

# Elisabeth Harnik/Improvisational Re-assemblies

Elisabeth Harnik, Hanns Holger Rutz and Gerhard Nierhaus

Elisabeth Harnik was born in Graz, Austria, and received her first musical education at the age of five.<sup>1</sup> At the age of 10 she started playing the piano, an instrument that became a constant companion during her musical development. After finishing school she initially studied piano at the Music University of Graz. During her student time she turned at first to jazz and jazz-singing, working with Ward Swingle (Swingle Singers) and continued her education with Ines Reiger, Sheile Jordan, and Jay Clayton in the field of vocal improvisation. Harnik received further important impulses as a pianist by studying the repertoire of contemporary music, participating at the Vienna days of contemporary piano music and she continued to work as an improvisation musician. Harnik did not find until her intrinsic approach of the instrument with free improvisation until meeting the French double bass player Joëlle Léandre, whose musical journey from classical music to improvisation she shared. In the following years she worked as a pianist in various areas of improvisational music and participated, amongst others, in the classes of Peter Kowald, Lauren Newton or David Moss. As a pianist, Harnik looks for the challenge to dissolve or disperse the long-established norms and apparently fixed boundaries of the instrument, where she considers it her task and challenge to permanently re-invent her playing and her instrument.

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<sup>1</sup> Biographical introduction and texts from the composer translated from the German by Tamara Friebe.

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However, in her artistic desire to “create” she was looking for an additional means of expression, and this is where her first compositions emerged. An encounter with the Swiss composer Beat Furrer during her participation in Haubenstock-Ramati’s *Amerika* conducted by Furrer a few years earlier is still alive in her memory. Harnik received essential further impulses and stimuli for the artistic development from the visits of a “Deep Listening Workshop” with the American composer and accordion player Pauline Oliveros.

After these events, Harnik studied composition at the Music University of Graz with Beat Furrer. Soon after finishing this study, composing quickly became a second essential aspect of Harnik’s artistic activities, alongside her practice as a free improvisation pianist. Harnik performed as a piano soloist and in ensembles with prominent representatives of improvisational music at national and international festivals; her composition activities also lead to commissions and performances of her works by well-known soloists and ensembles.

Despite the predominant separation of composed and improvised music in the present performance climate, there are more and more overlaps between both disciplines at festivals for contemporary music or improvised music emerging. In some of her works Harnik relies on a strategy where one influences the other, balancing a connection which uses economical and practical means between improvisation and composition, moving from a confrontation to a synthesis, nevertheless both fields of activities remain in the majority of Harnik’s oeuvre rather disjoint. When it comes to composing it is the fascination to move freely along the time-axis as well as the possibility to work meticulously on details of the realisation of sound and form. Improvisation is more about its enforced linear time lapse, but on the other hand she sees it as a “going backward into the future”—with the presentiment of approaching a future which is still open, that has to be shaped artistically as it emerges.

In Harnik’s compositional work, she rarely starts at the beginning of a piece; she likes to move erratically along the time line, where structures of a later section often feedback to previous parts. With respect to structures, she likes to work with complex rhythmical and melodic patterns, which are combined and selected in different ways. The musical progressions are notated with utmost precision, which in their frequent complexity open the sought-after “new”.

In the compositions of Harnik there is often a refreshing friction and/or tension between self-imposed rules and their modifications, even a breaking of the rules caused by intuitive decisions. The rules open an area of discourse, which gets evaluated and processed by the musical intuition as well as having the effect of completely re-forming the composition.

In her current work, the search for methods to give a composition more flexibility and elasticity, without losing the precision of conventional notation is an important focus of her artistic exploration. In a recent piece, *grafting* (*veredeln, aufsetzen, anreichern* . . .)<sup>2</sup> she translates methods from other working practices into her composition, for example, the role of how an improvisation orchestra uses signs and hints to initiate their play. These practices widen her scope, leading to modifications

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<sup>2</sup> “veredeln, aufsetzen, anreichern” roughly translates to: “refine, setup, accumulate”.

and changes within the compositional work. The processes act as a “medium” in order to be able to implement a flexible zone in the conventional musical score writing.

*Re-framing II (inside the frame is what we’re leaving out)* for string quartet is composed using an “elastic form”. The sequence of the form is set. Within the sections, however, are options for the individual players. The performer can alternate between different types of notational reading. Depending on the selected type of reading, the shape of the time and rhythm-melodic patterns are affected. Through this process, the time frame is reinterpreted multiple times, to bring flexibility within the established structure of the work.

## Artistic Approach

### *Statement*

The nautilus is a nomad which explores the oceans on its vast journeys. It collects particles of each investigated place to build its shell, becoming a sort of collection of its explorations. Every year the shell forms and adds a new chamber. The old chamber is sealed and the animal moves into the new chamber. . .

I see parallels in my artistic work as a composer and improviser to the journey of the nautilus. In both disciplines of composition and improvisation there is a drive for me to obtain something “new” within a particular framework of conditions and thus to extend the boundaries.

As a professional pianist and improviser, my hands have acquired a rich repertoire of gestures. This is further refined, extended or also revised by regular frequent practice and reflexion. It can be described like a ritual: from a state of alert curiosity, in which some decisions are consciously left up in the air, I let myself be guided by the expectation of what will come. I have an attentive anticipation of the possible outcome, but one which can still remain foreign or strange to me. It is like while playing, something can spontaneously occur which is new to the previous context. Hand and ear “localise” the incident and almost “anticipate” the foreign element. I then take this new engagement on with a readiness to take a risk and follow it up. When composing I also choose certain working methods, which make me follow up particular musical incidents spontaneously. Mostly, I do not know which result will come from it, but that is what constitutes the excitement in both disciplines. They are only differing ways to obtain a sought-after “new”.

I consider composing and improvising as a kind of interplay between the calculated and the inconceivable: a reflexion about a developed sound vocabulary—be it via preconceived or spontaneous interventions—and a tracing of an unconscious inner structure.

## *Personal Aesthetics*

Whether I write a piece in the conventional sense or I play an improvisation, both are highly complex creative processes. I like to put improvisation and composition as counterparts to each another, and the discussion often ends up being a kind of power struggle or trial of strength where either the one or the other loses. For me however both composition and improvisation represent a complex interplay of activities, which assigns meaning to musical material—I appreciate both disciplines because I can reach something with both different creative methods.

The possibility to move freely along the time-line when writing, to later exchange what's already written with new findings and insight—to let this influence future sections back in the beginning—leads to a completely different approach compared to the linear time structure of an improvisation. On the contrary the challenge of improvisation lies precisely in the brilliance of the moment since no posteriori correction is possible. The role of listening is crucial, which transfers and takes me into a state of subtle presence. Everything that is heard—the carrier of information and relation—is composed or made up of sudden, imminent direct sensory perceptions and sensations, or of a pensive leaning towards old experiences and intuitive presumptions.

