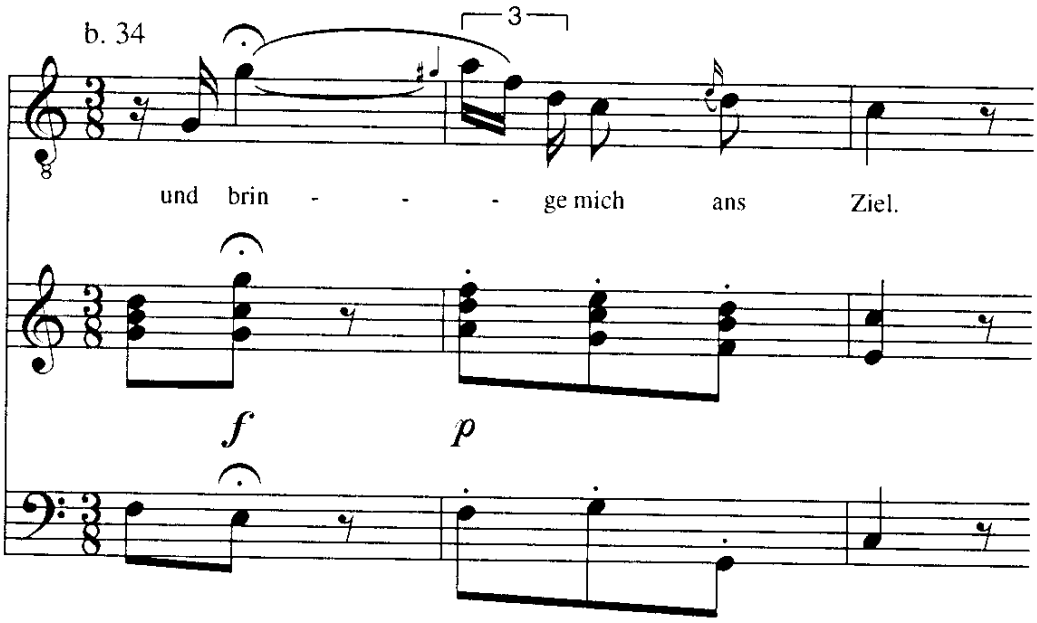
# Relazione tenuta all'Università di Evanston- Illinois, in occasione dell'8. International Conference of Music Perception and Cognition (ICMPC 8), in data 08.08.2004

## *The concept of auralising and trace in a formalized grammar of music*

Let me start with an example. It is a fragment from an aria sung by Belmonte in *Die Entführung aus dem Serail* by Mozart. The lyrics are:
"und bringe mich an Ziel"

Ex.1

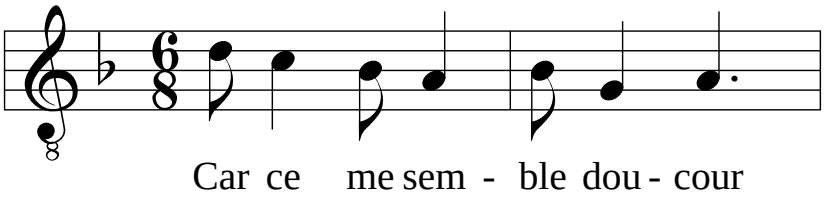



In a recently published book

Baroni M.-Dalmonte R.-Jacoboni C., *A computer aided inquiry on music communication. The rules of Music*, Mellen press, Lewiston New-York 2003

a theory of melody is presented according to which a melody is made up of a limited number of "melodic figures" applied to a fragment of scale, which plays the role of its deep structure. The hypothesis is that each phrase of a melody can be viewed as a stepwise monodirectional fragment, after the "reduction" of the surface figures.
An example of simple melodic figures in a phrase by Machault in a virelais.

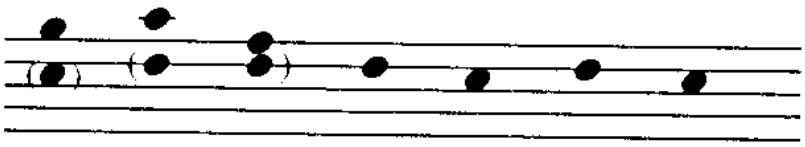
Ex.2




The actual phrase is neither monodirectional, nor stepwise, because of two figures: one *skip-figure* B-G-A (which adds a G to the deep structure), and one *neighbour note figure* A-B-A, which can be reduced to A. The resulting deep structure is: D-C-B-A.
One of these figures (the *chord transformation*) consists of the substitution of one note of the deep structure of the melody with one or more notes of the chord used in the harmony at that point .

