Multiphonics as a Compositional Element in Writing for Amplified Guitar (1)

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On the guitar, the technique of multiphonics consists of lightly touching the string at certain locations during or after its excitation (or both). It gives rise to (almost) harmonic complex tones whose spectrum facilitates the perception of multiple pitches. Scarcely researched up to now, few composers have used multiphonics in pieces for classical guitar, and those who have done so have not explored the amplification of the sounds. In order to supply composers with relevant information on classical guitar multiphonics, this technique is currently being researched by the authors. This paper addresses this topic, which has been long absent in scientific literature, for the purpose of presenting a formalized approach intended to give rise to reproducible sounds. These sounds are also believed to introduce novelty when amplified, making the technique particularly suitable in pieces for/with amplified guitar.

In his method from 1843, Aguado (n.d.: 54) categorizes as "obscure"[1] three sounds produced by the technique of harmonics (an excerpt of Aguado's table is depicted in figure 5).[2] These sounds belong to Devoto's recently denominated category of "distant harmonics" (Devoto 2011: 54). For the latter author, these are harmonics' sounds, the fundamental of which is equal to or above the eighth partial of the open-string. Aguado's categorization is probably due to either the damping of the higher partials by the greater finger pressure needed to play these sounds, or the blurred tone that is perceived when a lighter pressure is applied. In his Method from 1830, Sor had already stressed "that in so far as the sounds to be produced required a position closer to the nut, the act of plucking should be more forceful, and the pressure of the left-hand finger stronger" (Micheli 2003: 57). A higher pressure is necessary because the node at which the touching takes place, which is shared by the vibrational modes (v.ms., sg. v.m.) that give rise to the harmonics' sound, is closely surrounded by nodes of other v.ms. Touching with a lighter pressure, a sound would result, in which partials given rise to by these other v.ms. would have intensities similar to some of those given rise to by the v.ms. sharing the node at which the touching takes place. This is usually called *multiphonics*.

Although popular for some time in wind instruments, in stringed instruments the technique of multiphonics has remained in the shadows as a tool for composers and performers. Regarding the classical guitar, on which this research focuses, few composers have requested multiphonics in their pieces. This is perhaps due to an unawareness of the technique's executability on this instrument or too little enthusiasm for it. This situation could be explained by, on the one hand, a lack of relevant information,[3] and on the other, the fact that the sound fades away, is not controllable after the attack, and has a weak projection—a scenario not present in wind and bowed-string instruments. Also, composers are not always aware that amplifying multiphonics' sounds reveals their richness to the audience.

The aim of our research is to supply composers with relevant information on classical guitar multiphonics and thus contribute to establishing the technique as common vocabulary in writing for guitar, especially for amplified guitar. The research questions posed and the hypotheses formulated are here presented. They are preceded by an explanation of the phenomenon and the contextualization of the research.

Multiphonics on the guitar

On the guitar, the technique of multiphonics, like that of harmonics, consists of lightly touching the string at certain locations during or after its excitation (or both). Contrary to stopping the string, touching it contributes to its energy loss, since the vibration passes the touching surface (Fallowfield 2010: 110).

Guettler and Thelin (2012: 1) define multiphonics in string instruments as "a filtering technique, where the potential energy of certain partials [*sic* overtones] of an (in most cases) open-string fundamental is restrained by a left-hand finger pad lightly touching the string." This definition suits bowed-string multiphonics since the fundamental is always present in the sounds (Guettler / Thelin 2012: 1). With the guitar though, the fundamental is in many cases suppressible albeit sometimes nonetheless perceptible, since the perception of a missing fundamental can be evoked with only two adjacent partials (Smoorenburg as cited in Schneider / Wengenroth 2009: 317).

To understand the phenomenon, a comparison with harmonics is helpful. This technique damps out all v.ms. without a node at the touch location (Taylor 1978: 30). For example, the middle of the string is the location of a node for all even-numbered v.ms., and of an antinode (a point of maximum displacement) for odd-numbered v.ms. The latter are therefore damped out when touching occurs at this location. Figure 1 helps understand this example.

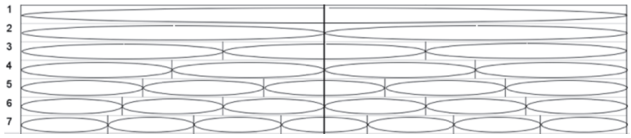

Figure 1. Juxtaposition of the representation of the first seven vibrational modes of a string (differences in their excitation strengths are not accounted for). The vertical line represents touching at the middle of the string.

With multiphonics though, not all v.ms. without nodes at the touch location (at which nodes may be absent) are damped out.[4] For example, at fret X of the guitar there are two nodes:[5] one of v.m. 16 and, possibly, v.m. 32,[6] and the other of v.m. 25. As Figure 2 shows, modes 7 and 9 (and their multiples) have close surrounding nodes. These two lower modes will not be damped out because, as Schneider (Schneider 1985: 136) stresses "the stronger lower harmonics will sound even if the node-producing finger is not touching exactly the right point on the string." In other words, the lower v.ms. have: longer loop lengths, thus their vibration is less affected when the touch location distances itself from the node (because the relative displacement of the loop is smaller); and higher excitation strengths[7]—although this factor causes a greater amount of damping in lower v.ms. (more energy is transferred to the touching surface), which, added to the amount of damping caused by touching the loop at a certain point of its displacement, may give rise to a greater overall amount of damping, this is deducted from a higher excitation strength and the partial might still be perceived.

