New Techniques, New Instruments: Juxtaposition, Modification and Design

Cor Fuhler, 2016

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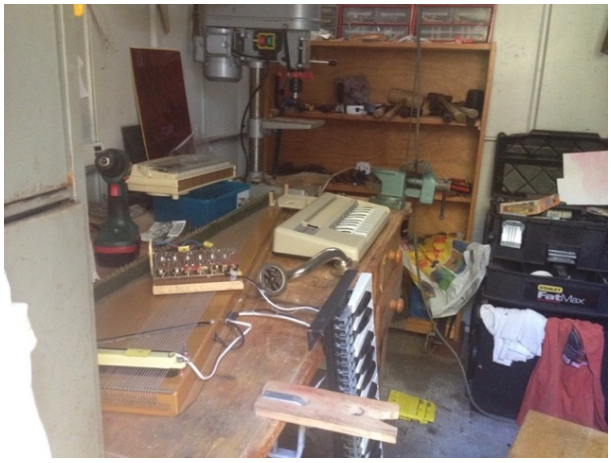
1 - Introduction

My DIY tools in my shed are an essential part of my musicianship and compositional thinking. A guitarist or accordionist adjusts his or her strap for physical reasons, I adjust musical instruments for musical reasons. My screwdriver, soldering iron and cordless drill are equally important to me as my guitar, piano or synth. This short writing describes my personal methodology in regard to instrument building, from playing an instrument utilizing a found object (juxtaposition), via developing customized devices and permanent alterations (modification), to building a completely new instrument (design). I focus on three of my main instruments: grand piano, analogue synthesiser 'EMS Synthi AKS', and keyolin: a hybrid violin/keyboard, and add a chapter about installations.



My shed on 01/05/2016, displaying a modified clavinet in repair, a gramophone soundbox in repair, and two (out of three) portable harmoniums for a computer controlled part of an installation for the Tyalgum Music Festival in 2016.

2 - The process

New techniques can lead to new musical instruments via various stages within a process: juxtaposition, modification and design. What do these words mean in this context?

Stage 1 - Juxtaposition

At some point in time, a person playing blues-guitar picked up a bottle and tried it on the strings, thus creating glissandos which would have fitted perfectly within the expressive style of the music. He/she could have lived happily ever after, however....

Stage 2 - Modification


Pleased with the results this person chopped the neck of the bottle and smoothed the sharp edges to make it more practical. Again, he/she could have lived happily ever after, however, a spectator witnessing this thought, "Let's make a dedicated piece of glass in different sizes and market it". Thus, the 'bottle neck' was born. Yet again, all could have lived happily ever after, however....

Stage 3 - Design


Another person started playing it the guitar on his/her lap horizontally and and thought of adding strings. Then, wanting more options with intervals, this person thought of a pedal system that could control the tuning of the strings. Dissatisfied with the shape of the guitar, the person in question built something anew that could fit pedals, adjoining mechanical systems, additional strings and electromagnetic pickups, and so, the 'pedal steel guitar' was born. This example shows clearly how new techniques sometimes are fine just the way they are; sometimes can/must be improved; and sometimes trigger an idea that leads to a completely new instrument.

3 - Piano

The inside of the grand piano is an ideal area for experimentation with easy access to the strings and with gravity to keep chosen objects in place. In history there are examples of experiments using your hands (or mallets) directly[1], or placing objects on the strings, ultimately leading to John Cage's *prepared piano*, in which objects, such as screws and bolts, are structurally attached to the strings. The prepared piano was a new instrument with new sounds, new functions and new approaches, for which many dedicated compositions were written. In contrast to this approach, this chapter describes a number of flexible devices I developed, which can be used inside the piano as a real-time additional improvisational or compositional tool. To demonstrate the process of developing a 'found object' into a modified stand-alone device, I will use three examples of my own practice: Ebows, THRAs and EMBs.

