ANALYSIS OF A GENUINE SCRATCH PERFORMANCE

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1. INTRODUCTION

To scratch means to drag a vinyl record back and forth against the needle on an ordinary turntable along the grooves, not across, though it might sound like it. This way of producing sounds has during the last two decades made the turntable become a popular instrument for both solo and ensemble playing in different musical styles, although mostly hip-hop. However, all musical forms seem to keenly adopt the turntables into its instrumental scenery, traditions like rock, metal, pop, disco, jazz, experimental music, film music, contemporary music and numerous others. The musicians are called *DJs* (disc jockeys) or *turntablists* (from the words ”turntable” and ”turntablism”).

The aim of the presented experiment is to model scratching based on analysis of an experienced performer. For this purpose scratching as an expressive musical playing-style is looked at from different views. The experiment investigates a real performance with aid of sensors on the equipment in order to understand what kinds of problems and parameters variation a model will need to deal with.

1.0.1. Subject

The subject is Alexander Danielsson, *DJ 1210 Jazz*, a professional DJ from Sweden. He volunteered for the experiment. 1210 Jazz (as he will be called throughout the paper) has no formal musical training, but has for almost 15 years been considered among the best turntablists in Sweden and Europe, a reputation he has defended in DJ-battles (as competitions for DJs are called) as well as in radio and television programs. He has made two records for DJ use, so-called *battle records*, one of which was used during the recording sessions.

1.1. Material

The recording discussed in the following was done at KTH in Stockholm during 2001.

The equipment used for the experiment is summarized in table 1.

1.2. Instrument line-up

Mixer and turntable were placed in a normal playing-fashion with the mixer to the left. The turntable was connected to stereo-in on the mixer. Output was only right channel, while the left channel was output to a headphone mixer so the DJ could hear himself.

2. EXPERIMENT: ANALYSIS OF A GENUINE PERFORMANCE

2.1. Analysis

In order to acquire knowledge about how scratching is performed and how it works and behaves musically, an analysis of several aspects of playing was necessary. Results from this analysis can be used as a starting point for implementing future scratch-models.

2.2. Method

In the DJ 1210 Jazz recording sessions eight performances were executed, all of which without a backing drum track. Since 1210 Jazz is an experienced performer, the lack of backing track was not considered a restraining or unnatural condition even though scratching often is performed to a looped beat.

2.3. Equipment

2.3.1. Vinyl movement

A potentiometer was decided to be best suited to easily map the vinyl movement. The 3 $\frac{3}{4}$ rounds coal bane 10 kW potentiometer was mounted to the vinyl with the help of a stand and a cylinder attached to the record centre. Output was recorded to a multichannel DAT. The potentiometer was chosen based on how easily it turned. No effect could be noticed in the performance and friction on the vinyl when it was attached. See Figure 1.

Turntable	Technics SL-1210 Mk2 with felt slipmat		
Cartridge	Shure M44-7		
DJ-mixer	Vestax PMC-06 Pro		
Faders	Vestax PMC-05 Pro		
Record	1210 Jazz - Book of Five Scratches. Book 2.[4]		
Potentiometer	Bourns 3856A-282-103A 10K		
DAT-recorders	Teak RD-200T Multichannel (*Exp. 2 only*)	Channel 1 (20 kHz)	Potentiometer
		Channel 2 (10 kHz)	Crossfader
		Channel 3 (10 kHz)	Sound
	Sony TCD-D10 (*Exp. 1 and 3*)	2 channels (44 kHz)	
Wave analysis software	Soundswell Signal Workstation[1]		
	Wavesurfer [5]		

Table 1: Equipment used for the experiment

2.3.2. Crossfader movement

The crossfader runs over 45 millimetres, but the interesting part, from silence to full volume, spans only two-three millimetres some millimetres from the right end of the slider. Two cables connected from the circuit board to the multichannel DAT recorder tracked the slider movement, but not automatically the output sound level. Because the crossfader did not respond as the DJ wanted to, he glued a credit card to the mixer, thus shortening the distance from the right end to where the crucial part (the so-called cut-in point) is. Positioned to the right, the crossfader let no sound through, and moved a few millimetres to the left it let all sound through.