In my work as an improviser I meet musicians from all different musical backgrounds. My personal aesthetic is based on a repertoire, which I have collected over many years in my improvisation and composition practice. It is affected by my cultural heritage and education and also by international and intercultural collaborations with performers of various musical genres. Contemporary music, jazz, electronic music, rock music and Indian music have crucially influenced my handling of aesthetic preferences. Improvised music is an artistic area that is influenced by different approaches and positions.

I would call my aesthetic as an improviser “integrative” rather than anything else. It is impossible to deny my central-European heritage—nevertheless I observe, especially in my practice as an improvisation artist, that by the exchange with musicians of other cultures and different genres I am repeatedly encouraged to consider the often unconsciously adopted concepts of western avant-garde art and music. This implicates that I allow a pluralistic point of view in the aesthetic of my improvisation, but of course, there are always boundaries.

Improvisation occurs often as a collaborative act. In my opinion this requires one to be open to “foreign” aesthetics and to be ready to leave behind your own preferences. I would go even further and say that in a group improvisation the group sound, respectively the form of the moment takes primacy over the aesthetic of the individual members. In a group improvisation the various kinds of information processing change. Separated and sequential linear sound vocabulary—with or without a pre-conceived system—is combined with non-linear, presently sounding, imagined or remembered information.

When composing conventionally or in a solo improvisation, the dimension of the collective nuance is of course missing, which is so eminently important in a group

improvisation. I alone am the “author/originator/creator” of my actions. Nevertheless I often manage also to take on a multi-perspective when composing or playing solos, which allows a plurality of discourses to happen simultaneously, whose individual layers can arbitrarily interrupt each other or respectively pass into fore- or background.

## *Formalisation and Intuition*

Each composition and improvisation carries within a certain interrelation between “interpretation” as formalisation and “spontaneity” as intuition. It is therefore interesting as a composer and improviser to gain within this respective framework something “new”.

In recent times, when I compose with pen and paper, I work increasingly with patterns, which I formulate as a form of basic configuration of sounds, which react, to different filter processes. For the filter processes, which blend in and out the sound and motion patterns I use mostly rigid rule-based systems like cellular automata.<sup>3</sup> The almost automatic execution of the rules allows me to react intuitively to the emerging body of sound. Unexpected musical situations often arise for me, which can significantly change the course of a composition, or sound qualities detach themselves from the initially formulated pattern, sound qualities which were not yet determined at the beginning of the composition process. It is an integrative process in which forgetting the rules of a system play an important role since otherwise no change, no transformation is possible. The moment of the sudden “neglect or oblivion” in order to follow up an intuitive idea appears in my work method often as an “insertion”, which is incorporated retroactively in the composition—sometimes also retrospectively. Therein, the driving engine is the improvising of solutions, which do justice to the system of rules as well as to the intuition.

The skill of improvising appears however, in the ability to anticipate the sum of all processed information without a comprehensive formal plan or design. Sound after sound, silence after silence is added where the respective form of the moment adapts itself to the actuality. Music itself is considered a field, which is open to all sides, which wants to be worked on artistically. In the flow of an improvisation an overemphasis of intellectual reflexion can detract from the spontaneous action and reaction. Derek Bailey uses the following image: you can approach the unknown with a method or a compass, but with a map you would never get there.<sup>4</sup>

**POINT:** Our project focuses on your artistic work as a solo improviser, what are the most important components for you in a solo improvisation?

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<sup>3</sup> A cellular automaton consists of a number of cells, which may assume a certain number of states. The temporal development of the system is represented in an n-dimensional cell space, where the cells change their states accordingly to their states and the states of the neighbouring cells.

<sup>4</sup> Translated from the German “Man kann sich dem Unbekannten mit einer Methode und einem Kompass nähern, aber mit einer Landkarte würde man niemals dorthin gelangen”.

**Harnik:** As a composer, when scoring music, I have all the time I would need to finish a composition. As an improviser I create the sound in the moment. In doing so I put myself into a meditative state to follow intuitively an internal structure, whereas the role of a composer and interpreter is merged in the process. The mental and corporal preparation as an improviser/performer for a concert is very important. The performance where creation of music is in “real time” leads to it becoming an event.

The stimulating challenge of a solo improvisation lies in the possibility to deal consciously with one’s own personal use of material. Without external intervention I immerse myself in an inner dialogue and am thus able to further explore my performance. Apart from the technical and conceptual exploration of the instrument, solo improvisation is based on the integration of certain elements in real time, with the option of bringing new material into the “game”. This spontaneous handling of the material is only possible because the patterns of movement are automated to an extent, freeing up one’s concentration to execute and perform new gestures. The particular instrument I play on is also a factor here because instruments can be very different in their build and can “disturb”, for instance, the application of “known” material. If an instrument does not react like one expects then this possible irritation holds the potential for a spontaneous finding of solutions.

Moreover, in the course of an improvisation I can react to instantaneous situations in two different kinds of ways, which can be called, according to Lydia Goehr<sup>5</sup> “Improvisation Extempore” and “Improvisation Impromptu”. The “Improvisation Extempore” denotes a familiar concept of every day music, namely to make music out of the moment and to develop it. The “Improvisation Impromptu” approaches the example of daily life as originated from a fracture, a problem, where an emergence necessitates an immediate (re)action. We have to react right away, without developing the reaction. In order to create room in a solo improvisation for the “Improvisation Impromptu” I often provoke unforeseen disturbances by risky preparations or materials, which are never fully controllable like mechanical toys, falling objects and similar things.

When improvising I also work very strongly with a knowledge and memory from the body of the instrument. Clusters, chords, and tonal sequences—both in intention and execution—are coupled to basic positions of my hands like “narrow hand”, “somewhat open hand” and “far open hand”. I also possess a repertoire of movement patterns of the hand along the keyboard, from conventional techniques of playing to self-developed performance techniques.

From my own playing a catalogue of typical basic material can be isolated which is subject to permanent selection and extension: diverse gestures at the keyboard such as melodic micro-segments, chord pattern, cluster forms, rhythmical cells as well as extended techniques, for example the use of mobile and fixed preparation of the interior of the piano, and more common materials from a combination of play on the keyboard and the inside of the piano, glissando effects, percussive play on the instrument body, linear processes of development, sound types, texture types, etc.

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<sup>5</sup> Professor of Philosophy at Columbia University, New York.

