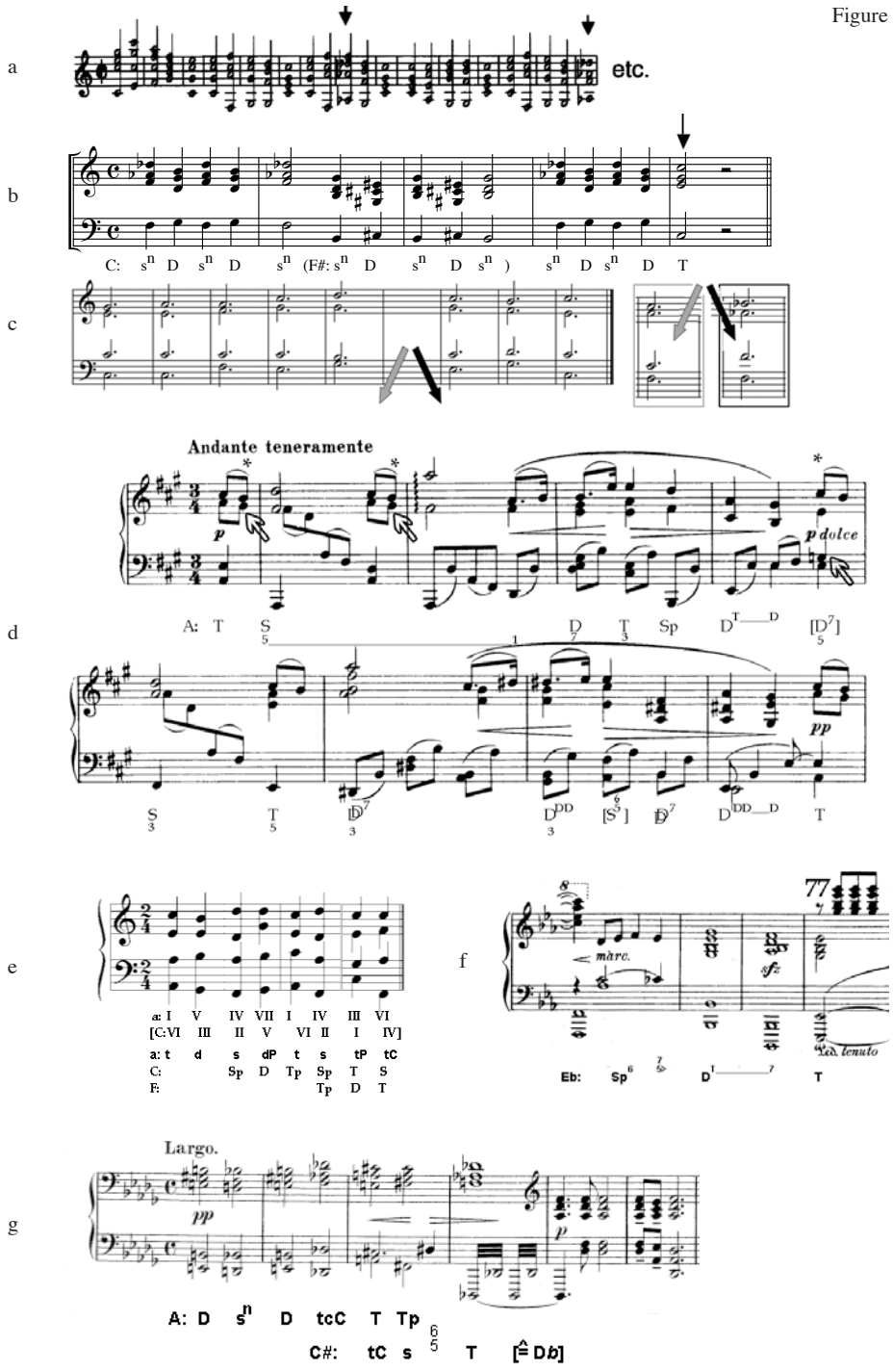
The following modification principles are able to change the categorization from “unexpected” to “expected”: At first, one or more added chords are able to heal the “violation” (Fig. 2i and 2j). This effect may as well occur in language syntax structures, but works also well with music. The second modification introduces the tritone relation of D and s^n already on another degree, here on the tonic (Fig. 2k). The third example builds a colourful harmonic context by non-functional progressions consisting of major seconds (Fig. 2l), so that the tritone progression of roots is embedded in a whole tone scale and thus losing its tonal exceptionality. Additionally, here the voice leading contributes crucially to the effect by an extended use of parallels (themselves being considerable as a reputed syntax violation, while being the only applied voicing principle). The fourth modification principle is using the D - s^n combination as basic harmonic principle: either, for example, as turnaround as shown in Fig. 2m, or as the only occurring progression like in Fig. 2n. The fifth modification is based on the observation that a harmonic relation in extreme registers works differently, so that transposition to another register may change the impression (Fig. 2o). As sixth modification, in an analogous way, also the dynamics and the timbre have a gradual influence on the harmonic structure (Fig. 2p). Additionally, when the pitches are played with increasingly enriched overtone structures, the harmonic interrelation is blurred and flattened, and disappears gradually. All of these constructions would also work with any other progression of chords, even with more familiar ones like D – S, D – Sp or D – DD combinations, which were used in similar neuroscientific studies (cf. Poulin-Charronnat et al., 2006; Koelsch and Jentschke, 2008; Koelsch, 2009; Koelsch, 2011).