2.3.3. Sound output

Only the right channel of the stereo signal was recorded to the multichannel DAT, but that was sufficient for evaluating the record movement output against the sound output.

2.4. Calibrations

Both crossfader and the potentiometer had to be calibrated.

2.4.1. Crossfader

To read the sound output level from the position of the crossfader every millimetre was mapped to a dB level, but there was a problem involved as the slider had some backlash (free play in the mechanics). By using two different methods, both with step-by-step and continuous moving of the crossfader, the sound levels on a defined sound (from a tone generator) could be found and used as calibration for the output level. See Figure 2.

2.4.2. Potentiometer

The potentiometer had a functional span of about 1220°, 3 $\frac{1}{2}$ rounds. Unfortunately it was not strictly linear, but we succeeded in making a correction to the output values so the adjusted output showed the correct correspondence between angle and time. See Figure 3.

The dotted line in Figure 3 is the original reading from the potentiometer going 3 rotations in 6 seconds. The dashed line is the correction-curve used to calibrate the readings. The drawn line is the corrected original signal later applied to all recordings. Voltage, with volts as unit, was adjusted to ”rounds” with degrees as unit.

2.4.3. Material

The DJ was asked to play in a normal way, as he would do in an ordinary improvisation. He was not allowed to use other volume-controller than the crossfader, but as the crossfader is by far most used in a performance, and the other controllers is used in a manner to achieve the same sounding results, this does not affect the analysis severely. The performances from that session are by all means representative examples of improvised solo scratching with a clearly identifiable rhythmic structure, and one of those will be used here. 30 seconds of music is analysed. All sounds produced are originated from the popular ”ahhh” vocal intro to ”Change the beat” [2]. This sampled part is found on most battle-records, including 1210 Jazz’[4].

The analysis was done with three signals; the crossfader, the record movement and a waveplot of the recorded sound, and for comparison even the audio track. Comparisons with previous recordings of the separate techniques will provide valuable information on the importance of knowledge of these techniques.

To find an easy way to orientate in the piece I decided to describe the music in terms of *beats* and *bars* in addition