All this basic material has a common allowance for ambiguity, where changes and adaptations must be possible if necessary. It is also advantageous if these ambiguities can be combined with versatility or if they are not too precisely defined in the area of application. I prefer the use of my bare hands, for instance, when playing in the interior of the piano, compared to using beaters and drumsticks, since quick changes in the sound production are easier done with the hands.

From the viewpoint of an “observer without commentary” I follow the sound formations and refine them, guide them into a certain direction or also reject them in some cases. Altogether one can observe that the sound colour potential of the material and its possible structural development takes primacy over the pitch organisation. Of course the pitch and temporal organisation of the musical events also play a significant role. During an improvisation however, the interval constellations are for me considerably more important than the selection of actual pitches. On the temporal level I work mostly intuitively, with a free combination of aperiodic material and rhythmical micro-segments where an instantaneous forming and sensing plays an important role.

### ***Evaluation and Self-reflection***

I do not “think” but at the same time it feels like “knowledge” as my eyes are mostly closed; it is a kind of “no-mind” state. If I think very deliberately about what to play next, I only manage with great difficulty to get into this state of “flow”, yet this does not mean that there are no conscious decisions during an improvisation. Conscious moments serve me an “in-between stop” and I don’t put too much emphasis on them since I want to be always ready to give up the conscious “control” in the right moment. It seems that I rely on my “bodily memory” and simultaneously move into the role of a “non-commentary” observer, which subtly directs the play.

### ***Project Expectation***

As a composer and improviser I am in a permanent dialogue with my own repertoire and the associated possibilities of structuring time. This way of dedicated awareness of the material constantly accompanies my artistic process. From participating in this project I expect a deepening of this debate. First of all I hope to unravel some unconscious processes and the implied knowledge of these processes. Amongst other things I am thus interested in the criteria by which I recognise and ascertain spontaneous discoveries or lucky coincidences, which may open new paths because these form mostly in conjunction with intuitive forces, the basis for artistic decisions. Yet the formation of such criteria can also imply wrong ways and dead ends. These imperfections and mistakes found at the edge between solving and finding problems are important for development.

I think that the analysis of my piano improvisation can also bring out this aspect of “failure”, which in return is a possibility to better understand my own methods.

How far it is possible to address the aspect of “embodiment” I cannot estimate. The connection between “hand” and “head” is crucial in my performance practice. As a “composer-performer” I become one with the sound and with the instrument. The basic impulse for every movement are my hands—their size for instance, or the way in which they cooperate, etc. This has a strong influence on my improvisation. This project is, in any case, a new way of reflexion. It contains a new perspective to study and analyse the “pathways of my hands”.

## Exploring a Compositional Process

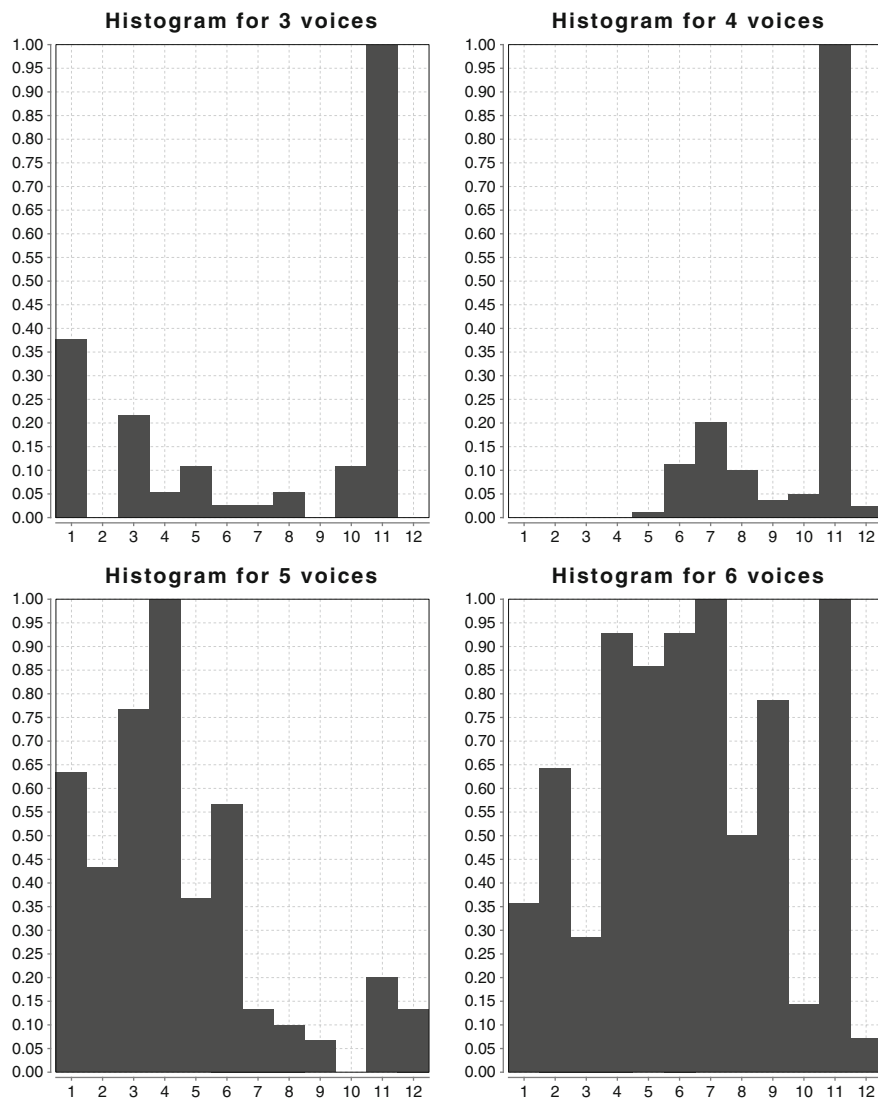
**POINT:** We decided to focus on Harnik’s improvisational work for our research. In order to gather some empirical data, we arranged a session in which she would play a number of small “snippets”, improvising with a strict constraint such as using only chords of a given number of voices. We recognised Harnik’s objection that this situation was highly unusual, however we still considered it useful for some initial observations. Figure 1 shows the relative frequency of frame intervals occurring within the total body of these improvisations. In contrast and reflecting the internal interval structure, Fig. 2 shows histograms of the neighbouring intervals occurring within chords of given sizes.

With respect to the frame intervals, the major seventh is particularly prominent, whereas minor seventh and major sixth are seldom. There are only few instances where octaves occur. With respect to the layered intervals the fourth and the tritone are prominent, except for the series of chords of four voices, where the major third is very frequent.