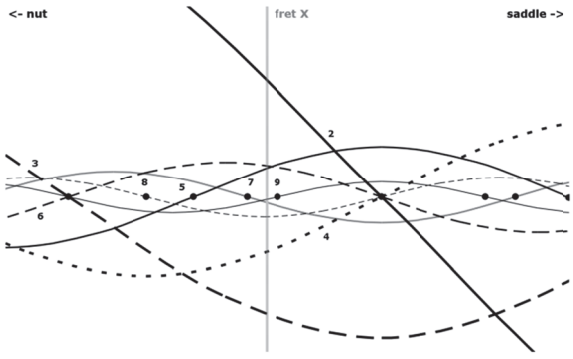

Figure 2. Close-up of the representation of the superimposition of a plucked-string's vibrational modes 2-9 between 30% and 60% of the string's length.

The damping of a v.m. depends then on its excitation strength, and on the relative displacement of its loop at the touch location.[8] The greater both of these factors are, the stronger the damping, since more energy is transferred to the touching surface.

How can one differentiate objectively between multiphonics and harmonics? Whereas with the latter the filtering is systematic in respect to mode number—every nth vibrational mode is not damped out—with multiphonics, it is not. Attempting a definition, the technique of string multiphonics is then a technique, which, by lightly touching the excited string, in respect to mode number unsystematically damps out some of its v.ms.

Considering that both techniques filter the open-string sound, the sounds they give rise to—"ultimately the open-string sound disguised" (Devoto 2011: 69)—are also (almost) harmonic complex tones.[9] According to Benade:

> Our nervous system processes complex sounds coming to it by seeking out whatever subsets of almost harmonically related components it can find. Each of these subsets then has a "best fitting" collection of true harmonics selected for it in the processor, and pitch is assigned on the basis of the repetition rate of these fitted components. … The better the heard components agree among themselves regarding the degree of harmonicity in their relationships, the quicker and more certain we are in our pitch decisions regarding them. (Benade 1990: 68)

The unsystematic filtering in multiphonics thus facilitates our nervous system in the grouping of the open-string overtones into subsets of fundamentals and their overtones. These subsets are then assigned to different pitches, albeit being all almost harmonically related to the (sometimes absent) open-string fundamental. Due to the individuality of sound perception (Schneider / Wengenroth 2009), multiphonics' sounds are perhaps recognized by spectral listeners as multiple-pitched, whereas holistic listeners might consider one of the fundamentals as the pitch of the sound.

Increasing the touch pressure increases the damping of the v.ms. since, as before, more energy is transferred to the touching surface.[10] This is more significant for the lower v.ms. due to their higher excitation strengths; and, as experienced by the authors, significant for classical guitar multiphonics. Depending on the touch pressure, the lower v.ms. 2 and 5 of the example given above (the lowest v.ms. of the next closest nodes after those of v.ms. 7 and 9) might not be damped out. At other locations, a higher pressure makes it possible to damp out all

surrounding v.ms. because their nodes are sufficiently distant from the touch location. On a guitar string there are then three kinds of touch locations:

A. Those at which only the technique of harmonics is executable, since the v.ms. with nodes surrounding the location are always damped out.

B. Those at which either the technique of harmonics or that of multiphonics is executable, depending on the touch pressure, because it is possible to damp out, with a higher pressure, the v.ms. with nodes surrounding the location.

C. Those at which only the technique of multiphonics is executable, due to the impossibility of damping out certain v.ms. with nodes surrounding the location.

With the guitar, multiphonics' sounds have a bell-like character. This is due to the inharmonicity of the higher partials, a phenomenon common to all instruments that "ring (and decay away) in response to an impulsive stimulus" (Benade 1990: 62), for which the string's stiffness is responsible (Benade 1990: 134).

Context

The term *multiphonic,* "customarily used to describe chordal sounds played on a woodwind or brass instrument" (Campbell 2001), was probably coined, albeit as an adjective, by Smith Brindle when translating the book *New Sounds for Woodwind* (Bartolozzi 1967[11]). This book's section on multiphonics is the first systematic treatise on this technique according to O'Loughlin (O'Loughlin 1968). Having been criticised for calling woodwind multiphonics *Bartolozzi chords* (Singer 1978), consequently implying they were discovered by Bartolozzi, he gives the following explanation for the term:

> The term "multiphonic" is useful, perhaps, but it has a ghastly pedigree. It combines Greek and Latin roots in a careless and probably ignorant way (cf. the word "television"). "Polyphonic" is clearly the correct word, but it has another meaning too well established to avoid ambiguity. I, too, believe that Reginald Smith Brindle invented the word "multiphonic", but at least he always used it adjectivally. What has gained wide currency in the USA, e.g. in Thomas Howell's The Avant-Garde Flute, is the use of the word "multiphonic" as a noun. A few Greek-derived words ending '-ic' are used as nouns (e.g. harmonic), but normally words ending '-ic' are adjectives. Some collective nouns ending 'ics' (acoustics, aesthetics, dynamics) are also in common use. There seems no compelling reason, however, to accept the hybrid "multiphonic" as a noun, even if it is just acceptable as an adjective. … So for the future, I will adopt Robert Dick's accurate and linguistically consistent phrase "multiple sonorities" (see Dick's The Other Flute, Oxford). (O'Loughlin 1978)