3.3.5 Stylistic framing as origin of „violations“

Some uses of the combination D - s^n appear to specific listeners as “inappropriate”, as there exist inappropriate or unconvincing uses of *any* combination of chords to accordingly sensitive listeners (see the example in Figure 1d for an inappropriate, incongruous use of the otherwise truly common progression D - T). But there are also many possible “appropriate” solutions for any combinations of chords. In other words, empirical effects of the studies assuming syntactical rules for single chord progressions can hardly result from the inappropriateness of the used chord progressions *as such*. If, for example, the neapolitan chord appears as a deviation of the listener’s expectation, like in the example of Figure 3a, this fact might have other reasons apart from a syntactical violation: In this case, the listener gets already a lot of information within the first 8 bars about the mainly used models by the composer, and hence what the author wants his listeners to expect – in short, a *style* has already been established. Moreover, in this specific style the voicing appears to be crucial, so that the impression of “roughness” or “plumpness” of a specific progression is more a result of a combination of several compositional means, especially not only the progression of chords. One root of this expectation might be found in the familiarity of the listeners with this specific style, that is typical for academic exercises, rather than for compositions of the literature (cf. Dowling and Harwood, 1986, p. 161: “Invariants across sets of pieces constitute […] a style. Experiences with pieces in a particular style facilitates the listener’s comprehension of the stylistic invariants of a new piece”). In addition to this more general observation, the main reason for a low probability of the appearance of the target chord is the redundant introduction by the first few events: they elicit in the listener a comparably exact expectation of the means employed by the composer, confirming the use of functionality in a special, a rather reduced and narrow manner. This redundancy establishes a probability extrapolation that allows only a weak prognosis of a (yet still possible and not prohibited) progression with a tritone root relation. As described in chapter 2, the function of a chord can be weakened or strengthened by the harmonic preceding and succeeding events. If these contextual events confirm a special function in a highly redundant way, listeners will build their expectations accordingly. In the case the function is confirmed in a weaker way, the expectations should blur with a similar less strength. If a listener was instead introduced for 8 bars in a composition using complementary models, the expectations as well might be reversed. For example, according to the fourth modification of 3.3.4. (Fig. 3b), an appearance of the tonic (unexpected, but “syntactically appropriate”) would act like the former “violating” neapolitan sixth, causing an impression of a deviation of the compositional context. Additionally, some of the “standard” cadences used in studies themselves show in fact violations of baroque composition rules, whereas the corresponding “deviant” cadences do not (Fig. 3c). Poulin-Charronnat et al. (2006) detected a weaker expectation deviation by using the combination “T – S” in comparison to the findings of the here discussed examples of experiments using the combination “D – s^n” (see the functional analysis in the end of chapter 2.4.). They interpreted these findings in the way that the subdominant appeared to be a weaker ‘violation’ as an ultimate than the neapolitan sixth chord. Also in this case, they could have composed stimuli that would have induced a much stronger (or even weaker) expectation deviation if they introduced their listeners to a redundant harmonic