**Harnik:** It is of course clear that within my normal improvisation process, such sequences of constrained chords are unlikely to occur. Harmonic consonances arise, though, due to diverse conditions, such as the physicality of my hands, movement patterns that have developed in the course of my improvisational activity, and also arise due to the transformation of melodic phrases. Nevertheless, these analyses show very clearly my harmonic preferences and motivate me to consciously break the patterns.

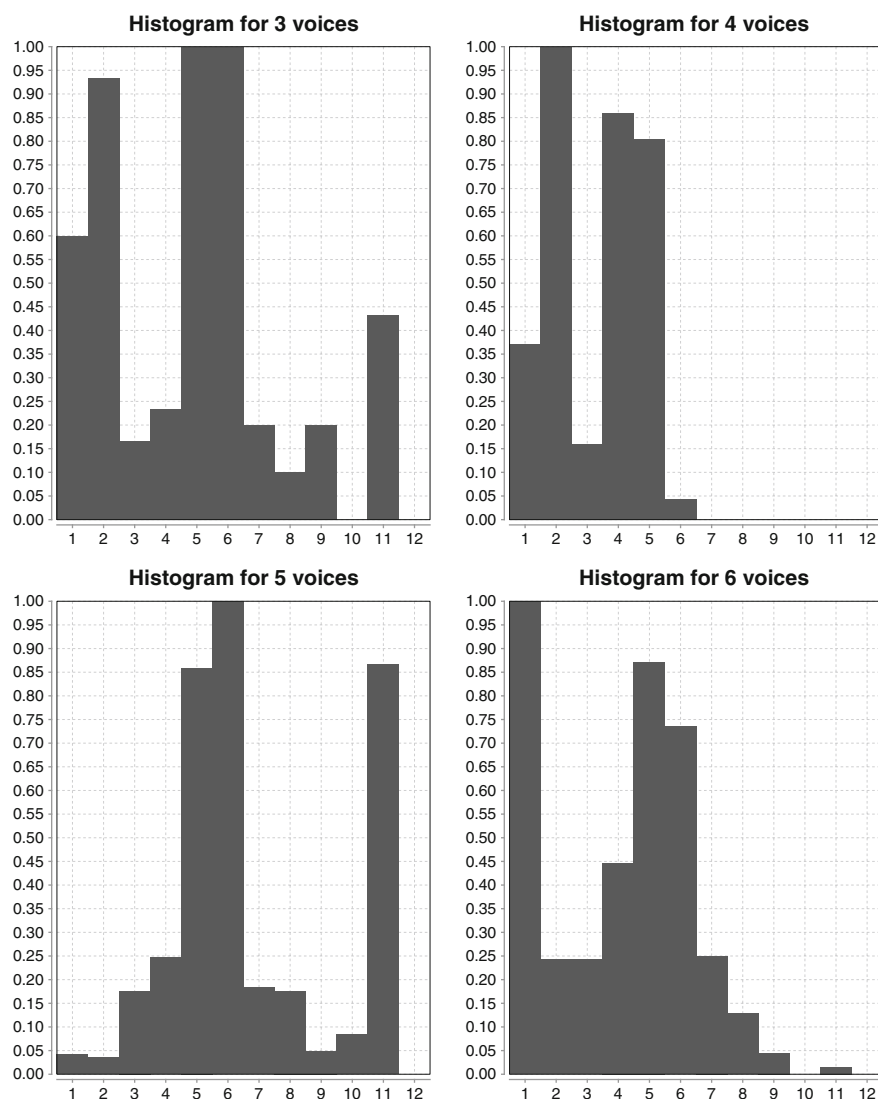
Would it also be possible to create new musical structures from my improvised material? I have indeed seen some interesting approaches to regenerating Bach preludes from existing preludes during our meetings. Such an approach would also be exciting for me, as it might be able to produce something like a mirror of my improvisational preferences.

**POINT:** There are various possibilities to generate musical structures using a corpus of existing data, such as using context based methods operating on prefix- or suffix-trees. A particularly interesting method is the *context snake* [3, pp. 112–117], an algorithm that moves along a context tree, effectively providing variable length Markov chains. The next section will introduce this concept and the possible configurations.



**Fig. 1** Frame intervals in the chord-only improvisations, for a given number of voices. Intervals greater than an octave are wrapped

Since we have access to the data produced by Harnik's play and more data can be produced on demand, we decided to train a computer algorithm so that it could somehow reproduce the improvisations, thereby revealing certain aspects that are modelled convincingly, and others that are not well captured. This would engage Harnik in a dialogue and help to explicate the aspects of the play that are only intuitively and implicitly known.



**Fig. 2** Layered intervals in the chord-only improvisations, for a given number of voices

A classical approach of modelling a sequence of events—such as pitches played on the piano or letters forming words of text—is to create a table of probabilities that describe the chances of getting from a particular event or state to another event or state. The table of probabilities may be the result of analysing an actual body of events (the corpus). Using chance operations, new chains can then be formed which resemble the original corpus with respect to the statistical properties of event frequency and transition frequency. These chains are called Markov chains, because

**Table 1** First-order Markov transition table for intervals in a free improvisation

	0	1	2	3	4	5	6	7	8	9	10	11
0	0.05	<b>0.22</b>	0.17	0.08	0.03	0.06	0.07	0.04	0.04	0.05	0.05	0.13
1	0.05	0.13	<b>0.17</b>	0.05	0.08	0.06	0.10	0.11	0.07	0.07	0.05	0.06
2	0.05	0.13	<b>0.13</b>	0.07	0.08	0.11	0.09	0.08	0.09	0.06	0.04	0.04
3	0.02	0.11	<b>0.20</b>	0.08	0.08	0.08	0.03	0.08	0.08	0.04	0.06	0.14
4	0.04	0.10	<b>0.21</b>	0.07	0.09	0.06	0.10	0.10	0.04	0.07	0.06	0.05
5	0.07	0.12	0.12	0.06	0.06	0.11	0.10	0.08	0.05	0.06	0.04	<b>0.14</b>
6	0.05	0.15	<b>0.16</b>	0.05	0.07	0.10	0.05	0.10	0.06	0.08	0.05	0.09
7	0.04	<b>0.14</b>	0.13	0.10	0.10	0.07	0.08	0.09	0.08	0.03	0.05	0.10
8	0.02	<b>0.16</b>	0.12	0.13	0.07	0.05	0.12	0.11	0.04	0.09	0.02	0.07
9	0.04	0.11	0.13	0.08	0.06	0.06	0.09	0.08	0.06	0.05	0.09	<b>0.17</b>
10	0.06	0.11	<b>0.14</b>	0.08	0.09	0.10	0.07	0.06	0.04	0.09	0.04	0.12
11	0.04	0.13	0.10	0.09	<b>0.14</b>	0.06	0.04	0.07	0.10	0.07	0.06	0.09