Two years before this letter exchange the explanation for the acoustics of woodwind multiphonics had been presented by Benade (Benade 1990: 559-567). He had been instigated by a letter of the early 1960's from a 'music-loving engineer' questioning him about 'certain multiple sounding tones' produced by the jazz saxophonist John Coltrane (Benade 1990: 559), since the latter refused to divulge the methods he used. Benade explains the term multiphonic based on our auditory perception:

> When we hear the conglomerate of partials making up a multiphonic sound, our hearing mechanism tends to pick from the collection sets of harmonically related or almost harmonically related components. Each of these sets is then heard as a tone of a more or less normal sort, having a pitch that is related in the normal way to the fundamental frequency of the set.
>
> … Our auditory habit of lumping a harmonically related set of partials into something that is perceived as a single tone explains why musicians give the name *multiphonic* to the sound we have been discussing. Each multiphonic, because it has sounds in it that are not harmonically related to each other, is perceived as being made up of a number of tones. (Benade 1990: 567)

O'Loughlin, reviewing the second edition of the book, welcomes Brindle's new designation for such sounds: "Professor Brindle's new phrase 'sound amalgams' is an excellent replacement for 'chords'" (O'Loughlin 1983).

To the guitar sounds being treated here, the denomination of *multiphonic* was possibly first applied by Schneider (Schneider 1985: 135-138).[12] He, after briefly explaining the phenomenon and suggesting a notation, presents a chart of "the multiphonics on the three [lowest-pitched] wound bass-strings", on which "the effect works much better" (Schneider 1985: 136). In this chart, he depicts the touch location, the sound's pitch content, and the loudness balance of the pitches. According to Schneider, on each string there are 14 locations at which multiphonics can be executed (giving rise to nine different sounds, since some are the symmetrical counterpart of five others). He finishes the section encouraging composers to use multiphonics: "these new sounds should become a part of the guitar's vocabulary as composers

find good musical uses for them" (Schneider 1985: 138). To our knowledge, the present paper is the first to tackle the subject of classical guitar multiphonics since Schneider.

Regarding artistic literature, to our knowledge, fewer than 20 pieces have been written for/with guitar asking (explicitly or implicitly) for multiphonics. Some composers let the guitarist choose the touch location freely (Bland as cited in Schneider 1985: 136;[13] Oehring 2000; Rădulescu 1985; Rak 1985). They are thus presumably not interested in the content of the sounds. This is also the case of Rojko (1984) who is interested in the multiphonic's sounds as transitions between harmonics' sounds:

> What is nice is how a tone (overtone) progressively turns into another one—sometimes through a whole palette of (multi)sounds [*Mehrklänge* is the word for multiphonics in German]. ... Multiphonics are ... the main theme of the piece—the TURNING thus of one overtone INTO another one.[14]

Other composers ask for the touching to take place at specific locations (Blondeau 1999, 2000, 2005; Pisati 1990; Sor ca. 1832),[15] some writing in parentheses the pitches that should result from this; or for specific sounds, notated in a second staff. The latter is the case of Pfeiffer,[16] and Nassif,[17] an excerpt of whose score is found in Figure 3.

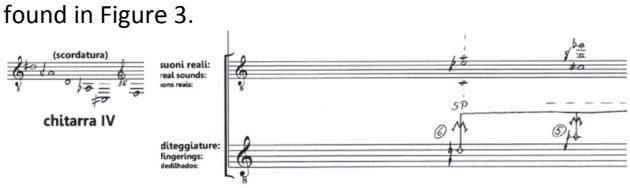

Figure 3. Excerpt from bar 1 of Nassif's guitar quartet *silhuetas de uma dança imaginária*.[18] Requested are specific multiphonics' sounds: "the musicians should practice enough to produce in a balanced way the sound amalgam notated."[19] (Published with permission by the author)

The content of the sounds is then of interest to this second group of composers. Their interest resides either in the sounds' 1. color, or 2. harmonic features. The first case was presumably that of Blondeau: "you tune the instrument then start an attempt at exhausting the guitar's harmonics. ... Bit by bit you approach the chord of a bell" (Blondeau 2009: 12). The sound of a bell was also Torres' intention[20] and certainly Sor's. In the third movement of his *Fantasie Villageoise* (Sor ca. 1832: 8-9), entitled *Prière* (Prayer), Sor requests harmonics at fret VI and alternates the sounds with a melody set alone or harmonized in chorale fashion. An excerpt from the score can be found in Figure 4. Fret VI is though a multiphonics location. But, as Gimeno (2011: A77-A78) notes, since Sor (and also Aguado) notates the touch locations not situated at frets with dashes above or below the number of the closest fret, as depicted in Figure 5, there is no doubt that the, at the time, unusual technique was his intention. Sor's piece is then probably the first, in which multiphonics on the guitar are asked for.