structure where the occurrence of the subdominant, or more precisely, the IVth degree triad, might have been much more improbable (or even more probable). It is not the degree alone that causes weaker expectation deviations, but the kind of harmonic redundancy of the composed context.

Figure 3



a) Stimulus as used in Maess et al., 2001, p. 541; b) example according to (Mod-4): the tonic as violation of the expected neapolitan sixth after dominant; c) Slevc et al., 2009 p. 376, parallel fifths in the outer parts within the “standard” stimulus. d) Intermezzo A Major op. 118 No. 2 by Johannes Brahms: the most prominent chord of the beginning phrase is D major, therefore claiming structurally for the tonic role, but the little and somehow hidden tone g# is indicating D major as the subdominant; only in the third occurrence it turns into g natural which confirms D major as the tonal centre; but then the harmonic progression is already leaving the region of D major towards the direction of the dominant key E major. e) Stimulus taken from Poulin-Charronnat et al. (2006), with correct (a minor) and original (C major) degree analysis, compared with the functional analysis after Riemann and Maler. f) Extract from “Ein Heldenleben” by Richard Strauss at number 77 (piano reduction by Otto Singer). g) Beginning of the second set of the 9th symphony “From the New World” op. 95 by Antonín Dvořák.

3.3.6 Context effects: Summary and re-interpretation of "violations"

Putting these findings together, mainly three arguments stand against an interpretation of a "violation of syntax" when replacing the tonic: (1) According to Franz Liszt, any chord is able to follow any other chord. Therefore, the impression of the appropriateness of a chord progression depends on particular stylistic limitations and the listener's familiarity with them, not on general rules. (2) The degree of expectancy of chords and of chord progressions depends on the (harmonic) context and the stylistic expectations of the listener. (3) The harmonic structure is highly dependent on other musical dimensions like voicing, rhythm, register, timbre, tempo, articulation and dynamics – whereas these dimensions do not comparably affect the syntactical structure of speech. As a consequence, the interpretation of the empirical data showing strong expectations in the listeners should consider the specific context of the observed effects: they might be more a result of the stylistic framing rather than the application of syntactical rules proper.

3.4 Individuality

Only once, we can listen to a piece of music for the first time. The second time our expectations may already differ (Feldmann, 1998; Louven, 1998; Szpunar et al, 2004). Expectations of listeners depend mainly on their general musical knowledge, their familiarity with a specific style and their memory for a particular piece (this was shown for different tonal cadences by Eberlein, 1994). Kuhn and Dienes (2005) were able to provoke liking of a new, yet unknown style through exposure to examples. Peretz et al. (1998) and Szpunar et al. (2004) showed the same effect of mere exposure on both recognition and preferences. On the other hand, Loui and Wessel (2008) report interfering effects on individual dispositions, exposure effects and cognitive competences while listening to unknown musical composition styles or systems. Overall, generally "unexpected" events can become "expected", and vice versa. As listeners, we can get pretty familiar also with contingent musical peculiarities – up to those that we will expect a crackle at a specific position if we are used to listen to the vinyl record of our favorite piece. In these pieces, a violation of an expectation would rather appear if the specific deviations were missing: For accordingly experienced listeners, the aria "Ombra mai fù" from the opera "Serse" (Xerxes) by G.F. Händel contains an expected deception; the Symphony No. 94 "Surprise" G major by J. Haydn features an expected surprise; an expected shift takes places at the end of the "Boléro" by Maurice Ravel (from C major to E major); an entire series of not only expected, but even desired shifts occur in the popular German song "Danke" (as e.g. Christoph Marthaler's use in "Murx"). And finally, even the most unmusical individual, it appears, can correctly sing the purported "deviant" minor third in Freddie Mercury's "We are the champions" in supportive surroundings like soccer stadiums.