Each cell shows the probability of a transition from the row index to the column index. The sum of each row is 100 %. The largest probability of each row is shown in bold-face

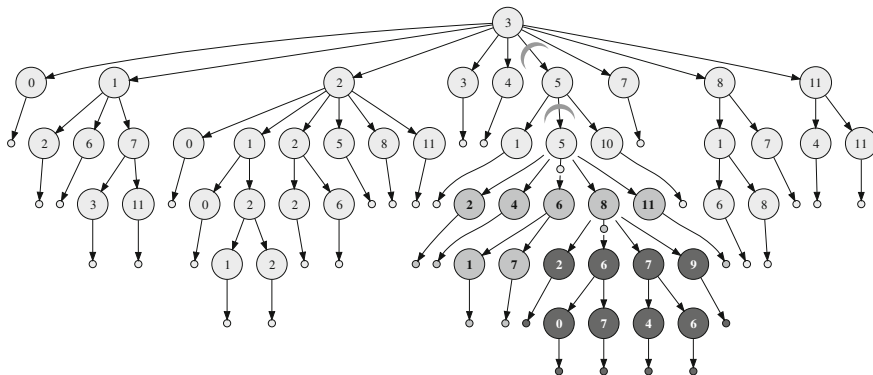
they have been invented by Russian mathematician Andrey Andreyevich Markov at the beginning of the 20th century.<sup>6</sup>

As an example, Table 1 shows a transition matrix created from looking at the succession of intervals in the recording of one of Harnik's improvisations. The intervals are shown as the number of semitones modulus octaves. Looking at the first row, the probability that a pitch repetition (unison) is followed by another pitch repetition is 5 %, whereas the likelihood that a unison is followed by a minor second is 22 %. Using this table and a random number generator, one could now generate new sequences of pitches that reflect these probabilities.

The problem with this approach is that the generative process is not sensitive to rules or probabilities that involve a longer back trace than just the preceding element. For instance, the corpus might contain transitions  $A \rightarrow B$  and  $B \rightarrow C$ , but no subsequence  $A \rightarrow B \rightarrow C$  exists. A first-order Markov process that only looks at the last element to produce the successor may come up with this result. One can use higher-order Markov chains to avoid this problem. In a second-order process, transition probabilities are given for pairs of preceding elements. On the other hand, the higher the order, i.e. the more the transition rules are constrained by looking at the longer backtrace of the sequence, the less likely one finds alternative transitions. The effect is that the original corpus will be more or less recreated without variation. At the same time, patterns that clearly reflect low-order Markov processes are concealed in such higher order representations.

To navigate between these two extremes—context-insensitivity at low orders and lack of variability at high orders—Kohonen has proposed the use of variable-length Markov chains [2]. His generative algorithm tries to use long contexts (high orders)

<sup>6</sup> For an overview of Markov chains, see for example [1, Chap. 11] and [3, Chap. 3].



**Fig. 3** Snake motion through a context trees of intervals. The initial tree, starting with element 3 and shown in *light gray*, successively expanded trees in *medium* and *dark gray*

but is restricted by a *depth parameter*, ensuring that the exploration stops before the maximum context length is reached, thus guaranteeing a choice in the successive elements of the generated sequence. A particular rendering of a variable-length Markov algorithm is the context snake. It builds a tree structure of the overall context. The “body” of the snake is the current context, a subsequence within the corpus. The tree structure allows us to find the successive elements of the current context. When there is zero or only one possible successor, the algorithm may either backtrack and move the snake’s “head” towards other sub-trees, or it may truncate the context, forgetting older elements and shrinking the snake’s “tail”. Efficient search structures are available for the implementation such as suffix trees [5].

Figure 3 shows a traversal through such a suffix tree. The data used is a subset of the interval transitions used for Table 1.<sup>7</sup> The snake was initialised with only one element, 3. At this shallowest context depth, there are nine possible transitions: 0, 1, 2, 3, 4, 5, 7, 8, 11 (for simplicity, the edges are all drawn the same, although the transition probabilities differ). If, using a random number generator, 5 was selected as the successive element and appended to the snake’s body, the context depth becomes 2, and now there are three alternative successors: 1, 5, 10. If 5 was selected again, the context depth or snake length becomes 3, but now the critical point has been reached where only one possible successor (6) exists. The algorithm could backtrack and try 1 or 10 instead of 5. Since these also do not provide longer context, the tail element 3 is removed and appended to the generated sequence. A new context tree starting with 5, 5 is found and the new set of successor elements becomes 2, 4, 6, 8, 11. The procedure is repeated as before, until the desired length of the generated output is reached.

Two aspects determine the quality of the generated sequences. Firstly, the size and exhaustiveness of the corpus—the larger the corpus, the more it reflects the knowledge embodied in Harnik’s play, the more exhaustively it covers all the possible

<sup>7</sup> We used a smaller corpus to make the figure more readable.

ways of conceiving such improvisations. The second aspect is the type of element represented by the context trees. In the previous examples, we have used the intervals between successive notes. It did not make a difference between an upward and a downward interval, so one would probably want to preserve the interval direction. Instead of intervals, one could use the absolute pitches, or one could model entirely different parameters such as the dynamics of the notes, their durations, etc. A particular problem is posed by the request to model multiple parameters at once, such as pitch and duration. This will be discussed later in the chapter.

To begin with, we tried to regenerate plain chord sequences, using a given number of voices. Examples of the input material are shown in Fig. 4. To model the generation of new chord sequences, an example corpus was first converted from raw MIDI notes to chord objects. In order to keep the dimensionality of the vectors small and the amount of alternatives high, we used multiple context snakes whose outcomes were combined: the first snake generated was fed by vectors formed from the pitch class taken from the lowest and highest note of each chord. For example, looking again at Fig. 4, the first chord would produce frame pitch classes (G, G) or numerically (7, 7), the second chord would produce (Ab, C) or (8, 0). A second snake used tuples of the registers (octaves) in which the lowest and highest pitches of each chord occur. Using MIDI conventions, the first two chords of the previous example would yield tuples (3, 5) and (2, 5). If chords of mixed size should be modelled, another snake would just generate the chord sizes.

To model the interval structure between the frame intervals, we maintained a nested dictionary from frame interval size to chord size to chord intervals. After determining the lowest and highest pitch of a generated chord, using the pitch class and octave snakes, we looked into this dictionary for the thus given frame interval and chord size. If no entry was found, we looked at the next smaller or greater interval and chord sizes, until a body of chords was found. A random chord is then picked, and its intervals are used in a random layering. Example generations are shown in Fig. 5.