The interest in the sounds for their harmonic features was the case of Pfeifer: "the multiphonics are part of the harmony and often even point of departure for the harmonic development."[21] And, along with color, also that of Nassif: "the multiphonics were searched for their harmony but also for their color."[22]

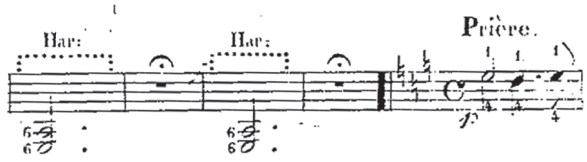

Figure 4. Excerpt of Sor's *Fantasie Villageoise:* transition from second to third movement (Sor ca. 1832: 8). The non-depicted clef is the treble clef.

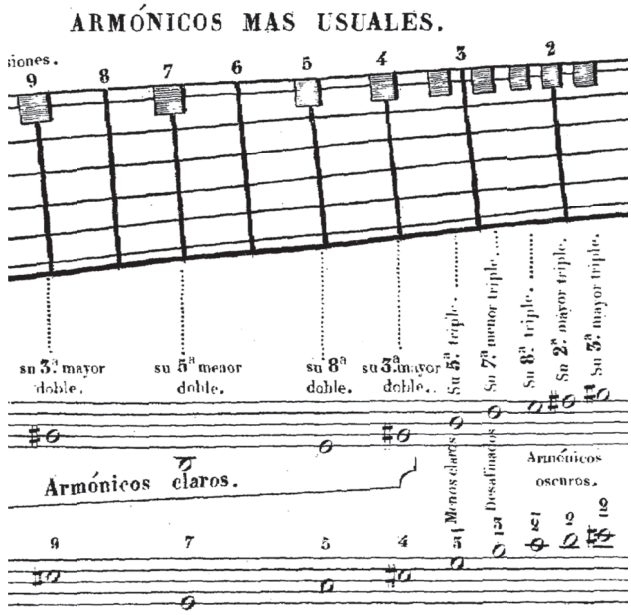

Figure 5. Excerpt of Aguado's harmonics-table showing above the notes of the lower staff his (and Sor's) notation for the locations not situated at frets (Aguado n.d.: 54). The non-depicted clef is the treble clef. The upper staff is for string 6 and the lower for string 5 (the pitches are notated in their sounding octave). The pitches on the far right are the last ones to be schematized.

There are situations, in which harmonics' sounds are asked for but multiphonics might end up being played because the composer is not aware that the location for the required sound is of the kind B or C described above. This is, however, not the case for Pisaro who advises the player: "It should be noted that, especially with the case

of higher harmonics, more than one tone is likely to sound, due to the fact that these harmonics are rarely to be isolated. These other tones have not been notated" (Pisaro 1996: 1). Due to the low level of some of the resulting sound's components, both situations are enhanced by amplification and are thus easily identifiable in recordings.

Low-level sounds are not to be confused with sounds played with low intensity. If a composer asks for the latter, which would be possible to play much louder, it is probably due to the specific timbre of that sound when played with low intensity. Both these sounds and those with low level are though barely heard in the audience. Moreover, if the concert hall is large, even normal-level guitar sounds are difficult to hear—as guitarist Miloš Karadaglić stresses referring to Andrés Segovia: "Just imagine what kind of stage animal you needed to be with a classical guitar to hold the attention of the whole Royal Festival Hall with no amplification" (as quoted in Cullingford 2012: 24). Nassif is aware of such problems:

> Unless the work is played on a small hall or in one where the guitar is favored, a subtle amplification may be necessary as the timbres are in general very subtle and have limitations concerning dynamics; in this case, four loudspeakers should be placed discretely beside their respective musicians.[23]

Nassif admits though that amplification is not of his "preference".[24] "One can lightly amplify it, we did it a couple of times"[25] recalls Rojko after having experienced in the premiere how, with normal amplification, "the piece [(Rojko 1984)] becomes a colossus, a monster."[26] And Christopher Sainsbury, in his 2001 concerto for guitar and orchestra, having tried to avoid amplification, had to resort to it in the end: "I wrote it so that the bitones[27] could be played with orchestra without amplification. That works in a smallish auditorium because of my orchestration ... , and it worked for all rehearsals, however in concert we used a little amplification after all."[28] Pfeifer, not satisfied with the resulting amplified sound of his guitar piece,[29] has "until now always opted for the non-amplified (=ppp) version."[30] For him, "the gestures of the player are as important as the sound itself"[31] which, in this case (in the absence of amplification), "does not leave the stage area"[32] acknowledges the composer.

