

Multiphonics as a Compositional Element in Writing for Amplified Guitar (2)

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ABSTRACT

The technique of multiphonics on the classical guitar is currently being researched by the authors concerning the reproducibility of the sounds originated and the suitability of the technique as a compositional element in writing for amplified guitar. Our hypotheses are to be tested, and for this reason some criteria for the data collection and treatment have been established and are detailed here.

Keywords: *Multiphonics; Extended techniques; Guitar; Guitar Multiphonics; Amplified guitar; Virtual fret; Compositional element.*

1 | INTRODUCTION

Although popular for some time in wind instruments, in string instruments the technique of multiphonics has remained in the shadow as a tool for composers and performers. Regarding the classical guitar, on which this research focuses, few composers have requested this technique in their pieces. This is perhaps due to an unawareness of multiphonics' 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, and on the other, the fact that the sound fades away, is not controllable after the at-

tack, and has a weak projection — a scenario not present in wind and bowed-string instruments. In addition, 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 second part of the paper presents the criteria for the data collection and the data treatment in testing the research hypotheses. This is preceded by a summary of the first part of the paper (Torres & Ferreira-Lopes, 2012, in press).

2 | MULTIPHONICS ON THE GUITAR

String multiphonics is 'a technique which, by lightly touching the excited string, in respect to mode number unsystematically damps out some its v.ms. [vibrational modes]' (Torres & Ferreira-Lopes, 2012, p. 74). This gives rise to (almost) harmonic complex tones [1] with a spectrum that facilitates the perception of multiple pitches (ibid.).

On the guitar, the executability of multiphonics depends on the touch location and sometimes on the touch pressure (ibid.). There are three kinds of touch locations:

A. Those at which only harmonics is executable, since the vibrational modes (v.ms., sg. v.m.) with nodes surrounding the location are always damped out by the touching [finger];

B. Those at which harmonics or 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 multiphonics is executable, due to the impossibility of damping certain v.ms. with nodes surrounding the location. (ibid., pp. 74-75)

With the guitar, the sounds originated by multiphonics 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, p. 62), for which the string's stiffness is responsible (ibid, p. 134).

3 | CONTEXT

To our knowledge, the present paper is the first to tackle the subject of classical guitar multiphonics since Schneider (1985, pp. 135-138). For this author, on each of the lower three wound bass strings 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).

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, p. 136 [2]; 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) whom interests the sounds as transitions between the lower harmonics [3]. Other composers ask for the touching to take place at specific locations, some writing the resulting pitches in parentheses (Blondeau, 1999, 2000, 2005; Pisati, 1990; Sor, n.d.) [4] or for specific sounds, notated in a second staff [5]. The content of the sounds is then of interest to these composers either due to their color, or their harmonic features. Some composers are aware that room acoustics might pose a problem in the perception of the low-level components of the multiphonics' sounds, and recognize the necessity of amplification [6].

The amplification of low-level sounds [7] goes

back to 1960 with John Cage's Cartridge Music (Emmerson 2007, p. 127), four years before Karlheinz Stockhausen's Mikrophonie I. The latter 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, pp. 76-87). This was also Stockhausen's aim when, in *Der Jahreslauf* (1977), the players are asked to move in front of the microphones (Stockhausen, 1996, p. 100). In Luigi Nono's *Das atmende Klarsein* (1981), the distance of the bass flute to 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, pp. 120-121).

4 | RESEARCH QUESTIONS

Schneider's locations for the execution of multiphonics (Schneider, 1985, 136) are just a few of the many possibilities. Some of the revisions in 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 [8]. This may lead to reproducibility problems. How is reproducibility of the sounds originated by multiphonics best achieved? After examining the degrees of uncertainty in situating a location (Torres & Ferreira-Lopes, 2012, pp. 77-78) the following hypothesis was formulated:

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. (ibid., p. 78)

The composer and the guitarist could then rely on such locations to give rise to reproducible sounds.

None of the pieces of the reviewed literature have been scored for amplified guitar, thereby it can be assumed that amplification of the sounds has not been explored [9]. Does the technique of multiphonics lend itself as a compositional element in writing for amplified guitar?

When writing for the amplified instrument, it is important to introduce a sufficient amount of novelty regarding the type and content of the sounds in order to have enough distance from

the non-amplified instrument (ibid., p. 78). The low level of multiphonics' sounds or of some of their components should guarantee that this requisite is fulfilled when the technique is used with the amplified guitar, since sounds/components are made available that otherwise would not reach the audience. The loudness balance of the components of an amplified multiphonics' sound depends on the position of the microphone since its frequencies are radiated by each part of the guitar with different intensities (ibid., pp. 78-79). This led us to formulate the second hypothesis:

Hypothesis 2: 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 sound originated), since this introduces novelty by making ... the sounds' lower level components [audible]. (ibid., p. 79)

The richness of the sounds, otherwise only heard by the guitarist, would then be revealed to the audience, and connotation with the non-amplified sounds avoided.