These examples show, that a careful analysis and investigation is needed for the question of what an individual listener really expects at a specific moment in a given piece. The term "expectation" includes at least three different situations: expectation based on knowledge or familiarity, expectation because of probability extrapolation of the encountered redundancy, and expectation according to personal preference or aesthetic desire. The first kind of expectation would resemble the answer to the question "what do you think is coming next?" (also called 'veridical' expectation), the second to "what would now be the most style-conform continuation?" ('schematic' expectation), and the third to "how would you continue?" ('artistic' expectation). There might be persons and situations in which a single participant could answer differently to the three questions (cf. Bharucha, 1987; Justus and Bharucha, 2002, Koelsch and Jentschke, 2008), including the situation in which a person expecting a progression in the first or second sense might prefer another continuation. Based on this observation expectancy deviations are also described as a source of artistic allurement (e.g., Meyer, 1956; Eberlein, 1994; Huron, 2006). However, most of the studies using the term "expected" mostly imply the second meaning, the schematic expectation or the extrapolation of the just encountered redundancy within a given style.

An exception can be found in the study of Steinbeis et al., 2005. They detected an arousal in electrodermal activity of participants while listening to harmonically manipulated chorals by J.S. Bach. The categorization was labeled "very unexpected" for the manipulated functional combination D – s^n, "unexpected" for the original combination D – Tp (a deceptive cadence), and "expected" for the also manipulated combination D – T. But sure some of the tested musicians were familiar with the chorals, therefore they should have expected the original progression. Even in case they did not remember the individual examples, they most probably had been familiar with the style of Bach's chorals, knowing

that a deceptive cadence is occurring frequently and therefore highly probable. That means, this labeling of harmonic “expectancy” is not quite aiming at the familiarity with the individual pieces (veridical) nor at the extrapolation on stylistic probability (schematic), and the individual preference was not reported. The assumption that the tonic is more expected by a listener than its parallel, especially in the context of a Bach choral, could at least be tested. For the results of this study the labeling of the stimuli is somehow irrelevant, as the electrodermal activity might also rise in cases when the expected event occurs, causing an arousal because of other effects than expectancy violation. For example, in case of baroque cadences it would be perhaps more adequate to speak of more or less “flattened” or “tensioned” target chords.

Additionally, and apart from pure familiarity, people of course differ not only in their liking of specific musical events, but also in their liking of deviations of their musical expectations in general – for example classical avantgarde musicians with strong aversions regarding octaves and triads. Krumhansl et al. (1987) stated: “What some people find irritating, others find interesting, and vice versa”. After Huron, unexpected surprises can even be experienced more rewarding than expected fulfillments. Additionally, the individual preferences may even differ within the same listener by different times and occasions (Huron, 2006, p. 168). Finally, looking beyond the framework of western tonal music, there exist members of other musical cultures who might experience western functional structure fundamentally differently (dto. pp. 169-172, cf. Krumhansl et al., 2000).

3.5 Contingence

Provided that an event itself is acceptable as musical at all within a given style, it can be used to build a musical model. This belief, that any sound can be musical, is not an invention of the modern avantgarde. Already musicians of the 15th century tried out odd sounds, and at the latest 19th century musicians claimed, that every harmony can be interpreted as functionally related to any harmonic centre (after Riemann's theory of functionality, cf. de la Motte-Haber and Schwab-Felisch, 2005), or that every chord can succeed any chord (as Franz Liszt became famous for, cf. de la Motte, 1976, pp. 237-248; Schönberg, 1922, p. 284: “all chords can be combined with each other”). Later on, John Cage taught the succeeding generations, “in music, everything is possible” (Cage, 1981). Lefkowitz and Taavola (2000) proposed a piece-sensitive analysis to consider any imaginable parameter of possible, at least subjective, parameter in listening to music. This opinion also became influential in popular music: Brian Eno reports a crucial experience with repeated recordings of street noises. He noticed, that he could detect musical structure in any acoustical sequence (Toop, 1997). An impressive demonstration of this core musical competence can be found in Diana Deutsch’s Speech-to-Song-Illusion (Deutsch et al., 2008, Deutsch et al., 2011): A spoken sentence mutates into music by pure repetition. These examples show, that ‘music’ is much more a mode of listening than a set of conditions of the acoustical parameters, thus applicable to any kind of acoustical stimuli. This general musical listening mode could be considered also as the main difference between music structure and language syntax.