When sounds are played with low intensity or have low level, in the absence of amplification, the gesture of the musician is what remains to the audience. This was experienced by Karlheinz Stockhausen, who stresses the need of amplification in such a situation:

> In Zyklus [1959], some percussionists now and then produce very delicate sounds—with their fingernails on cymbals, or with fingertips on drumheads. The audience sees gestures, but hears nothing. Hence it is exactly in such places that amplification is urgently needed, by which you approach the same thing that the percussionist hears.
>
> The thing is not only to archive music, and to create new artworks from known sound-sources through a new recording technique, but also to so amplify and spatially project music that one is physically enveloped in it like the interpreter, and the space of the auditorium is pervaded by acoustical events to such an extent that on all sides it takes on an omnidirectional character. (Stockhausen 1996: 87)

For composer Rebecca Saunders, executing the gesture without actually producing the sound can be a compositional element, moreover an important one since it emphasizes the gesture (that would produce the sound) showing its significance.[33] When sound is produced, its straightforward amplification may "add an element of acousmatic dislocation" (Emmerson 2007: 127). When the sound is not familiar and is further spatialized, it may give "the image of a performer conjuring up a soundscape 'maybe yet maybe not' related to the instrumental gesture *as seen*[, which] can be powerful in its ambiguity" (Emmerson 2007: 127). It is this kind of ambiguity that Pfeifer searches for in the gestures of the musicians—"a wide gesture of the hand and hardly no change in the resulting sounds"[34] and vice-versa—and that in his guitar piece[35] is lost without amplification, due to the low level of the multiphonics' sounds.

The amplification of low-level sounds[36] goes back to 1960 with John Cage's *Cartridge Music*. In the latter, small objects are to be inserted in phonograph pick-ups, and contact microphones are applied to chairs, tables, etc. (Emmerson 2007: 127-128). A similar approach is to be found in Hugh Davies' *Shozygs*, invented musical instruments which he had been building since 1968, consisting of various found objects amplified by piezo-electric pick-ups and possibly inspired by Cage's piece and by Stockhausen's *Mikrophonie I* (1964), the first performance of which he participated in.[37] Cage's wish to amplify *small sounds* dates already from 1937 though: "Centers of experimental music must be established. In these centers the new materials, oscillators, turntables, generators, means for amplifying small sounds, film phonographs, etc., [will] be available for use" (Cage 2004: 27-28).

Pianist and composer David Tudor, in *Rainforest IV* (1973), has also used contact microphones on objects to pick-up their vibrating surfaces, which were activated by

sounds played through transducers fastened to them, serving thus as "sculptural speakers" (as quoted in Collins 2007: 46). And in David Behrman's *Wave Train* (1966), loose guitar pickups (connected to guitar amps) on the strings of a grand piano give rise to "a loud mix of guitar-like feedback, amplified piano and percussive rattling" (Collins 2007: 42).

Mikrophonie I presents a particular case as the microphone is used as an instrument, changing the color of the captured sounds by picking them up from different directions and at different distances (Stockhausen 1989: 76-87), acting thus, in Emmerson's (2007: 129) words "as both a smooth envelope shaper and filter at the same time." "Just as a doctor uses a stethoscope to listen to a body, so the microphone was to make audible the 'inaudible' vibrations of the tamtam" (Kurtz 1992: 135). This same zooming-in practice is also present in Hildegard Westerkamp's work:

> I like to use the microphone the way photographers often use the camera, searching for images, using the zoom to discover what the human eye alone cannot see. I like to position the microphone very close to the tiny, quiet complex sounds of nature, then amplify and highlight them. (as quoted in Emmerson 2007: 10)

Whereas in *Mikrophonie I* Stockhausen requests the players to move the microphone, in *Der Jahreslauf* (1977), the first act of *Dienstag* from *Licht*, "the players move in various ways in front of the microphones, producing a definite effect on the dynamics ... When a saxophonist plays while moving around the microphone, fine alterations of amplitude and timbre are produced" (Stockhausen 1996: 100). Also, in his performances, Cage used his head (mouth) movement around/along "a group or line of microphones, each routed to a loudspeaker in a different location" (Emmerson 2007: 130). In Luigi Nono's *Das atmende Klarsein* (1981), the distance between the bass flute and the microphone also varies since the player is asked to play wind sounds very near the microphone. One or two extra microphones are then used along the flute in order to stabilize its normal sound (Haller 1995: 120-121).

Research Questions

Schneider's locations for the execution of multiphonics (Schneider 1985: 136) are just a few of the many possibilities. Achieving a high degree of reproducibility of the sounds was the criterion chosen for establishing other locations, as was the introduction of novelty by the amplification of the sounds, which established the criterion for the suitability of the technique as a compositional element in writing for amplified guitar.

Reproducibility of multiphonics' sounds

Some of the reviews of the existing compositions show that it is not always easy to come up with an orientation reference for the visual situation of the touch location when this does not take place at a fret. This is the case when the composer asks either for specific sounds, or for the touching to take place at specific locations, indicating in parentheses the pitches of the sound that should result. In these situations, especially when the higher pitches of the sound are also notated, there is a high precision as where to touch the string. When the pitches are not specified, or at least not the higher ones, there is a greater degree of freedom in interpreting the touch location. As Pfeifer remarks "one senses [during the performance] the millimeter work it means for the guitarist";[38] and Nassif stresses "in the beginning it was not clear for the musicians the exact point of the string where the multiphonics should be found."[39] The guitarist is thus compelled to memorize the location by instinct but, *microtonally*—a situation, to which players of fretless instruments are more used. Such a situation may lead to reproducibility problems.[40] How is reproducibility of multiphonics' sounds best achieved?

When not at a fret, the degree of uncertainty in situating a touch location is the greatest when this takes place between the last fret and the saddle; and the least when it takes place at the middle of the space between consecutive frets. This has led us to formulate the following hypothesis, which discards the string portion between the last fret and the saddle:

Hypothesis 1: when executing multiphonics at a location not situated at a fret, for the same touching and excitation conditions, a high degree of reproducibility of the sounds is achieved when the location is situated between consecutive frets and there is easy orientation reference to both of these, since this diminishes the uncertainty in visually situating the location.

