Paper II

Analysis of a genuine scratch performance

Kjetil Falkenberg Hansen and Roberto Bresin

Refereed article published in
Gesture-Based Communication in Human-Computer Interaction, 5th International Gesture Workshop, Selected Revised Papers, Lecture Notes in Computer Science, 2915. Springer Verlag Berlin Heidelberg, 519–528, 2004.

The layout has been revised.

Analysis of a genuine scratch performance

Kjetil Falkenberg Hansen Roberto Bresin

Abstract

The art form of manipulating vinyl records done by disc jockeys (DJs) is called scratching, and has become very popular since its start in the seventies. Since then turntables are commonly used as expressive musical instruments in several musical genres. This phenomenon has had a serious impact on the instrument-making industry, as the sales of turntables and related equipment have boosted. Despite of this, the acoustics of scratching has been barely studied until now. In this paper, we illustrate the complexity of scratching by measuring the gestures of one DJ during a performance. The analysis of these measurements is important to consider in the design of a scratch model.

1 Introduction

To scratch means to push and pull a vinyl record against the needle on an ordinary turntable along the grooves. 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. The turntable is mostly popular in the hip-hop style where disk jockeys (DJs) first started to scratch. However, all musical forms seem to keenly adopt the turntables into their instrumental scenery. Composers in traditions such as rock, metal, pop, disco, jazz, experimental music, film music, contemporary music and numerous others have been experimenting with DJs the past years. Experimental DJs and most hip-hop DJs now frequently call themselves "turntablists", and the music style of scratching and extensive cut-and-paste mixing is called "turntablism". These terms, derived from "turntable", are now generally accepted. It is also generally accepted that a turntablist is a musician and that the turntable is to be considered an instrument. The acoustics of scratching has been barely studied until now. On the other end, the business market of DJs equipment is quite large. It is therefore interesting to study the phenomenon of turntablism from a scientific point of view.

In this paper, one experiment is presented. Aim of this experiment is to understand how an expressive scratch performance is carried out by the artist. Previous

investigations of turntable scratching show that the DJs use a wide range of different techniques (Hansen, 1999), and that these techniques can be used to model scratching (Hansen, 2002). With better understanding of the performance practices, modelling scratching can be improved. This experiment investigates a real performance with aid of sensors on the equipment in order to determine what kinds of problems and parameter variation a model will need to deal with.

1.1 Method

Measurements

One of the things we needed 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 depending on the fabric and material. For these measurements, the DJ used his preferred felt slipmat, which allowed the record to be moved quite effortlessly regardless of the platter and motor movement.

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

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 the sound to perform with.

Subject

Only one subject was used in the experiment. He 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. He has made three records for DJ use, one of which was used during the recording sessions.

Equipment

The equipment used for the experiment is summarised in Table 1.

A potentiometer was used for mapping the vinyl movement. The 3¾ rounds (1220°) 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 the potentiometer was attached to it, and the DJ felt comfortable with the set-up. See Fig. 1.

Modern mixers give the DJ opportunity to change the fading curves of the crossfader. To get a reliable signal, we decided to find the slider position from reading the output voltage, not physical position. Two cables connected from the circuit board to the multichannel DAT recorder tracked the slider movement, but not automatically the sound level. To read the approximate sound output level

Table 1: Equipment used for the experiment

Equipment	**Description**		
Turntable	Technics SL-1210 Mk2 with felt slipmat		
Cartridge	Shure M44-7		
DJ-mixer	Vestax PMC-06 Pro with Vestax PMC-06 Pro faders		
Record	1210 Jazz - Book of Five Scratches. Book 2. (2001)		
Potentiometer	Bourns 3856A-282-103A 10K		
DAT-recorder	Teak RD-200T Multichannel	Channel 1 (20 kHz) Channel 2 (10 kHz) Channel 3 (10 kHz)	Potentiometer Crossfader Sound
Wave analysis software	Soundswell Signal Workstation (Hitech Development) Wavesurfer (Sjölander and Beskow)		

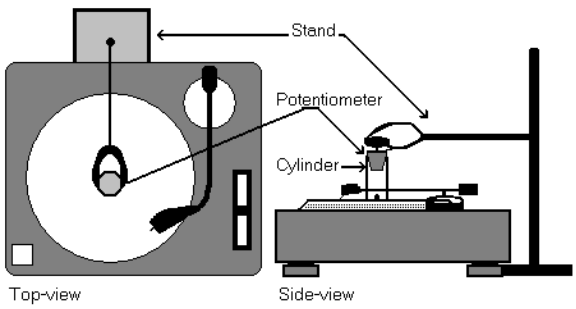

Figure 1: Potentiometer set-up with above and lateral views of the turntable.

from the position of the crossfader, every millimetre position was mapped to a dB level (using a tone generator). The crossfader run is 45 mm, but the interesting part, from silence to full volume, spans only two-three millimetres some millimetres' distance from the right end of the slider. Positioned to the right, the crossfader let no sound through, and moved a few millimetres to the left it let all sound through.