According to the theory of melody by Baroni-Dalmonte-Jacoboni, and according to the definition of the *chord transformation figure*, the deep structure of the Mozart fragment in Ex. 1 is (Ex.3):

Ex. 3



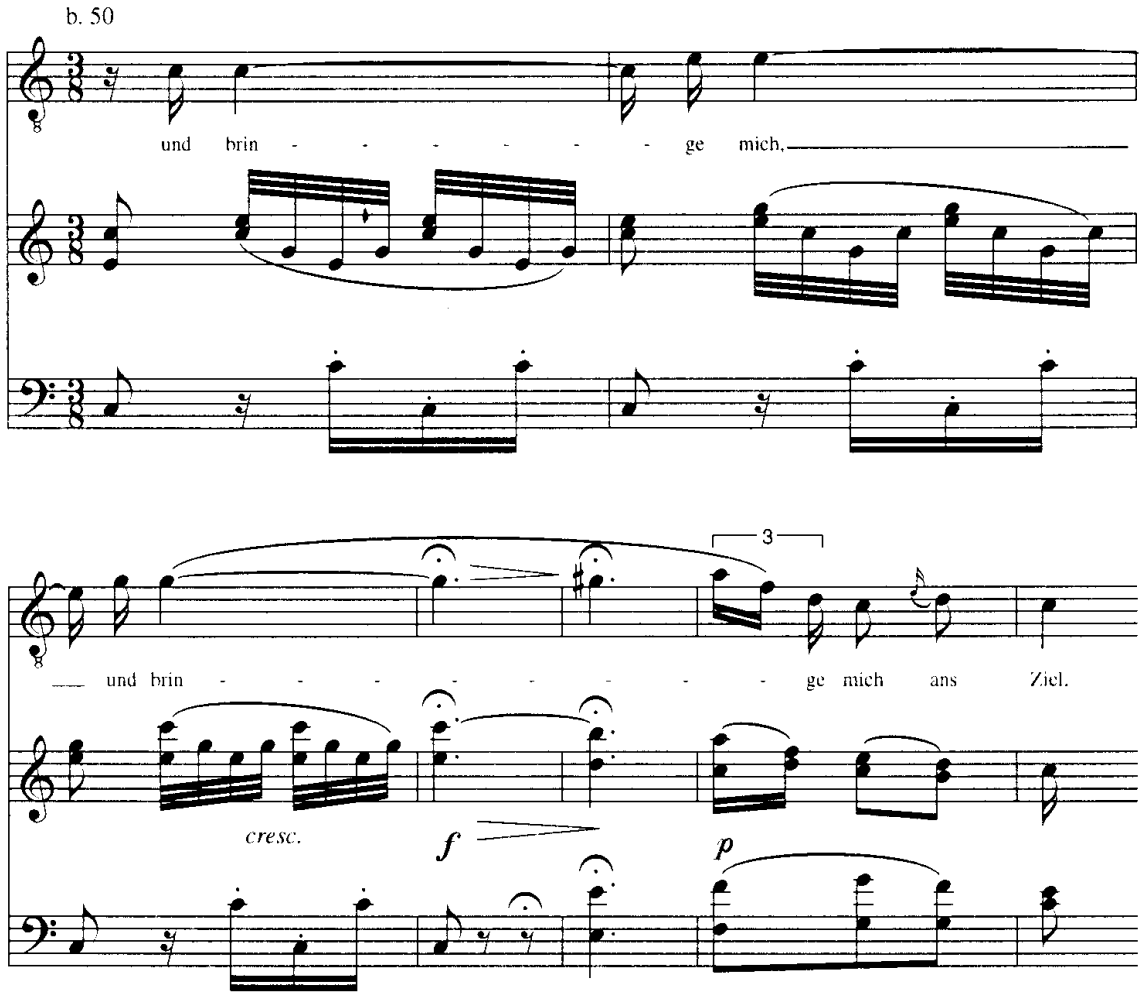
Is this analysis just a theoretical construction, or is there some psychological evidence for such a "reduction"?

Of course I am not asking if people listening to Belmonte's aria actually "hear" a simple sequence around C. One naturally perceives the heroic skip from $G_3$ to $G_4$ and the regular descent to the tonic – that is to the median pitch of the "tessitura" - as the achievement of one's expectations (Hippel-Huron 2000, 66).

Nonetheless our grammar hypothesizes that the pitches of this melody could be replaced by other pitches of the subjacent chords without changing the musical sense of the phrase.

In fact in the "ripresa" of the same aria Mozart starts the ascent to the top $G_4$ from $C_4$, the fundamental note of the chord.