Such an approach would deprive the composer of the freedom to choose the exact sound he would like to hear. However, it would assure him that what he notates for the execution produces the expected result (provided the conditions for it are met), thereby avoiding frustration and optimizing rehearsal time. The guitarist would avoid the stress of microtonally memorizing the touch location and the possible frustration of not having achieved the required sound.

Multiphonics as a compositional element in writing for amplified guitar

None of the pieces of the reviewed literature have been scored for amplified guitar except for a piece for ensemble and electronics (the latter consisting of pre-recorded sounds), which requests two multiphonics' sounds, each to be played once (Blondeau 2005). Thereby it can be assumed that amplification of multiphonics' sounds has not been explored.[41] Does the technique of multiphonics lend itself as a compositional element in writing for amplified guitar?

Amplification gives rise to sounds with a different identity: "a physicist told me one day: 'Timbre does not exist without its diffusion in space' ... thus, the manner in which a sound behaves in space [determined initially by the instrument's radiation characteristics] produces its identity, its color" recalls composer Marc-André Dalbavie.[42] When a sound is amplified, what reaches our ears is the projection, by a "piece of cardboard moving forwards and backwards in only one direction",[43] of a continuous *snapshot* of the sound at a certain distance from where it is radiated. One hears then another instrument, the presence and energy of the original sound are lost, stresses composer Beat Furrer.[44] Turetzky (1974: xi) also mentions the "individuality of the instrument" being "changed by technology" and thus the amplified double bass becoming a "*different* instrument". He gives the examples of some transducers having the tendency to make all registers sound even, the amplifier eventually changing the timbre and color, and the loudspeakers making "the $100 instrument sound just like the $1000 instrument" (1974: xi).

For a different instrument, a different playing technique is needed. The French ensemble *Le Balcon* amplifies every piece it plays even if amplification was not intended.[45] According to its conductor Maxime Pascal, this is done to practice the amplified playing technique which is "quite difficult and needs savoir-faire",[46] and is needed in pieces of mixed music. The latter he sees as a "tool", which "has not yet been subdued by composers nor interpreters … because we are still in the very beginning" compared for example with the orchestra's, or string quartet's, "tradition of composing and interpretation."[47]

In addition, a different compositional approach is to be pursued. Inglefield and Neill (1985: 63) stress the fact that most of the pieces that require the harp to be amplified "do not really take advantage of sounds that can be produced with amplification." When writing for the amplified instrument, it is important to introduce novelty regarding the type and content of the sounds, in order to have enough distance from the non-amplified instrument. For composer Pierluigi Billone, a sound in a context (for example, religious) has a meaning and a sacrality, and it would make no sense to use it as compositional material in another context.[48] If this took place, hearing the dislocated sound would give rise to its connotation with the original context. Given this, if the amplified sound did not introduce novelty, the listener would hear it as being related to the non-amplified sound, and perhaps be disappointed.

"Extended performance techniques (especially) may produce sounds of perceptually uncertain origin" (Emmerson 2007: 129). They are then a useful reservoir of sound sources when writing for the amplified instrument. Stockhausen's *Mikrophonie I* is perhaps still the best example in this regard, and also regarding the role of amplification as a compositional element—another important aspect along with spatialization when writing for an amplified instrument.

Multiphonics' sounds, or some of their components have a low dynamic-level. This is "usually synonymous with high frequency presence" (Emmerson 2007: 127)[49] and "demands close microphone proximity" (Emmerson 2007: 127), otherwise the higher frequencies do not reach the audience. Amplifying multiphonics' sounds should then introduce novelty relative to the non-amplified instrument by making the low-level components audible to the audience.

To each part of the guitar body, a frequency range can be attributed, for which that part is mainly responsible. The enclosed air (through the sound hole) is responsible for the low frequencies and radiates the most intensively; the back plate and the ribs are responsible for the middle range of frequencies; and the neck, with the least intense radiation, and the soundboard are responsible for the high frequencies (Bader 2005: 57, 153, 168-9; Fletcher / Rossing 1991: 208-209). The latter, although a poorer radiator than the air, is psychoacoustically the loudest, since it radiates in a frequency region, in which the ear is more sensitive (Bader 2005: 57). The loudness balance of the components of an amplified multiphonics' sound depends then on the position of the microphone. If the low frequencies are sufficiently intense, they might render the higher frequencies inaudible due to the masking effect (Meyer 2009: 11). With the guitar, movement of the player around the microphone is not practical, and the movement of the microphone by the player not always possible. The solution is then to position more than one microphone along the guitar.

Given the above-stated information, the second hypothesis was formulated:

Hypothesis 2: the technique of multiphonics lends itself as a compositional element in writing for amplified guitar

when there is close microphone-placement (depending the positioning along the guitar on the multiphonics' sound) since this introduces novelty by making the sounds' lower level components audible to the audience.

The richness of the sounds, otherwise only heard by the guitarist, would then be revealed to the audience. Connotation with the non-amplified sounds, and thus disappointment of the listener, would be avoided. This could help promote the presence of the guitar in large concert halls.