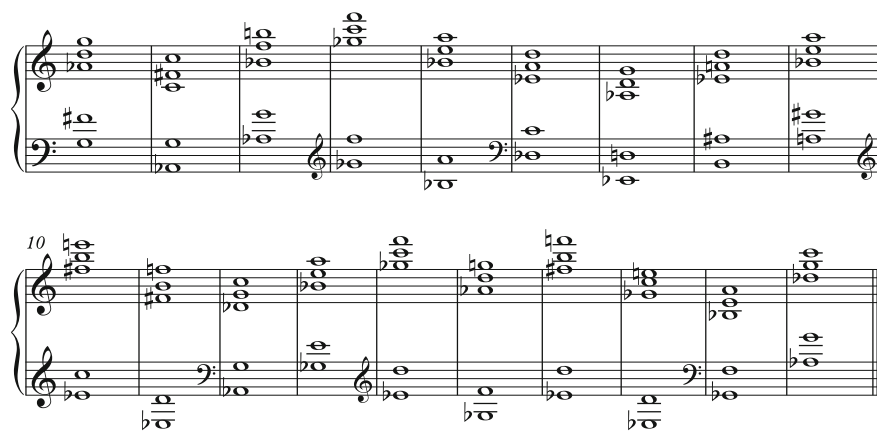


Fig. 4 Example chord sequence played by Harnik (cutout from recording No. 46)



**Fig. 5** Regeneration from recording No. 46

**POINT:** What do you think about the chords from our regeneration?

**Harnik:** Apart from the chords that are not possible to play due to their position for the hands, the regenerations are convincing. The consciously preferred interval combinations are reflected in the regenerations very well. The chords in bars 10 and 11 I would rather have played as 6-part chords. The combination of fourth and tritone, respectively, in the chord of bar 13 is also a very unlikely scenario.

I would also have formed the sequence of chords differently. Chords in a row are usually intuitively grouped during playing. Pedal points both in treble and bass would not normally be part of my repertoire. It would be more likely to have a single pedal point either in the treble or in the bass, but in this case I would have placed the flow of these chords only under certain conditions, deliberately and with effects that would follow.

**POINT:** In the next step, we regenerated freely improvised material. In order to handle the articulation of horizontal sequences, the entry delays—the time that elapses between two successive notes—needed to be modelled, and also the dynamic contour was a desirable property to be accounted for. Both velocity values and temporal values are problematic because they are theoretically continuous and practically represented using fine grained digital resolution, such that in a MIDI recording. So only with very low probability we would find identical velocity or duration values.

To produce meaningful corpora, we reduced the resolution of velocity and temporal values using a coarseness parameter. The velocity is linearly quantised from its original MIDI resolution of 127 to, for example,  $127/6 = 21$  steps. For the entry delay, we used logarithmic quantisation based on a coarseness parameter that specifies the number of steps per “time octave”. For example, with a coarseness parameter of 2, time values would be quantised to the nearest of 10, 14, 20, 28, 40, 56, 80 ms, etc.

Again, in order to keep the tree branching factors in the corpus high, we used separate snakes to model the pitches and to model the entry delays. With the entry



Fig. 6 Cutout from recording No. 48

delays being formed both from melodic progressions and chords, chord structures automatically appeared depending on the entry delays (if a chord appeared in the corpus, the entry delays for all but one note were nearly zero).

Besides making a selection from recordings of Harnik's free improvisations, the initial note and the seed of the pseudo-random number generator—used when a tree has multiple branches—influenced the development of the generated material. Figure 6 shows an excerpt from a recording of Harnik's play, and in contrast Fig. 7 shows material regenerated using the context snake method.

**POINT:** What do you think about the regeneration from recording No. 48?

**Harnik:** The interval structure and also the rhythmic flow of the regeneration are convincing. It is striking however, that in my recording the interval of the initially played fifth is then reflected back in further bars of the piece. The interval “floats” permanently as a thought, without manifesting itself. This aspect is only captured in the beginning of the regeneration.

**POINT:** Figure 8 shows a different excerpt from a recording (No. 9) of Harnik's play. We ran another regeneration, combining this recording with the previously shown one (No. 48). An example from the regeneration is depicted in Fig. 9. In contrast to the previous example, we used a separate modelling of horizontal and



Fig. 7 Cutout from regeneration of recording No. 48



Fig. 8 Cutout from recording No. 9

$\text{♩} = 138$

5

9

12

**Fig. 9** Cutout from regeneration from recordings No. 9 and No. 48

vertical structures here, alternating between them in the regeneration. Velocity and slight timing differences between the different notes of a chord are also incorporated, although not visible in the score.

For this alternative modelling, we partitioned the corpora into horizontal and vertical segments, modelling chords and melodic sequences separately. For example, the algorithm would start with a melodic fragment, choosing a number of notes according to the statistical distribution of sequence length. Next, a chord sequence would be generated as described above, incorporating the last melodic pitch. The results however sounded unnatural, probably because of the artificial division between purely horizontal and vertical segments.

In the discussion with Harnik, we concluded that horizontal and vertical structures can be understood as two renderings of the same underlying harmonic rules; melodic sequences thus can be seen as “horizontalised” chords, or chords as “collapsed” horizontal sequences. The technically simpler approach of the first regeneration, which disregarded any distinction between horizontal or vertical segments, was thus better suited.

**POINT:** What do you think about the regeneration from recordings No. 9 and No. 48?

**Harnik:** In this regeneration the flow of the rhythm is more successful than the interval structure. The beginning of the original recording No. 9 has an open-melodic character to it. From bar 4 the interval of the major second is spontaneously lit up and developed in the following sequence and at the end returns so that there is again an open melodic quality like at the beginning. The major second was thereby altered, for example, shifted chromatically or reduced to a minor second. The method of repeating the two tones only happens once. The regeneration also stresses an emphasis on single intervals, remaining involved with the repetition of sound. The choice of the six-part chord as a starting point for revealing the process I would definitely not have made. I would also not have played the repeating notes within such a quick gesture.

Overall, the regenerations are quite convincing. I observe that the subsequently conventionally notated originals and regenerations seem very strange to me. In fact, I don’t have this kind of notation in mind when I improvise on the piano. A closer match would be a sort of fingering notation that better honours the cooperation of both hands. This dimension does not open itself up, and makes reconstruction of my own playing very difficult. This insight confirms my assumption that the physical memory and the movements influence the process greatly.