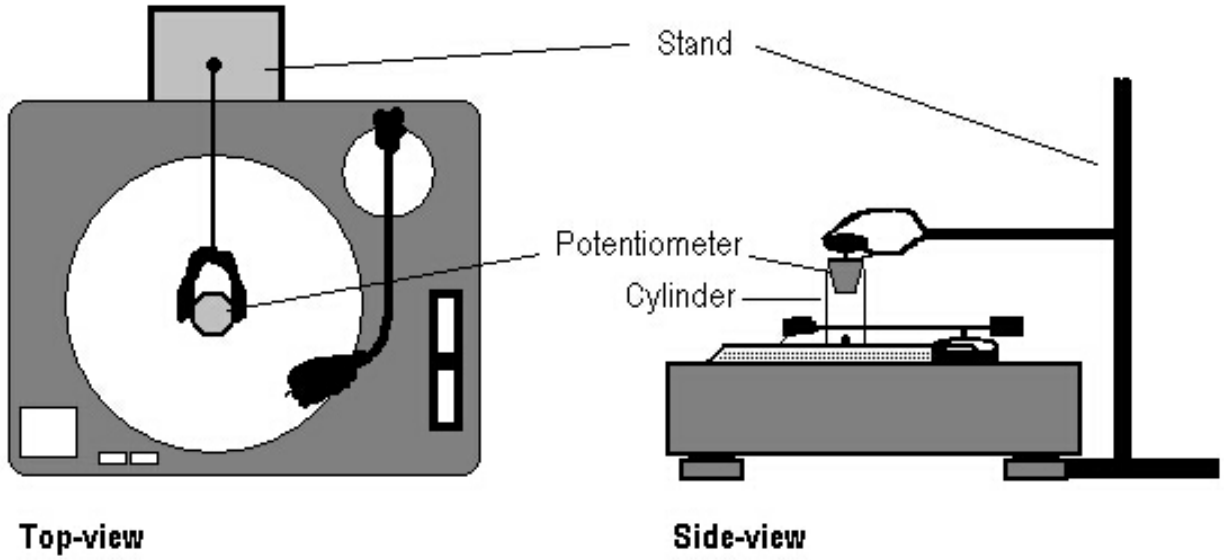

Figure 1: Potentiometer set-up

to looking at time. This method necessarily calls for interpretations, and especially at the end of the piece it is questionable if the performance is strictly rhythmical or not. In this analysis, however, that is a minor concern. With my interpretation the piece consist of 12 bars in four-fourth time. The tempo and rhythm is consistent throughout with exception from what would be bars 9 and 11. Bar 9 last almost three tenths of a second longer than the average, and bar 11 last equally shorter. Three tenths is here a half-beat since the overall tempo is just under 100 beats per minute. Figure 4 shows an excerpt of the readings and illustrates how the structuring to beats and bars was done. Channel one is the low pass-filtered signal from the crossfader in volts, channel two is the audio signal and channel three is the potentiometer signal in degrees. The excerpt is from bar 7.

2.5. Measurements outline

2.5.1. Vinyl movement

One of the things we wanted to measure was the movement of the vinyl record itself without considering the turntable platter or motor. The slipmat placed between the platter and the record reduces friction to a various degree depending on the fabric/material. For these measurements we used a felt slipmat, which allowed the record to be moved quite effortlessly in the opposite direction of the motor.

2.5.2. Crossfader movement

The second element we measured was the movement of the crossfader. To get a reliable signal we measured directly on the circuit board.

2.5.3. Sound output

The third signal we recorded was the sound output from the manipulated record. In order to let the musician play in a realistic manner he was allowed to choose a sound to work with. The specific sound, a long breathy ”ahhh”-sound is taken from the vocal intro of ”Change the beat” [2].

2.6. Focal points

In the analysis some key elements will be considered, namely the workings on the vinyl in terms of directional changes, angles and areas, speed and timing, the crossfader and volume, occurrences of predefined techniques, and finally occurrences of different kinds of patterns. The three variables considered in the measurements were (1) crossfader movements, (2) record movements, and (3) associated sound signal.

2.6.1. Sounding directional changes

One principle of scratching is that the dragging and pushing the record back and forth is the main means of produc-