Only the right channel of the stereo sound output signal was recorded to the multichannel DAT, but that was sufficient, and purposeful, for evaluating the record movement output against the sound output. The original sound from the record had no significant stereo effects, and both right and left channel appeared similar.

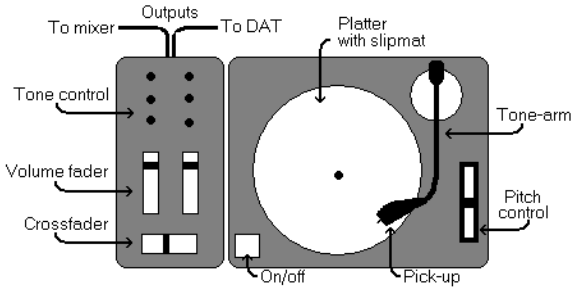

Figure 2: Instrument set-up with mixer on the left and turntable on the right side.

Instrument line-up

1210 Jazz placed mixer on the left and turntable on the right, as he uses his strongest hand (right) on the record. The turntable was connected to stereo-in on the mixer. The right channel was output to a DAT recorder, while the left channel was output to a headphone mixer so the DJ could hear himself. See Fig. 2.

Material

The recordings used in this experiment were done at KTH in Stockholm during October 2001. In the 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.

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 are used in a manner to achieve the same sounding results, this did not affect the artistic result. 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 are analysed. All sounds produced are originated from the popular "ahhh" sound from "Change the beat" (Fab Five Freddie, 1982). This sampled part is found on most battle-records, including the 1210 Jazz (2001) record used in the experiment.

2 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. By only looking at the individual technique taken out of the musi-

cal context, it is easy to get an impression of scratching as being very well defined and straightforward. This is not always the case. Techniques are not often played subsequently in full, but rather shortened or abruptly changed, going into next technique. Also, many moves does not necessarily classify as a technique, as intention or imperfections in the performance let a record movement get unexpected crossfader movements.

The analysis was done with three signals: the crossfader, the record movement and a waveform of the recorded sound. The audio track was used as control. Comparison with previous recordings of the separate techniques provides valuable information, and emphasizes the importance of knowledge of these techniques.

To facilitate its analysis, the recorded performance was described in terms of *beats*, *bars* and time. This choice 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 our interpretation the piece consists of 12 bars in four-fourth time. The tempo and rhythm is fairly consistent throughout with an overall tempo of about 96 beats per minute (bpm). Figure 3 shows an excerpt of the readings and illustrates how the structuring to beats and bars was done. The upper panel is the low pass-filtered signal from the crossfader in volts, the middle panel is the audio signal and the lower panel is the potentiometer signal (or rotation angle), in degrees. The excerpt in Fig. 3 is from bar 7.

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 crossfader movements, record movements, and associated sound signal.

Sounding directional changes

One principle of scratching is that moving the record forward and backward is the main means of producing sound. This implies that the record will change direction continually during playing. Directional changes can be grouped in three categories: (1) the ones where the crossfader masks the change, (2) the silent ones where the change is done on a part of the record where there is no signal (i.e. outside a sound), and (3) the ones where the sound is heard, here called *turns* for short. In the following, the turns are further be categorised in *significant* and *insignificant turns* according to how well the directional change can be heard.