5 | METHODOLOGY

To test the above-mentioned hypotheses, each of the lower three wound bass strings lightly touched at established locations will be recorded. With the classical guitar, multiphonics work much better on these strings (Schneider, 1985, p. 136). The winding allows a decrease of thickness by increasing the linear density 'without adding much stiffness' (Benade, 1990, p. 344). They therefore offer less resistance to bending, which allows the higher modes to vibrate easier than in the non-wound strings.

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 by invited composers. These are to be thus informed of the acoustical phenomenon and the content of the sounds that arise by executing 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. The confirmation the results of the test will be aimed by repeating

the concert program in another room with other amplification hardware.

Below, the criteria for the data collection and treatment of the testing of the research hypotheses are explained.

5.1 SAMPLE

The applicability of the results is in pieces for/with guitar or amplified guitar. It is not the behavior of a particular guitarist or guitar that is to be researched but of guitarists in general (each with their own physiognomy and set of idiosyncrasies) and their guitars. It was decided then to collect recordings of more than one take by more than one guitarist on his/her guitar. The greater the number of guitarists/guitars researched the lesser the error when generalizing to a larger population. Nevertheless, a convenience sample is to be used — the number and kind of elements will be subject to the availability of professional or semi-professional guitarists living in the city where, and on the days when, the recordings are to take place.

5.2 PREDICTING THE PITCH CONTENT FOR EACH LOCATION

The touching of the string is to take place at the frets and at *virtual frets* (v.fs., sg. v.f.)—locations on the portions of the string between consecutive frets. In each of these string lengths, the v.fs. are equidistant, which allows for good orientation reference to both frets. Ideally, the same subdivision should be applied to all spaces — this aids the internalization of the locations by the guitarist and thus, in the long term, the integration of the technique in the guitar's idiom. However, due to the gradual diminishing size of the space between frets it was decided to use different subdivisions in the lower and in the upper spaces. This allows for a greater number of locations at the lower spaces to be researched.

Five equally spaced v.fs. between each fret up to fret VII, and three from fret VII to fret XIX were established. The space between frets VII and VIII was chosen for the change in the subdivision because, at this space, it gives rise to v.fs., which are the same distance from each other as those between the nut and fret I do. Figure 1 schematizes the subdivision procedure and depicts the nomenclature for the virtual frets.

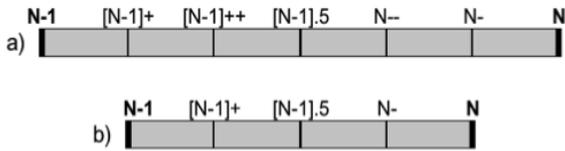


FIGURE 1 | Virtual frets between frets, and their nomenclature (N is the fret number). a) from the nut to fret VII; b) from fret VII to the last fret.

5.3 PREDICTING THE PITCH CONTENT FOR EACH LOCATION

This prediction takes into account all partials up to partial 39 — this is highest audible partial on string 6 of Taylor’s guitar (Taylor, 1978, p. 32). For each location, all nodes nearer to that location than to any other were determined and hereafter considered as *belonging* to the location [10]. V.m. 39’s closest node to the nut belongs to v.f. 0.5 (halfway between the nut and fret I). This was then the first v.f. from the nut considered for the execution of multiphonics. Three location types arise:

A. Those with just one node, being the next closest node at a distance of over 20% of the loop length of the lowest v.m. sharing that node. For example, fret XII with v.m. 2 as the lowest sharing its node;

B. Those to which the next closest node has a distance to the location of 10%, or higher, of the loop length of the lowest v.m. sharing that node, and have:

- only one node, being a v.m. with a number between 2 and 8 the lowest one sharing that node, for example, v.m. 5 at v.f. IV-;
- multiple nodes: one like the one in the previous case and the others with v.ms. with number around 30 as the lowest ones sharing them. For example v.f. XV- with v.ms. 7 and 33 as the lowest sharing its nodes. Figure 2, represents the v.fs. and the nodal points of the string between frets XIV and XV, allowing us to visualize this example;

C. Those with multiple nodes, being the next closest node at a distance of less than 10% of the loop length of the lowest v.m. sharing that node. For example, v.f. XIV+, visualizable in Figure 2, which has v.ms. 16, 25 and 34 as the lowest sharing its nodes, and v.ms. 7 and 9 as the lowest sharing the two next closest nodes.