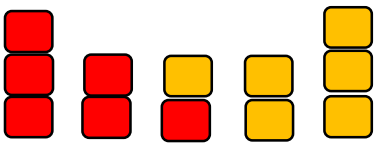
3.1 Ebow: Electronic Bow

> *The EBow is a battery-powered electronic device for playing the electric guitar. The EBow uses a pickup - inductive string driver - feedback circuit, including a sensor coil, driver coil, and amplifier,*

[1] For example, pieces by Ruud Langgaard, Henry Cowell and Percy Grainger.

to induce forced string vibrations. The Ebow is monophonic, and drives one string at a time, producing a sound reminiscent of using a bow on the strings.[2]

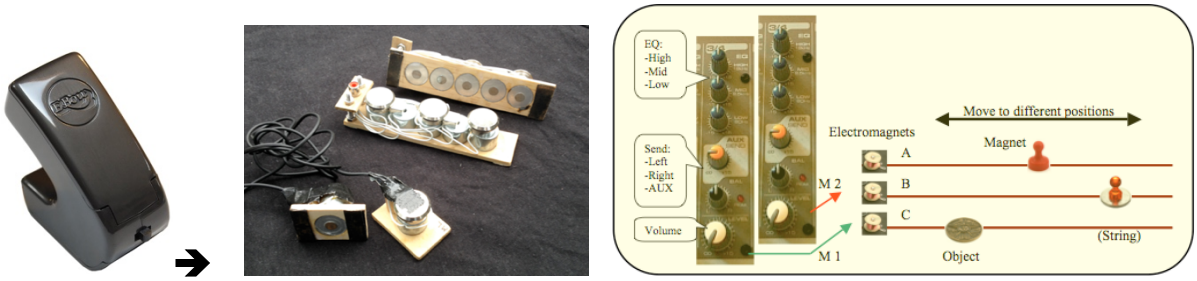
Around 1990 I bought an ebow, invented by Gregory Heet in 1969, and tried it inside the piano. Soon I realized the distance between strings and the electromagnetic field the ebow uses to activate the strings, was to large. Therefore, I used sandpaper to lower the distance with very positive results. However, when the distance is too small, the string rattles against the device itself, therefore I created three ebows with different heights for different areas in the piano: close to the strings for the high notes and further above the strings for the middle range. In this way I have a choice between a rattling sound and a clean sine wave. In 1991 I used these three ebows in *De Lamp, de Knijper en het Molentje*, during a solo concert in Amsterdam, and in 1994/95 I recorded my first solo CD *7CC IN IO*. A few years later I possessed 12 ebow and had to think of a system to instantly know the distance between device and strings.



More red stickers on the Ebow indicates larger distance, more yellow indicates less distance.

Around 2005, I was introduced to the 'super magnet'[3] which can be placed firmly on the ferrous[4] strings. This lowers the pitch considerably and therefore increases the range an ebow can activate, since the lower strings of the piano are made mostly of copper and are therefore non-ferrous and non-magnetic.

An Ebow is a passive device, it picks up a frequency and enhances it. In order to be able to influence its output, I replaced the battery with an audio signal which is translated into electromagnetic waves which activates the strings it is put upon. I can send noise, pre-recorded material, sound from a micro synth, radio signals, etc., and I can choose which string the ebow is put upon and which preparations to use. In order to improve the working of the Ebow, I first used guitar pickups and then built my own electromagnetic devices.



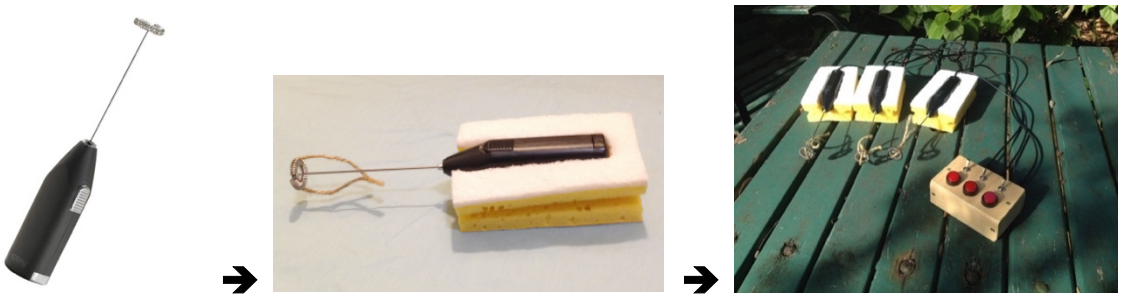
An Ebow, my self-made electromagnetic devices, and the setup in which they are used: input to mixer to electromagnets to (prepared) strings.