Ex. 4




The *chord transformation figure* is part of a grammar which describes a particular style, it is the description of the behaviour of certain given musical realities, which we observed in the repertory, and whose frequency allowed us to state the existence of underlying "rules". Since our study is in some ways indebted to linguistics, we could say that we tried, in the spirit of Chomsky, to seize from the "performance" the "competence" or, using Saussurian terminology, that we went from the "parole" to the "langue".
In the case of the *chord transformation figure*, in stating a musical character of the repertory, we also implicitly assumed the equivalence, for experienced listeners, of the sounds in a chord, in other words a mental fact. On the basis of characters in the repertory, but also on the basis of this equivalence in the mind of experienced listeners, we could imagine that the deep structure of the Mozart fragment (and of many like passages of that time) was a simple sequence around C. But we did not account for *how* a subject constructs the mental reality which produces that effect in the presence of some given external stimulus. In our book we did not refer to information processing. In Eytan Agmon's terminology, we did a "what-theory", and now I'll offer a "how-theory" (Eytan 1990, 299-301).
In this paper, in fact, I'll try to give a cognitive insight of our conceptualization, and in particular, I'll try to prove the reliability of *the chord transformation figure* and of the reduction based on it.

I would first like to discuss a few earlier studies that have greatly influenced the approach taken in the present study, and following Leonard B. Meyer terminology (Meyer 1989), I'll divide the matter into three categories: laws, rules and strategies.

## *LAWS

"Laws are transcultural constraints (…) they are the principles governing the perception and cognition of musical patterns" (Meyer 1989, 13). Here Meyer takes into account both physical and psychological "universals"; in my case – since the object of observation is very specific – it is better to distinguish between them and to consider as *law*s only physical principles.

Towards the end of the XIX century Carl Stumpf (1890) summarized centuries of observations regarding the affinity of sounds whose components stand in harmonic relationship, that is, whose frequencies are related by simple integer ratios. Even if recent studies have pointed out that the principle of "simple ratio" has been experimentally contradicted, because a variety of both "horizontal" and "vertical" factors have been identified as contributing to auditory streaming, modern psychoacoustics agree on the concept of *Tonverschmelzung*, or "tonal fusion", that is the tendency of the auditory system to interpret certain frequency combinations as comprising partials of a single complex tone (Huron 1991, 135).
Other principles, which help to give a physical proof to *the chord transformation figure*, come from Helmoltz's basic contributions to the theory of music and specially from his often re-written work *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (1863 up to 1877). Recent studies have extended his theory to general topics – such as the relationships between science and art – and to particular ones, such as the nature of consonance (Terhardt 1984, 277). What is most interesting for my subject is Helmoltz's hypothesis of sensory illusion, and how it was expanded from optic to acoustics by some scholars: "Shouten (1938) was the first to show conclusively that a pitch corresponding to the fundamental is heard even when it is absent at the level of the receptors cells" (Warren 1984, 264). Terhardt also asserted and experimentally proved the principle of the "virtual pitch ". The fact that a pitch can be perceived although there does not exist any spectral component at the frequency corresponding to that pitch (Terhardt 1984, 287-288), is a strong cognitive support to the theory of the *chord transformation figure*.
The proved physical realities of "tonal fusion" "virtual pitch" and "tonal illusion" are laws in the perception of chords that justify the possible reduction of a surface melody constructed with the notes of the chord to its fundamental through the figure of *chord transformation.*
Moreover, because "tonal fusion", "virtual pitch" and "tonal illusion" are a result of perceptual processing and are independent of specific musical acculturation we can find examples of *chord transformation* even in non-tonal repertories as Gregorian Chant or atonal music (see Baroni-Dalmonte-Jacoboni, chap. 15 and 19).

## RULES

"Rules are intracultural, not universal" (Meyer 1989, 17). This definition given by Meyer for the second level of stylistic constraints has in the present context a rather different meaning because here I'm dealing with perception not with stylistic rules. Perception rules are

intracultural in so far as they are typical of one culture; in this section I will refer to "experienced listeners" and more precisely to "tonally experienced ones".

A very interesting insight into an aspect of our conceptualization of pitches is given by William Thomson in a recent paper (Thomson 2004). He states that the fundamental notes of a tonal melody are the tonic, the third and the fifth and that these notes form a "pitch frame" essential in our tonal experience. This seems to have a function in perceptual development, that is in our earliest attempts to sing songs, as well as in composition from sixteen hundred to nineteen hundred, in classic as in popular music. "Like a wave whose particles shift as they move toward shore, melodic pattern horizontalize pitches of the shifting chords – or we can turn it around to say that the chords merely verticalize the skips and steps of concurrent melody." (ibid. , 449).
Extending this assumption a little further, we can hypothesize that the perception of a chord in melodic form can be conceptualized as the releasing of the possibilities intrinsic to the fundamental note, i.e. that each note of a chord can "take the place" of any other of the same chord.

The tonal triad plays a similar central role in the concept of "categorical perception" elaborated by Edward M. Burns (Burns 1999), since it forms a general perceptual model that provides an objective basis of interpretation for the other pitches. Starting from experiments by other scholars, he studied categorical perception using the "trace-context theory", originally developed as a model of auditory intensity perception. "Trace memory is the short-term iconic memory of the stimulus and fades rapidly with the time" (Burns 1999, 227). Even though "short", this type of memory allows us to remember forgoing notes and to rapidly process the relationships between them and what is actually sounding. This must be even more true when the notes are tonally related, as is the case in the *chord transformation figure*.