Methodology

To test the above-mentioned hypotheses, each of the three lowest-pitched wound bass-strings lightly touched at established locations will be recorded. The string will be touched at the frets and at *virtual frets*— locations between frets (or between fret I and the nut).

The recorded data shall be treated, the treated data interpreted and evaluated, and the results implemented in new pieces for/with guitar or amplified guitar by the authors and invited composers. The latter are to be thus informed of the acoustical phenomenon and the content of the sounds that arise by the execution of multiphonics at the established locations. As such, the scientific results shall be translated into musical ones. Also, the compilation of catalogues of the sounds according to different criteria shall be pursued.

The implementations will be tested in a public concert with various guitarists. Testing is then to be evaluated through inquiries made to the composers, the guitarists and the public. We will aim to confirm the test results by repeating the concert program in another room with other amplification hardware.

The results along with information on the technique will be made available on an audiovisual website. Composers should then have relevant information at their disposal, and it is hoped to entice them to use multiphonics when writing for guitar. The website will also serve as a practical reference for guitarists.

The criteria for the data collection and treatment of the testing of the research hypotheses are to be found in the second part of this paper (Torres / Ferreira-Lopes 2012).

Conclusion

The technique of multiphonics on the guitar has hardly been researched up to now and rarely used by composers in their pieces. To our knowledge, this paper puts an end to an almost 30-year-long absence of the topic in scientific literature. Also, the guitar is the only instrument (among woodwinds and low bowed-strings) that does not have, in the 21st century, a publication dealing with multiphonics.[50]

With the planned website, composers and guitarists would be informed about the technique and the phenomenon of multiphonics on the classical guitar. They would also at have at their disposal information on a reliable approach for obtaining reproducible multiphonics' sounds, and on these sounds' pitch-content. The sounds are believed to introduce novelty when amplified, for which the technique would be particularly suitable as a compositional element in writing for amplified guitar.

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[1] All translations from foreign languages are by the authors.

[2] In order to avoid confusion between a sound resulting from the technique of harmonics, a sinusoidal component of a sound, and a harmonic complex tone, the term *harmonic* (and, for coherence, also the term *multiphonic)* will be avoided either as a substantive or an adjective (quotations excepted). Instead, *harmonics*' (or *multiphonic's) sound* is used for the resulting sound. A sinusoidal component will be referred to either as *partial*, or *fundamental/overtone* (quotations excepted). The term *vibrational mode* is used for the physical movement that gives rise to a partial.

[3] A classical guitar online-forum on multiphonics puts this in evidence: the forum initiator (like, actually, all other participants) was "unclear on how to create them [multiphonics' sounds] on the guitar" (Aum 2012a) although he consulted Schneider's book (1985) (Aum 2012b), the only publication to that date, to our knowledge, dealing with the subject.

[4] Taking the location where the string is excited into account, in both techniques (as well as when exciting the open/stopped string), the vibrational modes that have a node at that location do not (ideally) give rise to partials in the sound, since they are not excited (Helmholtz 1877/1954: 52). The excitation location is left out of the following considerations though.

[5] The term *fret* is usually indifferently used for the metal strips on the neck and for the space between them, being the latter numbered after the number of the strip between the finger and the saddle. Here the term is exclusively used for the strips.

[6] "String stiffness tends to set a limit, somewhere between twenty and forty, to the number of effective modes of a guitar string." (Taylor 1978: 22).

[7] The excitation strength of a vibrational mode is inversely proportional to the square of its mode number (Benade 1990: 100).

[8] Which, in this study, was measured as the distance, relative to the loop length, of the v.m.'s nearest node from the touch location.

[9] "Harmonic complex tones are composites of at least two sinusoidal components whose frequencies are integer multiples of the fundamental frequency" (Schneider / Wengenroth 2009: 315).

[10] Damping also increases with decreasing density and increasing width of the touching surface (Fallowfield 2010: 150).

[11] The book's first edition was the English version (in Italian multiphonics are called *suoni multipli*).

[12] In the same year, the term was also used in *Subconscious wave* (Rădulescu 1985) though. This piece was composed for, and premiered by, Dora Filippone, with whom contact was pursued but unsuccessful.

[13] W. Bland*. Untitled Composition in Three Sections* [for flute and guitar, 1975]. Unpublished manuscript.

[14] U. Rojko. E-mail correspondence (German) with the authors. December 4, 2011.

[15] And the unpublished manuscripts: S. Hayden. *Axe[s]* [for solo guitar, 1997, rev. 2008-2009]; L.-N. Liao. *p.53* [for solo guitar, 2008] and *Imamusi* [for viola, guitar, baritone saxophone and piano, 2008] and *Le train de la vie I—Doris* [for guitar and tape, 2010]; and R. Torres. *Cyrano-Szenen* [for solo guitar, 2004].

[16] R. Pfeifer. *Die illegale Ausübung der Astronomie* [for solo guitar, 2002]. unpublished manuscript.

[17] R. Nassif. *silhuetas de uma dança imaginária* [for guitar quartet, 2009-2010]. unpublished manuscript.

[18] Nassif, op. cit., score, p. 1.

[19] Nassif, op. cit., directions for study and performance, p. 2.