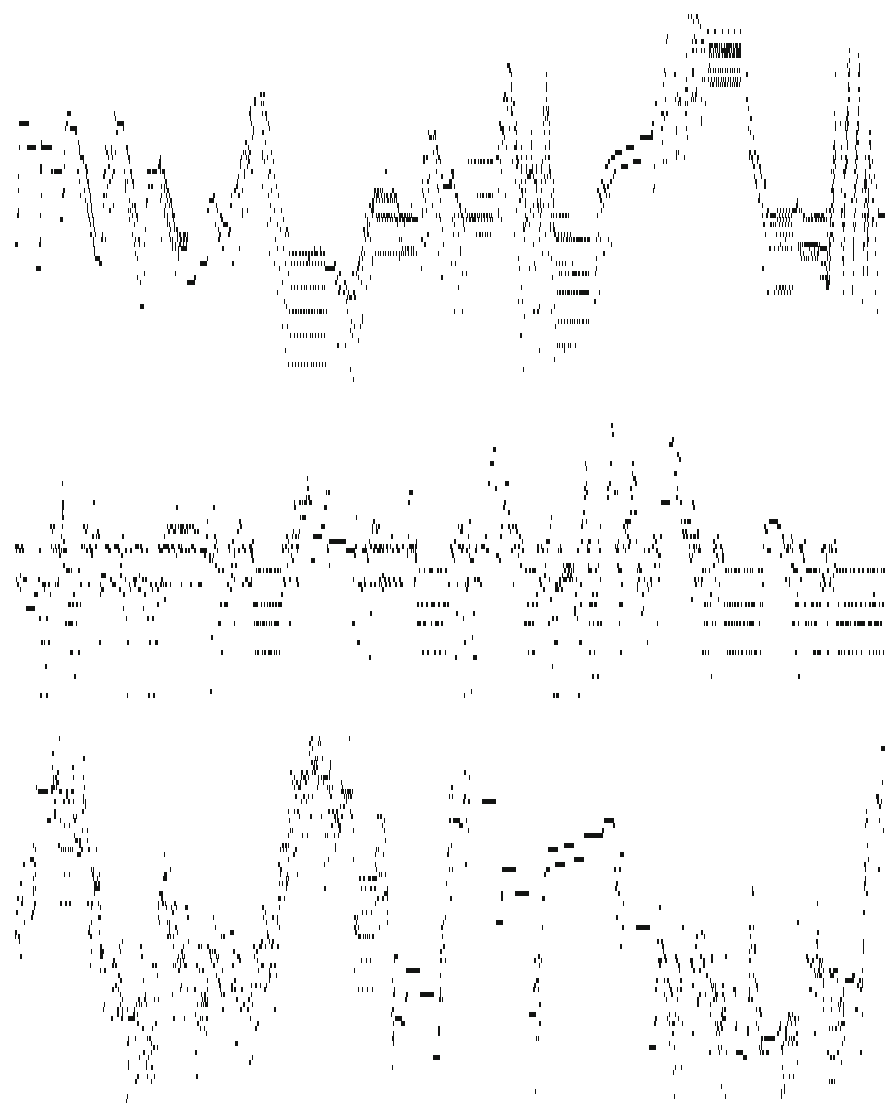
The tempo also plays an important role. The slower that I improvise, the more “analysis” is possible in real time. I can later on refer exactly to what I have played. My recordings would definitely be different if I reduced the speed. The examples given were deliberately performed at fast tempo, in order to investigate the unconscious flow of playing. I note that in addition to the conscious factoring out of diverse sound material for personal or aesthetic reasons, also the physical conditions of the body can effect the tonal expression. When playing at an instrument, complex patterns in movement occur. Fundamental in piano playing is the cooperation of the hands. I find it exciting to see patterns of solutions emerge from my play and how, in turn, they can be perturbed.

**POINT:** Harnik also pointed out that she was sceptical of the staccato character which can be observed in the acoustic rendering of the regenerated sequences. This resulted from the note durations being fixed, while the entry delays are modelled from the original corpus. Using the same logarithmic quantisation for the note durations, we were able to produce a new snake that used both quantised durations and entry delays as a combined vector. The result is a much more natural sounding articulation of the play.

Ideally, one would use a single vector that combines pitches, dynamics and durations, because these parameters are certainly not independent—for example, there might be a bias for low pitches to sound longer on average than the high

pitches—and generating sequences from “zipping” the output of individual snakes can lead to unnatural situations.

To alleviate the shrinking connectivity of the trees, one can try to shrink the feature space. As an example, we tried to use interval steps instead of absolute pitches, and acceleration instead of velocity, but we traded one problem for another. Figure 10 illustrates the different effect achieved on the overall form level. From



**Fig. 10** The *top* shows the original recording No. 42, the *middle* shows a regeneration using a context snake for absolute pitches, the *bottom* shows a regeneration using a snake for relative pitches (interval steps)

the original recording No. 42, shown at the top, two sequences were synthetically generated. In the middle, one sees the sequence produced from absolute pitches. Clearly, we can identify sections that share structure with the original recording, however the algorithm does not pay attention to the overall form and development, it lacks the slow motions across the keyboard which are seen in Harnik's play. These motions would require much larger contexts. We imagine that a future approach could try to model these "low-frequency" motions by decimating the material and modelling multiple "rhythms" on different scales. The bottom of the figure shows the attempt to allow slower oscillations to occur by using interval steps instead of absolute pitches. In the global picture, much slower motions appear now. On the other hand, the clear correlates in micro gestures are lost. As will be discussed further down, not all keys are "equal", for instance the layout of the keyboard with white and black keys is relevant, something that is captured by the absolute pitch snake, but lost with the interval step model.

A more refined model should also take specific styles of playing and movement into account. For example, often the highest played pitch has a significantly longer duration. In fast pattern repetitions, often there is one note that is replaced or dropped or added in each iteration. When playing localised "blocks", these blocks are often connected by the lowest or highest note of the preceding block that inverts its function in the succeeding block. In general, many oscillatory forms such as A-B-A-B-A'-B' can be found. There is in general a tendency of isolating specific elements from the play and elaborating them, going from "coarse to fine". Harnik described her strategy as an "enacted multitasking" or a "simulated multi-mind". She explains that her thought moves across different sound layers simultaneously. She is capable of adding these layers or "switching them off" at will, depending on the situation. A set of such "coordinates" of the sound space often define the initial situation in an improvisation.

To give an example, a "bothering" or irritating element is introduced. Also "mistakes" during the play function as a great trigger for changing the situation. In general, playing in an ensemble instead of solo, or having a prepared piano, makes it easier for such unforeseen elements to appear. Another important factor is the presence and dynamics of the audience. Further sources for a productive "irritation" might be a specific tuning of the piano (microtonality) or a noise emerging from the audience (a glass toppling over. . .).

We recorded video footage from Harnik playing on a grand piano. Figure 11 summarises some of the characteristic hand positions. Hands can be open or closed, there can be a small or large gap between them, or they are operating in "parallel", where usually the left hand is positioned above the right hand.