3.2 THRA: Thread Rotating Activator

When I first used a handheld, battery-operated milk frother, I simply used the end of the device, rotating against a string, much like a mallet. The THRA is a milk frother with a piece of thread attached to the end, which spins around and hits a number of adjoining strings. In contrast to the relative simple tone of an Ebow, this results in a relatively harmonious complex sustained sound, even if the thread hits a chromatic cluster

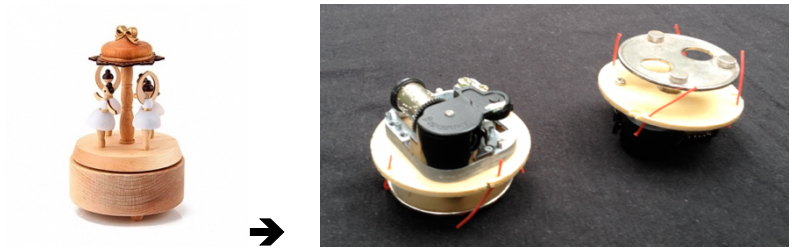
[2] https://en.wikipedia.org/wiki/EBow, accessed 08/04/2016.
[3] Developed in 1982 by General Motors and Sumitomo Special Metals, neodymium magnets (super magnets) are the strongest type of permanent magnet commercially available.
[4] Containing or consisting of iron (Fe).

of three to four notes. The THRA can be handheld (as a mallet) to play any strings inside the piano, or put in a fixed position within a customized holder in order to have both hands free.



Above picture shows a standard milk frother, a THRA (placed in a modified sponge) and three THRAs connected to a self-made switchbox with two types of on/off buttons: temporary and permanently. I built this setup for a piece for piano and violin[5] so the pianist could instantly access three different chords/harmonies via the switchbox whilst free to read the score and play the keys with the left hand.

3.3 EMB: Empty Music Box



Above two pictures show a traditional music box and two EMBs. First I took the plucked comb with tongues out (hence the 'Empty' in EMB), so it becomes silent and solely a mechanical rotating device. I then added four plastic 'straws', functioning as plectrums, to the top of the device. To make sure these plectrums were able to pluck the strings with enough force, the device needed to be in a fixed position on top of them. This is done via three super magnets, glued underneath the device, which simultaneously prepares the strings. I have used these devices in a number of my compositions and they have become a part of my usual piano setup.[6]

3.4 FlexRA, Flexible Rotating activator

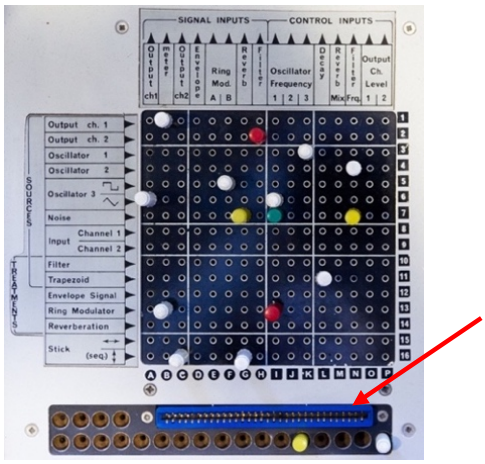
[5] *Please Shoot my Hovercraft*, 2014, was composed for Anna McMichael - violin with customized capo, and Zubin Kanga - piano and three THRAs, at the Workshop, Sydney Conservatorium, BIFEM in Bendigo and MONA FOMA in Hobart.

[6] For example, I used four EMBs in *18 Spoonfuls*, for piano and violin (track on etc.) 2012, eight for *Draaikolk (Whirlpool)*, for two pianos (four each) 2007, and six in *Draaimolen (Merry-go-round)*, for piano solo 2007.

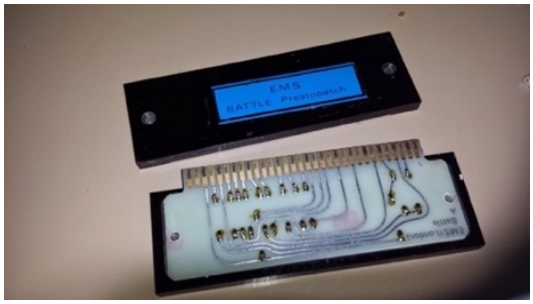
I had been using a motor with a plastic spinning wheel to 'bow' piano strings but I wanted to create something that was more pressure sensitive, resembling a violin bow. I took the lid of a peanut butter jar, created an empty ring in the middle and attached the outer ring to the inner part with flexible cord. Rather than the 'all or nothing' contact between device and strings, I now could apply different amounts of pressure, leading to more variety in volume and tone.