The locations V, VII, XII, and XIX are of type A. At these locations only harmonics are executable. A distance of 20% of a v.m.’s loop length (relative distance), of its nearest node to the touch location

is thus considered, in this prediction, the distance from which a v.m. is always damped out. Type A is then kind A of section 2 and types B and C should correspond approximately to kinds B, and C, respectively. In the locations of the latter types, their predicted pitch content is constituted by the partials originated by the lowest v.ms. sharing each node distanced to the location less than 20% of those v.ms.’ loop lengths.

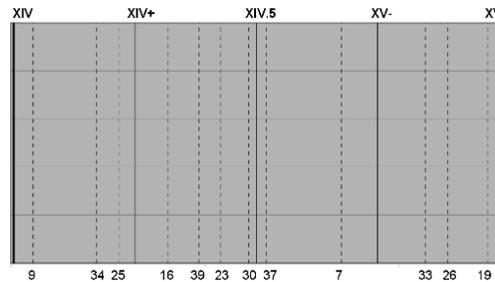


FIGURE 2 | Virtual frets (v.fs.; solid lines) and nodes of the string up to vibrational mode 39 (dashed lines) between frets XIV and XV. Above, in roman numerals: frets/v.fs. nomenclature; below, in Arabic numerals: number of the lowest v.m. at each node.

An idea of which techniques are executable at each location and which v.ms. should be damped out can thus be made. Also, knowing the relative distances of the nodes to the locations, a correlation between these distances and the partials’ relative-loudness results can be pursued. This would allow the determination of the partial content at established locations of the kind outlined in the first hypothesis.

5.3 TOUCH PRESSURE AND DURATION

A reference pressure is needed regarding the touching of the string. This was chosen based on the premise that, when the nodes have a relative distance to the touch location of 20% or more, the v.ms. are always damped out (see 5.2). However, this might not be the case for v.m. 1 when the pressure is very light. The reference touch pressure will be then the lowest pressure with which the fundamental is not perceived when touching at the location, to which a node of v.m. 1 has a relative distance of 20% (on the nut side this takes place at v.f. IV-). This is a subjective reference, for which small variations may occur, not only with each guitarist but also with each of their executions. It is assumed that these do not affect the loudness balance of the pitches (for the same excitation conditions).

Using a light pressure helps reduce the surface area of the finger pad touching the string, and thus

damping, especially of the modes with smaller loops, since a greater percentage of the loop length is covered by the finger pad.

The higher the excitation strength of a v.m. and the greater its node's relative distance to the touch location, the more its decay duration is affected by a longer touching after the excitation of the string, since more energy is transferred to the touching surface. The touch duration shall then take place during the excitation and be as brief as possible afterwards in order to minimize the influence of this parameter in the relative loudness results. The decay of the partials is then maximized, which is important in the case of the higher partials, since these have shorter decays (Meyer, 1985, pp. 9-10) — touching as briefly as possible avoids their early damping out.

5.4 EXCITATION OF THE STRING

Avoiding the suppression of v.ms. when exciting the string, and enhancing them is to be pursued. Results tend then to be achieved in which all possible partials (for a touch location and pressure) are present in the sound and with maximized intensity. From these results, the guitarist can alter the loudness balance of the pitches by varying the excitation parameters. The following parameters play a role in the degree of excitation of the v.ms. of the string:

The following parameters play a role in the degree of excitation of the v.ms. of the string:

- the fractional distance along the string of the excitation location (Taylor, 1978, pp. 20-25) — v.ms. that have a node at the location are not excited [11].
- the width of the exciter (ibid., pp. 25-26) — v.ms. with a loop length up to the width of the exciter are not excited.

The excitation of the string is then to take place near the bridge to pursue the excitation of all v.ms. [12]. Moreover the nail — the narrowest of the traditional exciters (the other being the finger pad) shall be used.

Although the sound of a guitar has its origin in the vibration of the strings, it is essentially radiated by its body. The sound radiated by the string is, in comparison, very weak. This is because 'firstly, it has a relatively small surface area, and therefore cannot produce a large disturbance of the air. Secondly, any compression wave coming from one side of the string is effectively cancelled by a wave of rarefaction from the other' (ibid., p.