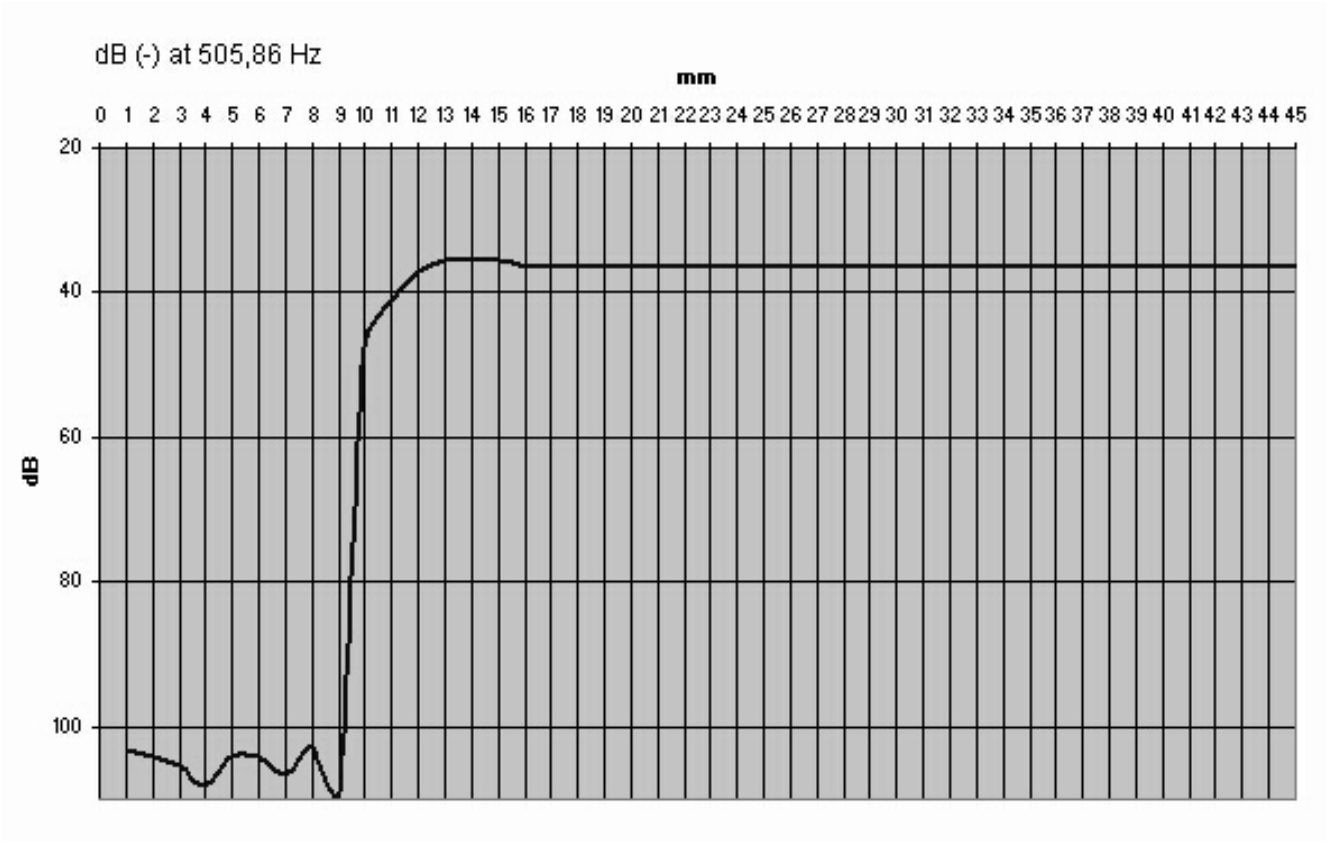

Figure 2: Crossfader calibration

ing sound. This implies that the record will change direction continually during play. Directional changes can be grouped in two categories, the ones silenced with the crossfader and the ones where the sound is heard, here called *turns* for short. The turns can further be categorized; in the following in terms of *significant* and *insignificant turns* according to how well we can hear the directional change.

A significant turn (ST) inside the sound will produce the attack of the next tone. An insignificant turn (IST) appears when only a few milliseconds of sound from the returning record is heard, either intentionally or by imprecision, also producing a kind of attack, although less audible.

All in all the record direction is changed 135 times. 18.5 % of them are significant turns and 6 % insignificant. 21.5 % of the directional changes are heard. A technique like *scribble* would influence this result considerably, as it implies fast and small back-and-forth movements (about 20 turns per second) with sound constantly on. This excerpt has two instances of short *scribble*-scratches, representing 36 % of the significant turns. It seems that in a normal scratch-improvisation (at least for this subject), about 80-90 % of the directional changes are silenced.

Further investigation is needed in order to explain why so many directional changes are silenced. More data from other DJs need to be collected and analysed. However, one possible reason could be that the highly characteristic and recognizable sound of a record changing direction is not a desirable sound among DJs wanting to express themselves without too much use of clichés, risking prejudice.

2.6.2. Angles and area

The length of a sample naturally limits the working area on the record for the musician, and moving the record back and forth can be obstructed by the turntable's tone arm. About a quarter of the platter area is taken up by the tone arm in the worst case. Big arm movements are difficult to perform fast with precision, resulting in a narrowing down, as the technical level evolves, to an average of about 90° (although not measured, recordings of DJs from mid-eighties seem to show generally longer and slower movements).

The occurrence of equally long movements in both directions is quite low, about 30 % of the pairing movements cover the same area. Only 25 % of the forward-backward movements starts and ends on the same spot.