3.6 Summary

There might exist shared structures and shared competences in perceiving and processing the undoubtedly overlapping domains of language and music (like shown in Levitin and Menon, 2003, among others). But we hope to have pointed out that several peculiarities of musical structure appear to be hardly comparable with the syntactic functionality of language and are not covered by the assumption of a general “syntax” or “grammar” of tonal music: a) Structural models of music are highly context-sensitive and context-dependent, b) different dimensions of musical structure are gradually interfering (harmony, melody, voicing, articulation, rhythm, timbre, register, tempo and dynamics), c) individual structural principles or rules can be newly invented and established within a short time in a musical piece, d) even powerful and common models leave room for flexibility, interpretation and innovation, e) expectations depend on an individual background, and they arise gradually rather than building strict categories and f) any acoustical event can be perceived in a musical mode, whereas language is bound to the recipient’s competence. Authors of music, in difference to authors of texts, have many possibilities to build individual rules for structure, and to provoke the listener’s global and local expectations beyond common established idioms or styles. And listeners of music, in difference to readers of texts, have many possibilities to constructively re- and “mis”-interpret their actual auditory perception, to integrate perceived structures in different environments and to build their own global and local expectancies.

4. Conclusions

In music it is difficult to conceive of syntax violations because there hardly is a common syntax: “Finally, language and music differ substantially in […] the form and function of their hierarchical structures.” (Jackendoff, 2009). A critical difference between language-like syntax and musical structure seems to be founded in the fact that musical perception works more like a mode of processing of acoustical events. Even language can show this musical quality: While listening to a foreign language, or to infinite repetitions in a known language, we tend to switch to the musical listening mode and recognize the musical structures of the speech rather than its language syntax or semantics. Music in general is foremost not a proprietary characteristic of certain human artifacts, but rather a mode of listening to any acoustical event. This musical mode is highly self-constructive and integrative, and rather not applying a definite system of rules (see Klein, 2010). Whenever a sort of musical “grammar” or “syntax” is assumed in empirical studies, the framing, the preselection of musical examples and the provoked listener’s expectations by the stimuli should be designed and analyzed carefully. We assume that listeners engage different model categories depending on their individual expectation of a musical idiom or style. These expectations can be disappointed or deviated, but this does not necessarily have to work in a sense of “syntactical violation”, but rather as categories of style. Additionally, a generalization from only one musical style, like the functional-tonal harmonic system, to a global musical “grammar” is misleading. Structural expectations of listeners to music are combinations of general familiarity with styles and composition principles, individual preferences and local framing. Those models can be shared by large communities and epochs, and therefore become cultural prototypes, but we suggest they work more as conventions than as a syntax - in an analogous manner as our expectation of the colour “green” after the combination of “red” and “yellow” because of our familiarity with the global convention for traffic lights. Further research about shared principles in music and language structure should discuss alternative explanatory concepts besides “music syntax”, and should clarify the differences of musical and syntactical expectations: “There is the possibility that the structures we identify are subjective appearances rather than objective realities.” (Huron, 2006, p. 371). If music processing worked exactly like language recognition, there would be no real need for additional features. On the contrary, “music and language seem to have a reciprocal relation” (de la Motte-Haber, 2005, p. 73). Music’s structure is flexible and innovative, and not bound to a definite syntax – this is the reason for the power of structural creativity in music.

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