Steve Larson discusses many music-theoretic issues in his article on the problem of prolongation (Larson 1997). He thoroughly analyses the concept of "inherent and contextual stability" as a central point in the debate around the problem of prolongation and structural hearing. He goes on to state that "stability" depends on three more terms: "auralize", "trace" and "displace", terms that are crucial also for the cognitive theory of melodic figures.

> "To auralize means to hear internally sounds that are not physically present. A trace is the internal representation of a note that is still melodically active (…) A trace can be displaced by subsequent notes. (…) This idea of displacement relies on an important distinction between steps and leaps. (…) In a melodic step the second note tends to displace the trace of the first leaving one trace in the musical memory; in a melodic leap, the second note tends to support the trace of the first, leaving two traces in musical memory. Regardless of whether hearing this distinction between steps and leaps is learned, innate, or some combination of the two, it is clearly an important part of how experienced listeners give meaning to tonal music". (Larson 1997, 104-105)

The *chord transformation figure* plays its role in a melody moving by leaps, that is in a way very much apart from the stepwise deep structure of the phrase. Nevertheless we perceive this leaping melody as formally correct, musically meaningful, and even elegant. Because leaps leave traces, it is possible that the fragment in Ex. 1 leaves something like Ex. 3 sounding in our memory. It is thanks to this "transformation" that notes on the superficial level turn into

notes on a deep level, so that the “reduction” is not only a theoretic exercise, but corresponds to a way of processing melodies. Plenty of experiments tell us that tonally acculturated listeners can recognize the tonic and the other principal notes of the tonality even in unfamiliar tonal compositions without effort. The quickness and the apparent ease with which the principal tones of the key are recognized suggests that this act of perception must be based on a relatively simple mental process, possibly like “auralizing” and memorializing “traces” of already heard sounds.

STRATEGIES

The first section of this article (LAWS) emphasised the physical nature of the affinity between notes tied together by “simple ratio” and thus justifying the presence of the *chord transformation figure* also in non-tonal repertories; the second section (RULES) described the behaviour of acculturated listeners processing tonal music from sixteen hundred to nineteen hundred, in classic as well as in the popular area. Here I’ll use the term “strategies” in a way rather different from that used by Meyer; by STRATEGIES I intend to underline a particular character of a particular repertory: the operatic arias of the XVIII century. In the above quoted book by Baroni-Dalmonte-Jacoboni the 17$^{th}$. chapter is devoted to the analysis of some arias taken from the most famous operas by Handel and Mozart. The aim of the study was to check the role of the various types of melodic figures in the construction of the phrase, and the result was that never in the history of western music had the *chord transformation figure* such a profound influence in shaping melodies. Even if this figure is the most diverse from the stepwise motion of the deep structure, everybody can recall incipits of famous pieces of the XVIII century not only in operatic arias but also in symphonic and piano repertoires. Now the question is: how did a melody moving through large skips and leaps encounter the expectations of the listeners and fulfil them if the template melody was a scale-step motion.

*Studies by Diana Deutsch on the representation of pitch sequences help to solve many problems, and give insights also into this one, especially when dealing with the concept of “melodic archetypes” (Deutsch 1999b, 355). According to the results of these studies also non-musically trained subjects are able to recognize as similar two different melodies based on the same archetype, such as the ”gap-fill” model or the “changing-note” model. They are very general models, possibly valid for every time and style. But it seems not incorrect to imagine the existence of “melodic archetypes” tied to a particular style, such as, for instance, the leaping melody on the notes of the chord in the classic era.

Another less recent but very useful concept is that of “alphabets”, that is the existence of schemata or formulas typical of a given musical style. “Through extensive exposure to such music, the listener acquires a repertoire of hierarchically embedded alphabets, most prominently the chromatic scale, diatonic scales and triads (Deutsch-Feroe 1981, 506).

There is no doubt that the classical music of the XVIII century presented the listeners with a model of leaping melody, which they became able to process and to “reduce” to the deep scalar structure, in order to give it musical meaning. Listeners of the previous decades, even if experienced in the rules of tonal system, would have had difficulties to “understand” these melodies, and would have possibly judged them a-musical or wrong, because the physical properties of the triad, and the cultural exposure to the rules of the tonal system would have been insufficient for processing a particular, non yet historically mature style. Only towards the mid XVIII century the perfect equivalence of the notes of a chord as a mental fact and the leaping melody on the notes of the triad became realities, never mind which one came first.

Through the three passages – laws, rules and strategies - I hope to have offered a cognitive basis to the grammatical conceptualization of the *chord transformation figure*

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