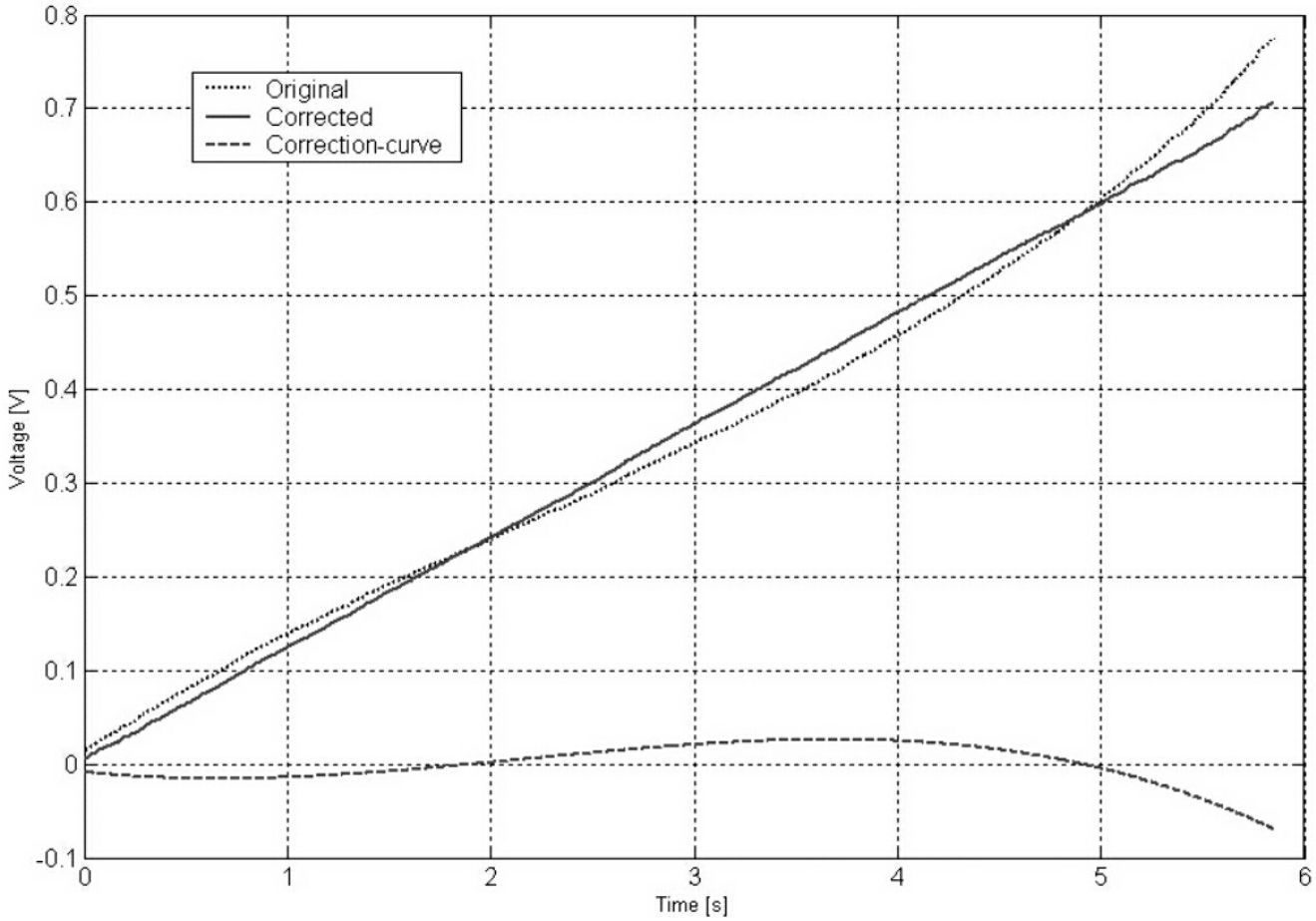

Figure 3: Calibration of potentiometer

2.7. Issues concerning rhythm and timing

An attempt to transcribe the piece to traditional notation will necessarily mean that some subjective decisions and interpretations have to be made. Still some information can be seen more easily from a musical analysis point of view. This transcription allows an analysis of timing in relation to the various scratching techniques by looking at movements' speed of both record and crossfader and its relation to the corresponding waveform.