Overall, we could make out the following distinct forms:

- Glissando-forms, dragging the thumb across the white keys; this often used to separate repetitions of a particular gesture, where the repetition would change a particular aspect such as tempo or strength.
- Playing very fast and dense textures in the extreme high register of the piano, where one perceives rather an overall glassy granular texture instead of individual pitches.



**Fig. 11** Stills from a video recording of Harnik playing. Different motion patterns can be seen, as discussed in the text

- Clusters: a number of cluster techniques are available, for example using the hand flat or laterally, employing the whole arm (usually the right arm), or gliding with the back of the hand across the keys.
- A preference of the left hand for the black keys and the right hand for white keys can be observed when they play parallel.

- A circular motion between the two hands.
- Incorporating the sustain pedal; both hands are free to stimulate the overtones.
- “Mute” keys; one hand holds a number of keys silently in the bass register, then the second hand adds accentuating sound material, often using staccato, thereby making the open strings of the mute keys reverberate. This way, different overtones can be heard.

When discussing her techniques, Harnik said that the initial impulse comes from a bodily memory, for example whether the hands open or close. Subsequently, there are a limited number of possible movement patterns, which are constrained by the structure and various positions and motions from her hands.

**Harnik:** David Sudnow describes in his book “Ways of the Hand: The Organization of Improvised Conduct” [4] how he learnt to improvise jazz at the piano (“Improvisation Extempore”!) After initial unsuccessful attempts to mimic the sound, a breakthrough only came by practicing scales, phrasing and chord sequences: “As I reached for chords, and reaching for chords in the song context involves reaching for patterns of chords, for characteristic sequences, I was gaining a sense of their location by going to them, experiencing a rate of movement and distance required at varying tempos, and developing, thereby, an embodied way of accomplishing distances. What ‘there’ means is how it is to go from place to place as an accomplishment. The symmetry of the body, and that sort of extensional ‘self-consciousness’ that enables you to use a toothbrush without monitoring the course of the gesture and without smacking yourself in the face, entails a ‘system’ with elaborate distancing capabilities.” [4, p. 12].

Instrumentalists from all performative practices can certainly confirm this experience. It does not matter what type of pattern you play, the feedback system between perception and motor skill applies. Any form of music, whether composed or improvised formulates “patterns”. One can indeed “objectively” classify and transcribe these patterns, but the dynamical basis of the sensorimotor processes that is in a state of oneness with the instrument cannot be described.

Before a sound is created on the instrument, there is also a preparation in the body. Even before the sound is physically shaped, it is already modelled in the imagination in this state. In improvisation this ability is used more than in interpretation. Any type of movement is coupled to a more or less predictable sound result. The different basic positions of the hand are more open in their usage. They mark a “place” and can be interpreted differently depending on the situation. Remembered or imagined sound material can certainly trigger movement impulses. Conversely, however, a given impulsive movement can trigger sound and its processing. These decisions, out of necessity, often happen very quickly. Certain compositional methods, in which a real-time analysis is not possible, are eliminated from the outset. Position of the hands and types of movement define these loose sound “folds” that can be expanded depending on the situation. Active listening acts as an inner compass.

There is also another aspect concerning the hand gestures. They can, for example, not only be used for a particular expression to reinforce, or to strengthen. They can also be deliberately “played with”. A gestural preparation can trigger a certain tonal

expectation from the audience. It is possible to acknowledge this as a performer, or not to. The surprising “breaking” of expectations gives the audience a possibility to witness for themselves the flash of the moment. In addition, it keeps the creation alive. Due to irritation on the plane of movement possibilities, I am challenged as a performer to improvise a new solution. A variety of pianistic gestures—historic to contemporary—are available to draw from. Here I would emphasise again the cultural conditioning. Since my classical piano lessons, I have expanded my repertoire of gestures—partly from other genres but also by experimental development of my own movement patterns. It is interesting to me that I often assign gestures and playing techniques that come to me from other instruments. In this sense I observe a tendency of multi-instrumental gestures, which I bring into my repertoire.

**POINT:** What additional components come to fruition in an improvisation, for example, in response to the audience, preparations. . . ? How about all the aspects that evade modelling, aspects that cannot be notated as pitches, durations and dynamics?

**Harnik:** Exclusive performance on the piano keys comes into my performance practice very rarely. In my improvisations it is mostly a combination of the piano keys and playing techniques in the interior of the piano. I use various types of preparations, including moveable objects. Furthermore, I also use sounds and noises that can be generated on the surface of the instrument or on the body itself. It is also possible to include the sound material that may be evoked by a loose piano stool or the creaking of a stage floor. Furthermore, the quality and acoustics of the concert room together with the presence of the audience is part of the creation in real-time.

## Project Review by Elisabeth Harnik

The interaction of imagined sound and its realisation on the instrument is a central aspect of any improvisation for me. How strongly will physical memory and automated motion patterns control the improvisation? Would other sound solutions be provoked through the changes in movement or does the realisation on the instrument follow the sound imagination? The work and results of this project have delivered me an interesting incentive to observe these queries from a new perspective. It was very enlightening to me, especially through the diverse generated music examples in this project, to trace my musical patterns, which arise from an embodied knowledge, in an innovative way. That the regenerations arose only out of my well-rehearsed material, offered by evaluating the results, a musical counterpart, which allowed me, to a certain degree, to perceive my improvisational structures from an external perspective, thus to reflect in a new and unusual way. In the time of this project a greater incentive was built to deliberately break the collections of movements in my future improvisation practice.

I also found with respect to reflecting on my work, the question of an adequate notational representation of the improvisation processes very stimulating. Notation is not normally the goal of an improvisation. Until now, I have not found a method to do justice to transcribe my improvisations. I can well imagine that the future of

my compositional work will reflect on transcribed or regenerated sound material, to extract from it, or to use it as a basis for various methods of composition. As an improvisational musician, it is more and more obvious to me that what especially interests me is how the “tonal language” emerges, regardless of the art or type of productions used.

## References

1. Grinstead CM, Snell JL (1998) Introduction to probability. American Mathematical Society, Providence
2. Kohonen T (1989) A self-learning musical grammar, or ‘associative memory of the second kind’. In: International joint conference on neural networks IJCNN. IEEE, pp 1–5
3. Nierhaus G (2009) Algorithmic composition: paradigms of automated music generation. Springer, New York
4. Sudnow D (1978) Ways of the hand: the organization of improvised conduct. Harvard University Press, Cambridge
5. Ukkonen E (1995) On-line construction of suffix trees. *Algorithmica* 14(3):249–260

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