[20] Torres, op. cit., I.

[21] R. Pfeifer. E-mail correspondence (German) with the authors. May 10, 2011.

[22] R. Nassif. E-mail correspondence (Portuguese) with the authors. October 31, 2011.

[23] Nassif, op. cit., directions for study and performance, p. 1.

[24] R. Nassif. E-mail correspondence (Portuguese) with the authors. November 12, 2011.

[25] U. Rojko. E-mail correspondence (German) with the authors. January 4, 2012.

[26] ibid.

[27] Low-level sounds resulting from the vibration of both sides of the string when this is hammered.

[28] C. Sainsbury. E-mail correspondence with the authors. March 13, 2011.

[29] Pfeifer, Die illegale Ausübung der Astronomie.

[30] R. Pfeifer. E-mail correspondence (German) wih the authors. November 16, 2011.

[31] R. Pfeifer in M. Rebhahn (producer). *Cluster—Introducing: Roman Pfeifer* [Radio broadcast on *HR2 Kultur* on April 6, 2010]. Transcribed by the authors from an excerpt sent by Pfeifer.

[32] ibid.

[33] R. Saunders in an open individual-composition-class at the *Impuls Academy* in Graz, Austria. February 15, 2011. An example of such a gesture without sound can be found in Jens Joneleit's guitar quartet *Spuren* (2011, unpublished manuscript), in this case preceded by the gesture with sound.

[34] R. Pfeifer in Rebhahn, op. cit.

[35] Pfeifer, Die illegale Ausübung der Astronomie.

[36] Named by Emmerson of *projection*: "Projection is the bringing to perceptual foreground or focus of relatively lower amplitude sounds (or constituent components of sounds)" (Emmerson 2007: 127) but also "the additional placing of sounds into space" (ibid., p. 129).

[37] S.F. Palermo. *From Found Objects to Sounds Heard: Salvaging in Hugh Davies's Work*. Oral communication at the Third International Symposium on Music/Sonic Art (MuSA 2012) in Karlsruhe, Germany. July 8, 2012.

[38] R. Pfeifer. E-mail correspondence (German) with the authors. May 6, 2011.

[39] R. Nassif. E-mail correspondence (Portuguese) with the authors. October 31, 2011.

[40] The question of reproducibility has not been ignored by Thelin (2011) nor Fallowfield (2011: 59) regarding bowed-string multiphonics.

[41] When using tape, the instruments are often amplified. It cannot be excluded then the possibility that in such pieces, the composers took the amplification into account in their compositional approach.

[42] M.-A. Dalbavie in R. Bruneau-Boulmier (producer). *Le portrait: Marc-André Dalbavie* [Radio broadcast on *France Musique* on March 21, 2011]. Transcribed by the authors from the audio podcast (from 10:00 on), whose retrieval was possible during one week after the broadcast.

[43] E. Oña. Seminar at the Portuguese Catholic University in Porto, Portugal. June 26, 2010.

[44] B. Furrer in an open individual-composition-class at the *Impuls Academy* in Graz, Austria. February 11, 2011.

[45] M. Pascal in A. Merlin (producer). *Le magazine de la contemporaine* [Radio broadcast on *France Musique* on 26 December 2011].

[46] M. Pascal in A. Merlin, op. cit. Transcribed by the authors from the audio podcast (from 35:27 on), whose retrieval was possible during one month after the broadcast.

[47] ibid.

[48] P. Billone in an open individual-composition-class at the *Impuls Academy* in Graz, Austria. February 8, 2011.

[49] Because these frequencies are preferentially absorbed by the air and thus more lost with distance (Eargle 2004: 17-18).

[50] See for example: Del Grazia ca. 2003; Fallowfield 2012; Gallois 2010; Levine / Mitropoulos-Bott 2002; Thelin 2011; Van Cleeve 2004; Weiss / Netti 2010.

[51] N. Del Grazia. E-mail correspondence with the authors. October 16, 2012.

[Abstract in Korean | 국문 요약]

증폭장치를 사용하는 기타 음악 작곡에 있어 작곡 요소로서의 다중음multiphonics (1)

리타 토레스 / 파울로 페레이라-로페스

기타에서 다중음multiphonics 기법은 현이 자극되는 순간이나 그 후, 또는 자극되는 순간부터 그 후까지 현의 특정 지점들을 가볍게 건드림으로써 구현된다. 이 기술은 여러 음고를 인식하도록 하는 (거의) 화음 같은 복합음으로 구성된다. 현재까지 연구된 바가 거의 없어 클래식 기타 작품에서 다중음을 사용한 작곡가는 거의 없으며, 이를 사용하였다 하더라도 소리의 증폭을 시도한 작품은 아직까지 없었다. 저자는 작곡가에게 클래식 기타의 다중음에 대한 적절한 정보를 주기 위해 이 기교를 연구하고 있다. 이 글에서는 재생산이 가능한 소리를 얻기 위한 체계적인 접근 방식을 제안하기 위하여 과학 문헌에 오래도록 존재해 오지 않은 전술한 주제를 언급한다. 이러한 소리들은, 특히 증폭장치를 사용하는 기타를 위한 음악에서 적절한 기교를 만들어 내며, 증폭되었을 때 참신함을 이끌어낸다고 생각된다.