2.7.1. Speed

Not all movements follow the same accelerating lines. About half of all movements are done slower than the original tempo in this recording, both forwards and backwards. The backward moves are more often performed faster than the forwards, 33 % compared to 26 %. Due to different factors as inertia and muscle control, and the fact that scratching implies a rounded forward and backward stroke, it is hard to perform a movement with constant speed. The majority of all movements tend to have unstable speeds and do not give straight lines in the potentiometer output.

2.7.2. Sound position

Even though a DJ have great control over where a sound is positioned on the record, aided by visual marks such as coloured stickers, a minor inaccuracy can inflict the result greatly. Here 1210 Jazz only has one sound (and position) to focus on, so he does not make any serious mistakes that cause unexpected attacks or silences. The sound used is also quite uncomplicated to deal with. With continual change of sound samples, or sharper sounds like drumbeats and words with two or more syllables, this issue is more important.

2.8. Crossfader

This analysis will not distinguish extensively between crossfader movements done with the hand or by bouncing

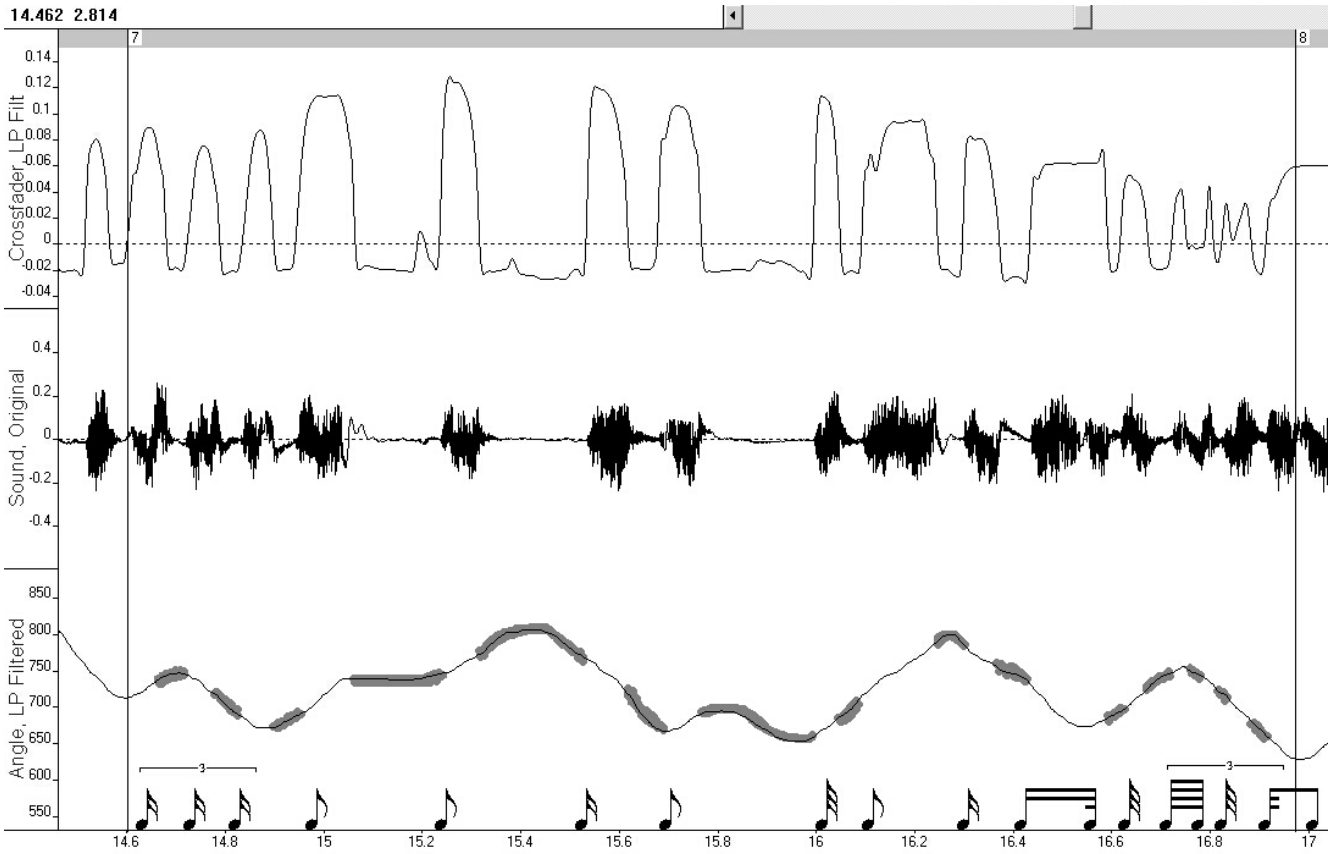

Figure 4: Bar 7 transcribed to musical notation. Grey areas mark where the crossfader silence the signal. Channel one is the low pass-filtered signal from the crossfader in volts, channel two is the audio signal and channel three is the potentiometer signal in degrees.

with the fingers, but some evident cases can be pointed out. It may seem that the crossfader should be left open for a number of techniques, but the longest constant openings in this performance have duration shorter than half a second. The crossfader is turned/clicked on about 170 times in 30 seconds (more than 5 times per second). The total amount of sound and silence is approximately equal.

53.3 % of the draws have one sound only, and 11.8 % of the draws are silenced. Of the remaining draws, 24.4 % have two sounds, 6.6 % have three sounds and 3.7 % of the draws have four separate sounds. Multiple sounds per draw are distributed quite evenly on backward and forward draws, except for the five draws carrying four tones; all are done on the backward draw.

2.9. Techniques