4 - EMS Synthi AKS

Starting on a transistor based Eminent organ, I have played electronic keyboards for most of my life: synths, organs, clavinets, pianets, samplers, cheap toys, etc. In the 1990s I focused on the digital, FM based, DX7, and around 1998, I bought an analogue modular 'EMS Synthi AKS'. The EMS uses a matrix patch board for making the connections between the modules.



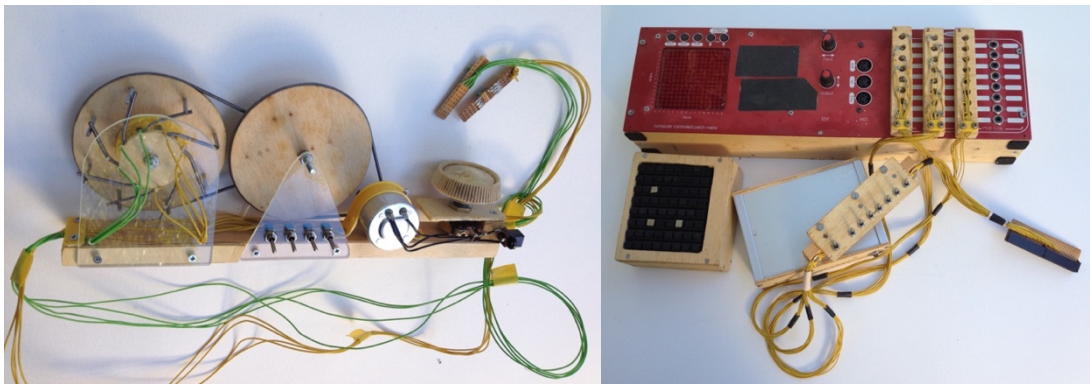
Above picture shows the EMS Synthi AKS and a close up of the matrix with white and coloured pins, sending an output to an input and thus creating a 'patch'. A unique feature of the EMS is that it presents all ins and outs beneath the matrix in the blue rectangle (indicated by the red arrow). The EMS company made 'prestopatch' boxes which could be pressed into the slot and present an 'instant' patch.



An opened prestopatch box, called 'Battle', showing the routes from ins to outs.

This slot with all ins and outs makes it possible to create devices that route the connections in various ways which makes it a useful tool for live performance because I can instantly make a new patch without having to change many pins. I have added a whole range of self built routers, either operated manually, mechanically or via computer.

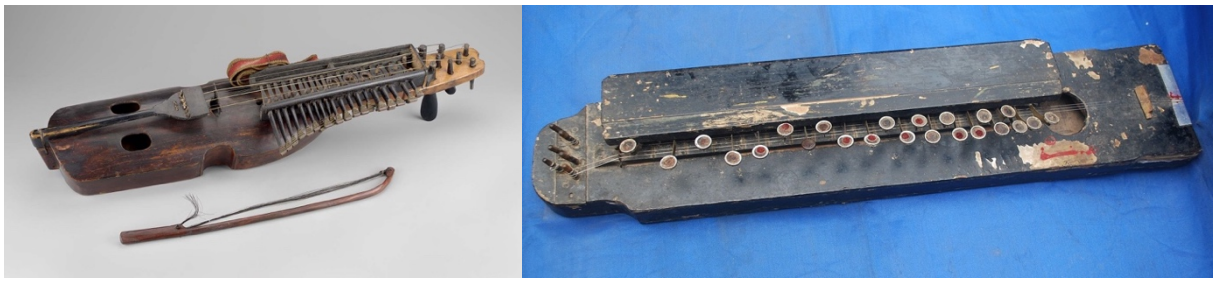
Left picture: An ‘official’ prestopatch next to a number of my first experiments making flexible prestopatches with more options to generate instant patches. Middle picture: two rotating ‘wheels’ that are attached to the side of the EMS, the one on the left has 2 x 4 connections (to be put anywhere in the slot) to a fixed pattern inside the wheel that can be rotated into eight different positions; the one on the right has 2 x 8 connections and can be controlled via different wheels (three are shown in the picture). Right picture: a close-up of the 16 connections upon which a wheel is placed. These connection points are tiny springs which are not aligned perfectly and therefore, by adding different pressure to the wheel, more connections are made which makes the wheel a physical and intuitive instrument in itself.