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

In the analysed piece of music, the record direction is changed 135 times, in average 4.5 times per second. 21.5 % of the directional changes are heard; 18.5 % of them are significant turns and 6 % insignificant. A technique like *scribble* would

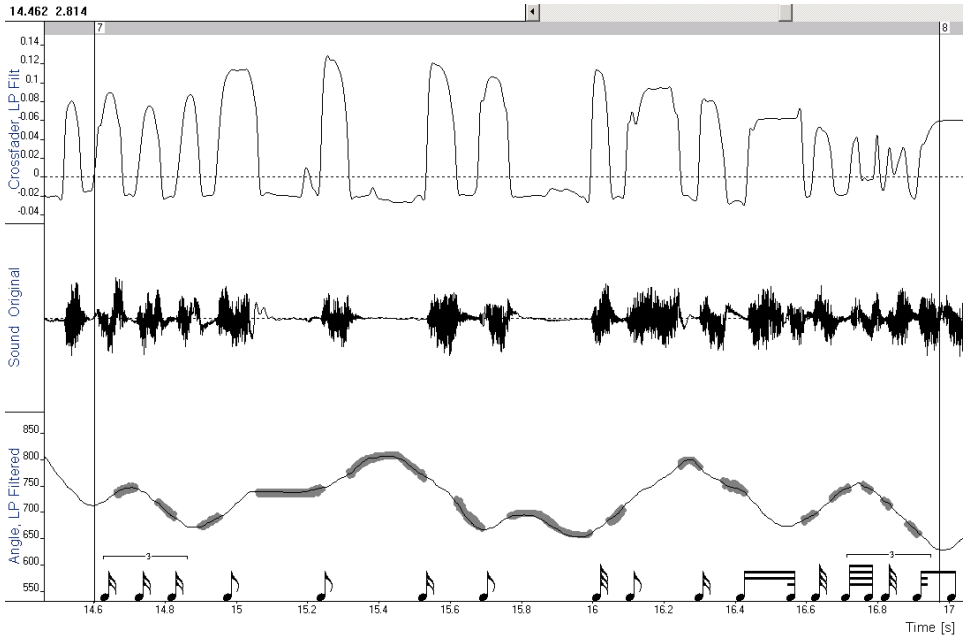

Figure 3: Bar 7 transcribed into musical notation. Grey areas mark time intervals when the crossfader silence the signal. Upper panel shows the low pass-filtered signal from the crossfader in volts. In the middle panel is the audio signal, and in the lower panel the rotation angle in degrees is shown.

influence this result considerably, as it implies fast and small forward and backward 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 70-90 % 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 no longer a desirable sound among DJs wanting to express themselves without too much use of clichés, risking prejudice. These characteristic sounds of a record changing direction are associated with the early, simple techniques.

Angles and area

DJs can only change the record speed by applying a force either in or against the direction of the record. Pushing the record hand will increase the speed, and

pulling it will play the record backwards. In the following, a *push* means a forward hand/record movement, a *pull* means a backward hand/record movement, and a *stroke* means a movement in either direction.

The length of a sample naturally limits the working area on the record for the musician, and moving the record 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, i.e. when the S-shaped tone arm (used in most turntable brands) is close to the record centre. 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. We consider long movements to be those that exceed 100°. In the performance analysed here, a little less than 50 % are long 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 push-pull movements starts and ends on the same spot. Backward strokes tend to be longer than the forward ones, and almost every long forward results from letting the record go (releasing it). It is easier for a DJ to control pulling than pushing, so long backward strokes can be performed to do difficult crossfader patterns, but also to bring the record back to an exact spot, i.e. the start of a sound.

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 the speed of movements of both record and crossfader and its relation to the corresponding waveform.

All bars starts with a pushing movement, with the exception of the tenth bar. In seven bars, the fourth beat is a long (released) forward movement followed by a fast pull to prepare the next bar. In a few cases, the push starts before the first beat, and the crossfader is used to cut in the sound on beat. Apart from the start and the fourth beat of the mentioned bars, DJ 1210 Jazz performs strokes freely within his rhythmical framework with movements producing eights, triplets and more intricate rhythmical figures.

Speed

About half of all movements are done slower than the original tempo in this recording, in both directions. The backward moves are more often performed faster than the forward moves, 33 % compared to 26 %. Different factors make it difficult to perform a movement with constant speed, i.e. the platter's inertia and muscle control for pushing and pulling. Also, holding on to a vinyl record forces movements that

follows the rounded path of a rotating turntable. The majority of all movements tend to have unstable speed and does not give straight lines in the potentiometer output.

Sound position

Even though a DJ has great control over where a sound is positioned on the record, aided by visual marks such as coloured stickers, a minor inaccuracy can spoil 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 easy to deal with. Accuracy is more critical when the DJ is performing with continuous changes of sound samples, or controlling sharper sounds like drumbeats and words with two or more syllables.