The aesthetics of today's musicians roots in a mutual understanding and practice of attentively explained techniques. However, the actual improvising does not necessarily turn out to be a series of perfectly performed basic techniques. Scratch research so far have naturally been most interested in the separate techniques and the record moving part. A run-down on which techniques are being used in this piece clearly shows the need for a new approach considering combinations of techniques and basic movements. All recognized techniques are here associated to the bar number they appear in. The duration of a bar is approximately 2.5 seconds, i.e. the DJ played with a metronome of about 96 bpm.

Forwards appear in the same place in almost every bar. There are 9 *forwards* in 12 bars; 7 land on the fourth beat (in bars 1, 2, 3, 4, 6, 10 and 12) and 2 *forwards* land on the first beat (in bars 6 and 9). All *forwards* on the fourth beat are followed by a pickup-beat to the next bar, except for the last *forward*.

Tear-like figures happen from time to time when the sound is clicked off during the backward draw, but will not sound as *tears* because the change in tempo is 'hidden'. 3

of these *tear*-likes are executed, in bars 6, 10 and 11. Normally several *tears* are performed in a series, and leaves the sound on all the time. None of the *tears* here are clean in that sense, or perhaps even intended.

Chops normally involve a silenced return, as stated, and prior to 10 of the silences, a *chop* is performed. That happens in bars 3, 4, 5, 7, 8 and 11. A *chop* can be followed by another technique (but the whole forward move is used by the chop) as in bars 5, 7 and 11.

Stabs and *drags* are similar to *chops*, but performed with more force (faster). They both appear in bar 8. Many movements (35 %) use the crossfader swiftly. There are two states of crossfader position during scratching; with the sound initially off, the sound will be temporarily let in, and oppositely with the sound initially on, the sound will be temporarily cut out. Main techniques of sound-off state are different *transform*-scratches, while *chirps*, *crabs* and especially *flares* are typical for sound-on state. Sound-on state should give more significant turns. Most of the significant (and insignificant) turns happen with variations on the *flare* scratch.

Some common techniques were not found in the recording of the performance under analysis, including *baby*, *hydroplane*, *chirp* and *tweak*. The reasons for this could be many; *baby* scratching will often seem old-fashioned while *tweaking* can only be performed with the motor turned off, so it is more demanding for the performer to incorporate it in a short phrase. The absence of *hydroplane* and *chirp* can be explained as artistic choice or coincidence, as they are widely used techniques.