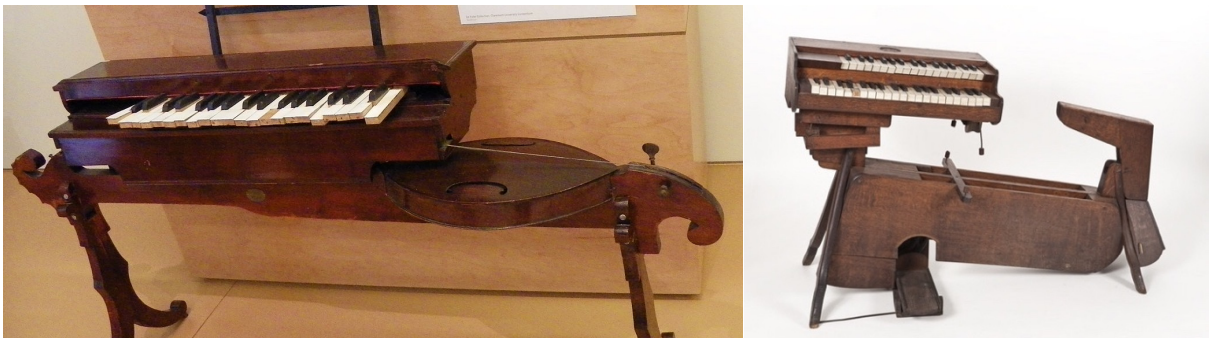
Above picture on the left is an automated connector working via a motor with speed control. The four possible connections are made via three cm long springs and can be turned off individually. The picture on the right shows the computer controller (the red box), a box with 64 buttons for instant access to the pre-programmed patches, and a small device that can disconnect eight outputs individually.

5 - Keyolin

With the piano and the EMS, I had two instruments that already worked perfectly on their own. The only thing I dad was add devices and techniques to adjust them to my personal preferences. With the keyolin I solely had an idea in my head, which made the whole process uncertain and full of doubts. For certain techniques and building structures I had to test and practice them for a substantial amount of time before deciding it was worth pursuing or a dead end road. In hindsight, there already were numerous existing instruments using a mechanical system to control pitch of a single string, such as in traditional folk music (either plucked, or bowed via mechanical wheel or traditional bow): hurdy-gurdy, nyckelharpa (Sweden), schlusselfidel (Germany), bulbul tarang (also called benjo, India) and taisho-koto (Japan). Also, in the classical music tradition there have been attempts towards an instrument similar to the keyolin.



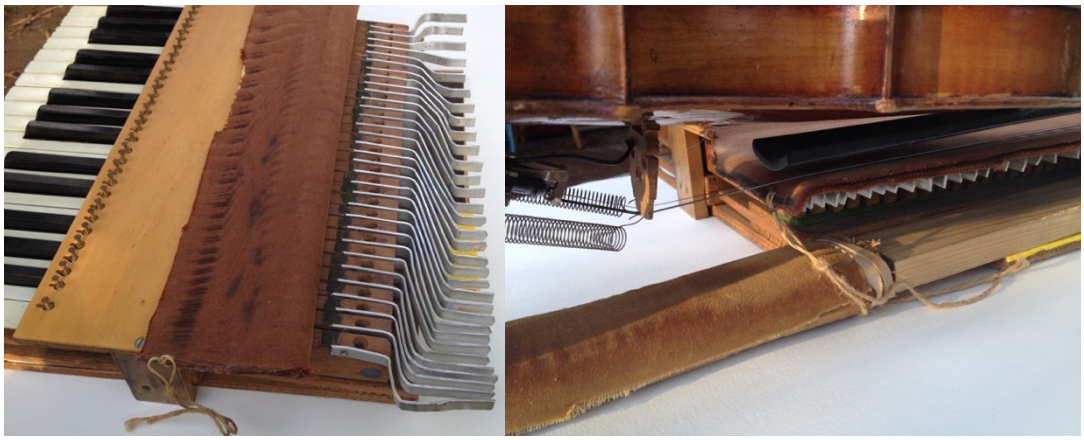
A traditional Swedish nyckelharpa, using buttons, and an Indian bulbul tarang, using old parts of a typewriter.