33) [13] because diffraction takes place, since the string's diameter is very small compared with the wavelength of the vibration. The higher the frequency, the more successful its radiation by the string (Meinel, 1991, p. 62), for which only the higher partials are directly radiated by the string (ibid., p. 58). The guitar body has a large enough surface to move a sufficient amount of air and to disallow a movement of the air molecules 'either sideways or into the region of negative pressure underneath the top plate. Thus, the only direction in which the stimulated air molecules can move is directly away from the instrument.' (Bader, 2005, p. 34).

When exciting the string, the following parameters, which play a role in the degree of excitation of the v.ms. of the soundboard, should also be taken into account:

- the manner in which the string is released and the density of the plucker (Taylor, 1978, pp. 26-27; Meyer, 1985, p. 15) — the more gradual the release of the string is, the less excited the higher v.ms. of the soundboard are. This is because a gradual release smoothens the edges of the waveform of the impulses that travel along the string and exert force on the bridge. This effect is enhanced by a less dense plucker.
- the direction and magnitude of the string's displacement on release (ibid., pp. 38-41, pp. 48-51) — the lower partials tend to be enhanced by an *apoyando* stroke and the higher by a greater displacement of the string. The *apoyando* stroke tends to give rise to vibrations with a stronger component perpendicular to the soundboard. It is this component that drives the soundboard directly and favors the lower frequencies [14]. The parallel component drives it indirectly by producing a very slight rocking of the bridge, which may become significant at higher frequencies (Fletcher & Rossing, 1991, p. 208). Since there is 'a limit to the amplitude of the perpendicular component which may be imparted without causing fret-rattle... different amplitudes of the parallel component may be imparted along with the maximum downward component, and the direction of the string will vary accordingly' (Taylor, 1978, p. 50).

The string is to be plucked with an *apoyando* stroke in order to compensate for the lesser excitation of the lower v.ms. due to plucking near the bridge (and thus nearer to a node than to an antinode). The stroke shall be played *forte* to aid the excitation

of the higher v.ms. of the soundboard. Being a less common articulation request, it shall not be requested to release the string in any specific manner. A gradual release is then expected. The density of the nail is not controllable.

5.5 AMPLIFICATION

Condenser microphones shall be used, due to their 'extremely high quality output, and... the relative accuracy and strength of their very high frequency response' (Stark, 1996, p. 84) and also because these microphones most accurately reproduce impulsive sounds (Meinel, 1991, p. 61). Due to the low level of the sounds or of some of their components, the higher the sensitivity, the better.

In order to study the variation of the loudness balance of the partials with microphone placement, the sounds are to be recorded simultaneously at different positions. The comparison requires the same model of an omnidirectional microphone, since when acoustic labyrinths are present (the case of directional microphones) 'coloration of the sound is rather more likely' (Rumsey and McCormick, 2002, p. 66) and at short distances the proximity effect is felt (*ibid.*, p. 59). In a concert situation, directional microphones are preferable, and these are to be used parallel to the omnidirectional ones in order to compare possible changes.

The parts of the guitar in front of which the microphones shall be positioned and at which they should aim, are standard in microphone placement and close-placement procedure (Albrecht, 2010, p. 50; Bartlett, 1981, p. 729; Owsinski, 2009, p. 190). The distances of the microphones to the guitar shall be as close as possible after ensuring that there is enough space around the guitarist so that possible bumping into the microphone is not a stress factor, and the proximity effect is minimized (Owsinski 2009, p. 188). Additionally, a miniature microphone is to be used, attached to the body of the guitar where it causes no inconvenience to the guitarist.

5.7 ANALYSIS

Due to the quantity of recorded sounds, an analysis tool that allows batch processing will be used. Each sound is to be subjected to partial tracking analysis up to 39 partials (see 5.2). For each touch location, the reproducibility of the sounds and the availability of the components with lower level are to be determined with the analysis results from: 1. a time segment situated as early as possible after the initial transient, in order to detect as many

higher partials as possible. With the guitar, the initial transient lasts approximately 50 ms (Bader, 2005, p. 134) [15] and this value is to be used as a reference to establish the initial time of the segment; 2. a time segment situated 300 ms after the attack. Up to this moment the soundboard is the radiator with the highest spectral centroid (*ibid.*, p. 153) and it was decided to determine the loudness balance of the pitches in a second segment free from this influence.

The duration of the time segments will be the minimal appropriate duration— that of the window size. This is to be the same for the recordings of the three strings, and its calculation based on the frequency of the lowest string when approximately a half-tone lower. This takes into account a possible negative deviation, either due to detuning, or to a longer initial transient — a characteristic of the lower partials (Meyer, 1985, p. 11).