2.10. Patterns

Some movements and series of movements are repeated frequently. Often a significant turn will be followed by a silenced change and a new significant (or insignificant) turn. This particular sequence is performed 6 times (in bars 1, 4, 6, 11, 12).

In the performance analysed only 5 long (more than 100°) forward strokes are followed by another long forward stroke, and there are never more than 2 long strokes in a row. On the backward strokes, long strokes happen more frequently. 16 long strokes are followed by another long stroke; on three occasions 3 long strokes come in a row, and once 6 long strokes come in a row.

No forward stroke is silenced, while 16 backward strokes are silenced with the crossfader. As the *chop* technique involves a silenced return, this technique is often evident around the silences.

Two bars, bars 4 and 5, start almost identically, the major difference is that bar 4 have a *forward* on the fourth beat while bar 5 have a *chop* on the third offbeat.

2.10.1. Twin peaks

One returning pattern is a long forward stroke with a slightly shorter backward stroke followed by a new long forward stroke (shorter than the first) and the backward stroke returning to the starting point. This distinctive sequence looks in the record angle view like two peaks standing next to each other, the left one being the highest, and as it returns 8 times in 30 seconds it was for convenience named *twin peaks* (after the TV-series by David Lynch called ”Twin Peaks”, with a picture of a mountain in the opening scene).

The *twin peaks* pattern is repeated 8 times with striking similarity. The first peak is the highest in all cases, ranging from 100° to 175° (132.5° in average) going up, and from 85° to 150° (120° in average) going down. The second peak ranges from 50° to 100° (77.5° in average) going up, and from 75° to 150° (128.75° in average) going down. All have about 10 crossfader attacks (from 7 to 11), more on the second peak than the first. The second peak is always a variant of a *flare* scratch. *Twin peaks*-patterns take up almost one third of the performance in time.

2.11. Discussion

The division and structuring of the recording into bars reveals that the techniques are used taking into account timing and rhythmical composition, such as fourth beats. For a better understanding of musical content in scratching, more recordings should be analysed as only 12 bars and one subject is not suffice to build an in-depth musical analysis.

3. DESIGN ISSUES FOR A CONTROL MODEL FOR SCRATCHING

Considering the analysis from the experiment, a scratch simulator must include a volume on/off function, as almost none of the scratches are performed with the volume constantly on. There is no need to be able to control bigger scratch areas than 360°, and 180° should be easily controlled. Probably a *touchpad*, the pointing device found on laptop computers, could be efficient for controlling the vinyl part. These are fairly inexpensive and have advantages compared other controllers. Finding some controller to match a real turntable will perhaps prove difficult and expensive due to the strong motor, heavy platter and the inertia.

To simulate the record playing, the sample to scratch should be looped. An altered standstill sample do not correspond to any real scratch situation, the closest will be to *tweak*-scratching where the motor of the turntable is turned off, but then the platter spins easily with low friction. Many simulators today have the standstill approach. When the sample is running with a loop, a mouse may be used for dragging the ”record” back and forth. It will not feel much like scratching for real, however, as you have to press the mouse button on the right place on the screen and move the mouse simultaneously. Even if the ability to do this smoothly and efficiently can be trained, there are hopefully better ways. A touchpad is more suited to this task than both keyboards and mice. Since the touchpad registers touch, hold-down and release, it can be programmed to act as the vinyl would upon finger touch; a finger on the vinyl slows down the record easily to a halt without too much pressure, and the same can be achieved with touchpads.

From the analysis and data of this experiment and a previous one [3], a model for scratching was built using Pd. The readings of the potentiometer and the crossfader were used to control an audio file. By first using the output from the potentiometer to change the sample-rate of the audio file that was played back, and then using the output from the crossfader circuit board to change the playback volume level, we successfully resynthesized the few techniques we tested on. 3 techniques involved record movement only; *baby*, *tear* and *scribble*, while 2 techniques, *chirps* and *twiddle*, also involved crossfader.

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