A monochord using a keyboard, built around 1890 in France[7], and a contraption in which a cello had to be placed and that also had a vibrato pedal.

However, I did not know these instruments when I started to build the keyolin in the 1990s (first performance in 1997), and I could have ended up building something very similar to one of the above mentioned instrument. So, what makes the keyolin unique?

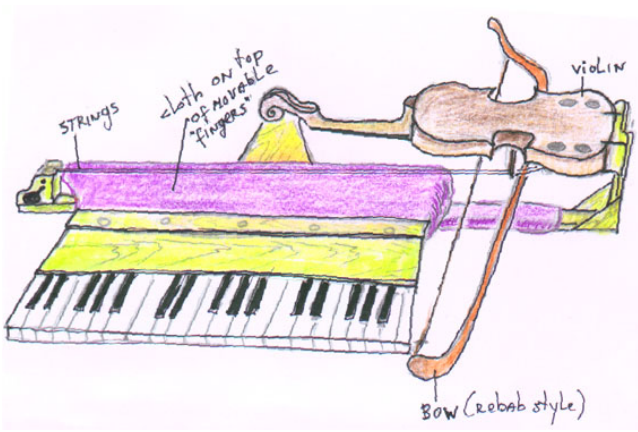
All these instruments above have mechanical parts that one can hear directly or indirectly, in short, there is a bit of 'clang' added to the attack of a note. Furthermore, the ones that are bowed, are played with the bow above the string, and are therefore working with gravity and the weight of the bow. I solved the 'clang' issue and I choose a very different bowing technique. I will explain.



I started with the keys of my first piano. I used the lever system of the key to attach an aluminium strip. My first goal was to make all mechanisms from keys to the string fit perfectly without touching each other whilst the end of the aluminium strip still arrives at the right position for the corresponding pitch. Naturally, towards the high notes, with less space to work with, this was increasingly difficult. Playing the first version of the keyolin with the aluminium directly on the string, sounded mechanical and the pitch of the note was often

[7] A similar instrument can be heard and seen on: https://www.youtube.com/watch?v=UdJB76hOGIc, accessed 10/07/2016.

unstable similar to wolf tones.[8] I started to experiment with different materials in between aluminium and strings, and found that a thick layer of cloth worked best in the way that now it resembled the flesh of my fingers and at the same time dampens the sound of the mechanical parts (the cloth is folded back in the above picture on the left, but it can been seen in between string and aluminium on the picture on the right). But, most importantly, I can, by slowly going to the adjoining key, make a glissando, as there is now a gradual transition phase made by the cloth. Also, partials can be made by slightly pressing a note above the played note (naturally, a major 3rd, perfect 4th or perfect 5th interval works best). I decided to use two strings[9], tuned an octave apart.



At first I had problems with controlling my bowing, because, when a key is depressed and aims for a vibrato effect, the string goes up and down a substantial amount and the bow will start bouncing. Also, I wanted to use a real violin to make it an acoustic instrument and the only position the violin could be, without major alterations to the instrument, was above the mechanism. After making a provisional setup, I tried my rebab[10] bow from underneath, the wooden part of the bow resting on the contraption in which the violin was fixed, and the hair pushed against the string. In this way the vertical movement of the string can be 'absorbed' by the hair without gravity interfering. Furthermore, by 'flinging' the hair rhythmically against the string with a movement of the wrist, I could imitate a breathy pan flute. In order to avoid external noises, I wound a piece of soft cloth around the area where the wood of the bow slides across the wood of the contraption.
A few years later I attached two small springs to the bridge to create an acoustic reverb effect. I also added a simple mechanism, in the form of a screw and a hole, that could keep a key depressed, functioning as an open string. In the above picture on the right one can see the note 'b' kept down via this system.