A minimum duration of the partials relative to the duration of the time segments is to be set. This takes into account the possibility that their detection ends before the end of the segment, due to a quicker damping caused by a longer touch duration. The value for the minimum duration shall be based on the extrapolated value (from values of Hartman (1998, p. 319)) of the tone-pitch threshold (the shortest duration for which a tone burst sounds mainly like a tone) of the frequency used for the calculation of the window size.

6 | CONCLUSION

This research-in-progress sheds light on a technique that: to our knowledge, was first and last tackled almost 30 years ago; on which there is a lack of relevant information; and of whose executability on the guitar composers are not always aware. Supporting the results our hypotheses, composers could rely on an approach for the execution of multiphonics that gives rise to reproducible sounds, and on the technique as a suitable compositional element in writing for amplified guitar. Our research would then contribute to the establishing of multiphonics as common vocabulary in writing for guitar and amplified guitar.

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ENDNOTES

[1] 'Harmonic complex tones are composites of at least two sinusoidal components whose frequencies are integer multiples of the fundamental frequency' (Schneider & Wengenroth, 2009, p. 315).

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

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

[4] 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 electronics, 2010]; and R. Torres. *Cyrano-Szenen* [for solo guitar, 2004].

[5] As is the case of the unpublished manuscripts: R. Nasissf. *Silhuetas de uma dança imaginária* [for guitar quartet, 2009-2010]; and R. Pfeifer. *Die illegale Ausübung der Astronomie* [for solo guitar, 2002].

[6] Nassif, op. cit., directions for study and performance, p. 1; U. Rojko, E-mail correspondence (German) with the authors. January 4, 2012.

[7] Named by Emerson of *projection*: 'Projection is the bringing to perceptual foreground or focus of

relatively lower amplitude sounds (or constituent components of sounds)' (Emmerson, 2007, p. 127) but also 'the additional placing of sounds into space' (ibid., p. 129).

[8] 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.

[9] 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.

[10] The calculations were made using the theoretical distances of the frets to the nut. The real distances of the nodes to the frets/v.fs. will differ slightly from the calculated due to string compensation: either the string is slightly longer (Fletcher & Rossing, 1991, p. 228) or the frets are shifted to the nut (Jahnel, 1996, p. 152) to compensate the change in tension in fingering of fretted notes.

[11] 'Since all strings have stiffness and imperfections and all plectra have finite width, it is much more realistic to say that the partials with nodes at the plucking position will be suppressed, not completely absent' (Schneider, 1985, pp. 17-18).

[12] The first node of v.m. 39 is distanced ca. 1.5 cm from the saddle.

[13] This is called *acoustic short circuit* (Bader, 2005, p. 33).

[14] Experiments by Richardson requested by Taylor show that at frequencies below 1500 Hz 'considerable higher sound intensities are produced by perpendicular than by parallel plucking' (Taylor, 1978, p. 40). Above that frequency value 'there seems to be no consistent difference between the two directions of plucking' (ibid., p. 41).

[15] Given that the string has to overcome the resistance of the touching, the initial transient in this case is probably longer.

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BIOGRAPHIC INFORMATION

Rita Torres was born in 1977 in Lisbon, Portugal, where she obtained degrees in Chemical Engineering and Guitar. She received a diploma in Composition from the class of Wolfgang Rihm at the Hochschule für Musik (HfM) Karlsruhe in Germany, having been awarded the Baden-Württemberg Graduate Scholarship and later the Mathilde-Planck Contract Lectureship. She is currently a Music

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Paulo Ferreira-Lopes is Professor at the School of the Arts of the Portuguese Catholic University (UCP), since 2007, guest Professor at the Institute for Musicology and Musical Informatics (IMWI) at Karlsruhe's University of Music in Germany. He is founder and former Director of the Research Center for Science and Technology in Art (CITAR) in Porto (2003-2007), of the Electronic Music Studio C.C.I.M. in Lisbon (1992-1995), and of the Summer Workshops olhAres de Outono in Porto (UCP; 2000). Since 1998, he has been artist in residence and researcher at Karlsruhe's Center for Art and Media (ZKM). His works have been produced at this institution as well as at the Calouste Gulbenkian Foundation in Lisbon and at international festivals like Musica in Strasbourg, Musica Viva, Estoril Summer Festival, S. Paulo Biennial and World Music Days as well as at the documenta X in Essen and the Expo 98 in Lisbon, having been interpreted by leading ensembles of the contemporary artistic scene such as AccrocheNote, OrchestrUtopica and Ensemble Modern Frankfurt.