Crossfader

This analysis will not distinguish extensively between crossfader movements done with the hand or by bouncing 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, or about a dotted eight note in 96 bpm. The crossfader is turned or clicked on about 170 times in 30 seconds (more than five times per second). The total amount of sound and silence is approximately equal.

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

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 has naturally been most interested in the separate techniques and the record moving part. An overview of the techniques being used in this piece clearly shows the need for a new approach considering combinations of techniques and basic movements. All recognised techniques are here associated to the bar number they appear in.

Forwards (where the record is released to play a sound as it is) appear in the same place in almost every bar. There are 9 *forwards* in 12 bars; 7 occur on the fourth beat (in bars 1, 2, 3, 4, 6, 10 and 12) and 2 *forwards* 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*. Most forward movements exceeding 145° are *forwards*.

Tear-like figures appear from time to time when the sound is clicked off during the pull, but will not sound much like *tears* because the breakdown in the backward draw is silenced. Three 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 for its entire duration.

Chops normally require a silenced return, and 10 of the silences are part of *chops*. They are found in bars 3, 4, 5, 7, 8 and 11. A *chop* can be followed by other techniques as in bars 5, 7 and 11, but the whole forward move is used by the chop. *Stabs* (forward) and *drags* (backward) are similar to *chops*, but performed faster by using more force. They both appear in bar 8.

The majority of playing techniques use crossfader so that one single, fast record hand movement can produce multiple tone attacks, normally from 2 to 5 and sometimes even more. Many strokes (35 %) have a swift crossfader use. 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 analysed performance, 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 not obvious or usual 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.

Patterns

Some movements and series of movements are repeated frequently. Patterns are not considered to be unique techniques, and they are not necessarily so-called "combos" either. A combo is a combination of two or more techniques, performed subsequently or simultaneously.

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 both directions.

In the performance analysed, only five long (more than 100°) pushes are followed by another long push, and there are never more than two long pushes in a row. On the pulls, long strokes happen more frequently. 16 long pulls are followed by another long pull; on three occasions three long pulls come in a row, and once 6 long pulls come in a row.

No push is ever silenced, while 16 pulls are silenced with the crossfader. One silenced stroke is a long one of 220°, the rest are all less than 75°. As the *chop* technique uses small movements and involves a silenced return, this technique is often evident around these silences.

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

Twin peaks

One returning pattern is a long push with a slightly shorter pull followed by a new long push (shorter than the first) and a pull 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 eight times in 30 seconds it was for convenience called *twin peaks* (from the TV-series "Twin Peaks" by David Lynch, with a picture of a mountain in the opening scene).

The *twin peaks* pattern is repeated eight times with striking similarity. The first peak is the highest in all cases, ranging from 100° to 175° (132.5° in average) going up (forward), and from 85° to 150° (120° in average) going down (backward). 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), and 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.

3 Discussion

Modelling scratching in hardware and software can be done with several different approaches. One is to just make a virtual turntable that is controlled with existing or specially designed input devices. From a playing practice point of view, this approach is straight-forward as the performer will need to learn to play in the same way as on real equipment. A second approach is to have a sort of "scratch sampler" with synthesised techniques that can be performed in real time. This approach is static in the sense that techniques will follow each other in sequences and probably not in a very realistic way. A third approach is to design a computer program with scratch techniques and patterns in software without the possibility to perform it in real time.

The three approaches to scratch modelling have been implemented in commercial products, but they do not easily allow the performer to play convincingly. How important the scratch techniques are, is still an unanswered question. For a better understanding of musical content in scratching, more recordings should be analysed as only twelve bars and one subject do not suffice for formulating general conclusions.

References

DJ 1210 Jazz. 2001. Book of Five Scratches. Book 2. LP: Snickars Rec., SR1206.

Fab Five Freddie. 1982. Change The Beat. New York: Celluloid Records, CEL 156. 12" EP.

Kjetil Falkenberg Hansen. 1999. Turntablisme - His Master's Voice: The Art of the Record Player. Master's thesis, Department of Music, Norwegian University of Science and Technology. Written in Norwegian.

Kjetil Falkenberg Hansen. 2002. The Basics of Scratching. *Journal of New Music Research*, 31(4):357–365.

Hitech Development. Soundswell Signal Workstation. URL `http://www.hitech.se/development/products/soundswell.htm`.

Kåre Sjölander and Jonas Beskow. Wavesurfer – An Open Source Speech Tool. URL `http://www.speech.kth.se/wavesurfer/`.