6 - Walking, Skiing, Floating

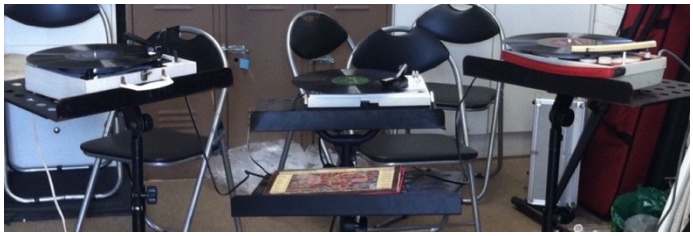
One can compare playing piano to the act of walking or running: everything continuously has to be set into motion, otherwise the motion will simply stop. The EMS can be compared to skiing downhill: the motion and energy are already there. One has to channel these forces and continuously adjust one's decisions to a number of unpredictable factors. Both running and skiing are fascinating sports, but they can be opposite

[8] From Wikipedia: A **wolf tone**, or simply a "wolf", is produced when a played note matches the natural resonating frequency of the body of a musical instrument, producing a sustaining sympathetic artificial overtone that amplifies and expands the frequencies of the original note (https://en.wikipedia.org/wiki/Wolf_tone, accessed 12/06/2016).
[9] I ended up choosing a viola 'd' and a guitar high 'e' string, leading to a range of (F / F#, difficult to activate) G - c''''' (which can be pushed up to d'''''). One has to keep in mind that the two strings sound very different, which should be taken into consideration when composing for the keyolin.
[10] The rebab is an Indonesian gamelan instrument, with two strings, bowed via a bow in which the distance between the wood and the hair is approximately 10 cm. The hair is tightened by the bowing hand during playing. I have played this instrument for many years in the 1990s and 2000s as part of the gamelan ensemble 'Wido Sari' in the Netherlands.

and not to everyone's liking or scope. When I play piano or play EMS, working with different forces and acoustic projections, I have to appeal to different sides of myself, my personality and my brain, and also adjust my function and relationship within an ensemble.
In the process of making instrumental alterations, one can try and compensate for whatever one thinks the instrument lacks for whatever personal reasons. Because the piano is a very 'one on one, action = reaction' type of instrument, I was aiming for a certain amount of unpredictability and ongoing energy in order to juxtapose the fundamentals of 'normal', historic if you will, piano playing. With the EMS, I tried to add a certain amount of temporary control by building devices that gave a number of consistent sounds that I could use to create a certain momentum.
Sometimes one finds something that is new to one's self. Then one has to find a place for it in one's musical strategies and re-write one's own musical knowledge. Such was the case with the keyolin. At first, my musical thinking and musical focus points did not overlap much with the possibilities of the keyolin. The instrument was soft, unaffected by gravity and constantly floating in the air, due to the unique bowing technique. It acted more like an 'eternally floating butterfly' than the solid sonic world of the piano, guitar and synths I was used to. However, the instrument is extremely pronounced and detailed when playing melodies and with phrasing and colouring within a clear pitched world. After a number of situations that was less than optimal for the keyolin[11], I decided to form an acoustic band (called 'PPP5'[12]), operating mostly within soft volumes, and write dedicated compositions within the appropriate range for the instrument. The keyolin could thus be featured and do what it was best at: pitch related melodic, harmonic, oriental and in-tune virtuosic improvisations.

7 - Installations

Above instruments, piano, EMS and keyolin, are traditional instruments in the sense that they posses a number of real-time parameters for *musical processes* to create form via melody, harmony, tone colouring, volume, density, etc.
When making an installation, one's approach and motivation to instrument building is different. What is musical development with an inner logic during a piano concert, becomes a static process in relation to space and the environment within an installation. A concert is attended from start to finish; an installation is visited randomly for a flexible amount of time. However, in my installations I aim at a sound world that are static and complex at the same time, using *stochastic processes*[13] that never repeat, but are consistent nonetheless, and worth to be revisited because time and the environment will have changed one's perception.



Above picture shows an installation called 'Instant Poetry' consisting of three turntables, controlled by a computer based microcontroller[14] which switches randomly between them. All three turntables play LPs

[11] During the first years of playing the instrument I encountered a socially related problem: I noticed much scepticism and confusion from colleagues that simply could not accept/picture me as a virtuosic 'violinist'.
[12] PPP5: Cor Fuhler/keyolin, Alex Waterman/cello, Jan Rokyta/cimbalom, Michael Moore/clarinets, and Steve Heather/percussion.
[13] Stochastic: having a random probability distribution or pattern that may be analyzed statistically but may not be predicted precisely. (from Apple Inc. Dictionary, v 2.2.1)
[14] Arduino Uno board connected to a board of relays which are connected to the speakers of the turntables and thus turn them on and off in an order created via the software of the Arduino Uno.

solely with spoken word, thus the microcontroller will create random sequences of (parts of) sentences and single words. The listeners brain is linguistically 'hardwired' to make sense of these words which can lead to absurd, humorous and also strangely profound outcomes.

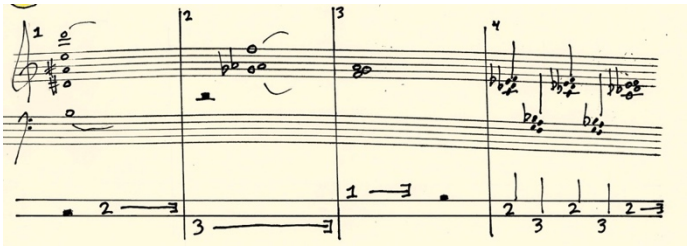
Above picture on the left shows a juxtaposition in the form of a row of fishing rods with a hanging vibrator, each randomly hitting three brass bowls/bells/cups, creating a consistent but ever changing rhythmic and harmonic sound world. The picture on the right shows *Doze(n)*: a combination of a musical composition, conceptual visual object and interactive installation. It consists of 12 CTMBs: 'Comb Transplanted Music Box'. Within a music box there are two music generating elements, a comb with reeds (the notes) and a cylinder with embossments to pluck these reeds in the desired order to create the classic melody it was designed for. I replaced all combs with another comb from a different music box (hence 'transplanted') and therefore they now produce an '*otherly song that remind you of something*' instead of the classic song intended. I added rules regarding how to play these 12 CTMBs and put them in the frame of a broken mirror.

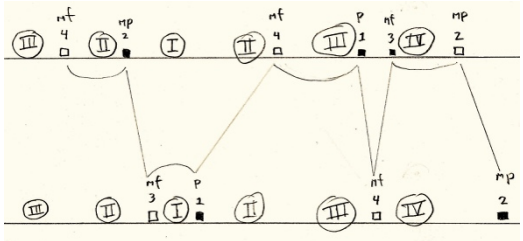
8 - Encores

Above picture shows the 'magnophone' (which was my working title) which uses parts of a pianet.[15] The right picture shows reeds from the pianet plucked by a magnet and, by pressing the key, another magnet makes the pitch go up. I 'tuned' the magnophone so all pitches would go up a major 2nd when the key was pressed fully. The 'magnophone' is an example of a not very successful instrument. Mostly I have an idea which I can test quickly to see if it worthy of pursuing, but sometimes one has to go through a long tedious process to come to the same conclusion: fail. History is full of similar examples, and personally I feel we should celebrate these as much as the successful ones: Yin and Yang.

[15] The Pianet is a type of electro-mechanical piano, built by the Hohner company during the 1960s and 1970s, which uses reeds.

Above is a picture of the 'boutar': a combination of bouzouki and guitar. I made this instrument from the body of a Hofner style bass guitar and the neck of a guitar in order to play rebetiko[16] style music. The only (permanent) modification is the addition of a second e-string, so the melody can be played on a pair of strings just like a bouzouki. The magnets placed on the lower strings create a temporary capo, in this case the open strings become a D major chord.





Two examples of notation within a formal composition: an excerpt from *Hiccuped Aquarium* for piano solo from 2015, using three THRAs (called 1, 2 and 3 in the lower stave), and an excerpt from *Draaikolk (Whirlpool)* for two pianos from 2007, using 2 x 4 EMBs (called I, II, III and IV).

9- Summary

The act of instrument building and playing with music and objects, is one that should be a natural part of our musical education system and everyday musical practice. It promotes curiosity, experimentation, 'thinking out of the box' and it instigates critical thinking towards traditional instruments and their history. Subsequently, a healthy questioning attitude can lead to understanding and appreciation of history as an ongoing development that needs to be fine-tuned continuously by the present. It leads to new approaches, new ideas and new inventions, which can lead to solutions of today's problems on many levels, big or small.

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[16] Rebetiko (also rembetiko, rembetika) is a style of urban music with Greek and Ottoman influences originating from the 1930s. It combines western harmonies and melodies with oriental modal (and sometimes microtonal) playing. Although claimed by the Greek as their own national 'Greek blues', the foundation of rebetiko is the juxtaposition of many musical cultures including Western art music, Ottoman (Turkish, Arab), Greek, Romany (Gypsy), Jewish, Armenian, Balkan, etc.

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