Playing the turntable: An introduction to scratching

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Abstract
This article deals with the popular and rarely studied art form of manipulating a vinyl record by rhythmically dragging and pushing it, commonly labelled “scratching”. With sufficient practise, a Disc Jockey (DJ) can have great control over the sounds and treat the turntable as an expressive musical instrument. Even though a digital-based model of scratching might seem preferable to the vulnerable vinyl record, the acoustical behaviour of the scratch has not been formally studied until now. To gain information of this behaviour a DJ was asked to perform some typical scratching patterns. These common playing techniques and the corresponding sounds have been analysed. Since the focus of the article is on the basics of how the instrument works, an overview on standardized equipment and alternative equipment is given.

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, though 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. Experimental Disk Jockeys (DJs) and most hip-hop DJs now frequently call themselves turntablists, and the music style of “cutting vinyl” with all its scratching and extensive mixing is called turntablism. These terms, derived from “turntable”, are now generally accepted.

In the early eighties, scratching DJs – and the entire hip-hop community – got the attention of the record-buying generation, inescapably spreading their sounds to the rest of the musical world (see “List of key recordings” in the References section). It is yet more than seventy years ago that Paul Hindemith, Ernest Toch, Percy Grainger, Edgar Varèse, Darius Milhaud, and first and foremost, John Cage and Pierre Schaeffer, did the first experiments with use of phonograph to create music. None of the first five made any noticeable impact, and Cage and Schaeffer are remembered mainly for their approach to sounds, not the turntable. Pierre Schaeffer’s (and Pierre Henry’s) concept of musique concrète is as much a result from tape-manipulation as vinyl-manipulation, and his practices would probably have been commenced even without the phonograph technology (Griffiths, 1995; Khazam, 1997).

Instrumentalists must learn to employ a variety of techniques and methods for manipulation. It is unproblematic to state that a fundamental ground has now been established with an almost compulsory assortment of techniques. All new ways of playing and scratching are persistently explained and debated on, especially on Internet discussion forums on sites devoted to turntablism (see “List of Links” in the References section). There are moreover numerous techniques today that more or less resemble and originate from the ones that will be described and analysed in the following. Many ways to scratch do not fit into the general scheme, and are not widely used. They are, however, all explained on turntablism Internet sites as soon as they surface. This overview will not deal with the more unconventional scratches.
Turntablism includes both scraping, using one turntable and an audio mixer, and beatjuggling, using two turntables and a mixer. Scratching is a typical solo-playing style, comparable to that of electric guitar. The musician expresses in intricate rhythmical patterns and in tonal structures. Beatjuggling sometimes has a rhythmical backing function to rapping, but is often played in expressive solo-acts. An overview of the practice of using turntables as instruments and a short history of turntablism is reported in a previous paper by Hansen (Hansen, 2000).

Research in this field has lately led to improved “scratchable” CD-players and software like Flash-based applications and turntable simulators. Still they seem insufficient as replacement for the present equipment as the turntablism-society unfailingly sticks to vinyl. The apparent unwillingness to make use of these innovations has a counter-side in a desire to be spared the hassle of skipping needles and replacing wrecked records. Some actual examples of such hardware and software will later be discussed shortly in the paragraph “Scratch-equipment based on digital technology”.

Equipment

Any turntable might be used for scratching, but the standard is a direct-driven machine with the platter mounted on the motor. Scratching also utilizes a mixer that mostly is used for controlling the onsets and offsets of each tone. So the turntable as a musical instrument includes the turntable with pick-up, stylus and slip-mat, an audio mixer and a vinyl record. Relatively few manufacturers have succeeded to enter the market with purposeful equipment, compared to the massive popularity and prospective of good sales. Why this is so and which consequences this inflict on the evolution of the scene is an extensive discussion, but in brief there seems to be a general unwillingness among the turntablists to adept to radical innovations, especially those that oversimplify and trivialize playing. One example is the production of a mixer that with the push of a button imitates one of the hardest techniques to acquire. This mixer, Vestax Samurai, never got much positive attention from the professionals, even though this new equipment could aspire to development of new techniques.

A list grasping over most of the major manufacturers include Technics and Vestax, that make DJ turntables, Vestax, Numark, Ecler, Stanton and Rane that all make specially designed mixers, and Shure, Stanton and Ortofon that make cartridges (pick-ups) for scratching (see Manufacturers in List of Links paragraph). Low budget equipment from countless less-known manufacturers fail to convince users. The standard line-up for many turntablists is two Technics SL-1200/1210 Mk2 turntables with Shure M44-7 pick-ups, and a scratch mixer without unnecessary controllers. Normally this equipment is organized with one turntable placed on either side of the mixer, and to avoid uncontrolled contact with the sensitive tone-arm the turntables are even flipped 90 degrees with the tone-arms away from the body.

The quartz direct-driven turntable (Figure 1) has advantages to the belt-driven in terms of pick-up speed and motor strength (the starting torque of a Technics is 1.5 kg/cm). When pushing the start-button, a mere third of a revolution (0.7 seconds) is needed to reach full speed at 33 \(\frac{3}{4}\) RPM (revolutions per minute), and stopping the record goes even faster (Online 1200 in List of Links).

With a felt slipmat lying between the platter and the record, moving the record in both directions with the motor on and the platter still going is fairly easy. In rougher moves and when maintaining a heavier touch, the platter might follow the record back and forth, but because of the pick-up speed, that is not a problem.
The pick-up mechanism (Figure 2) is specially designed for scratching to prevent the diamond stylus (needle) from skipping from one groove to another, and even the stylus is designed to make scratching easier. Normal high fidelity styli are often elliptical at the end while scratch styli are spherical and made stronger as the force on the needle get so high that both the reels and the needle are in hazard of being damaged. An M44-7 can handle three times the tracking force (from the needles tip to the groove) of the hi-fi cartridge Shure V15 VxMR – up to 3.0 grams on the M44-7 compared to 1.00 gram on the V15. Output voltage from the scratch cartridges is 3-4 times higher (9.5 mV) than the hi-fi cartridge. The hi-fi cartridge has of course better frequency response, from 10 to 25.000 Hz, compared to M44-7’s 20 to 17.000 Hz.

The mixer (Figure 3a) has several features, the volume controls being the most important. It was originally made for switching smoothly between two turntable decks when doing beat mixing, making one section of a record last for as long as wanted by cross mixing between two identical records. All mixers have for both stereo channels at least a volume fader, tone controls (bass, mid and treble ranges) and often also a kind of sound on-off switch. The central control is the crossfader, positioned at the near end of the mixer (Figure 3b shows crossfader and volume faders).

The crossfader glides seamlessly from letting in sound from channel 1 (left turntable), through channel 1 plus channel 2, to channel 2 (right turntable) alone. Whether a left-positioned crossfader shall let in sound from left or right turntable is now adjustable with a special hamster-switch. Several varieties in how the crossfader operates are fabricated, the newest development being Rane’s non-contact magnetic faders. “Fader” might, however, be a misleading term as the fading curve on the crossfader normally is adjusted to be very steep, making it act as an on-off switch.

Any vinyl record might be used for scratching, but during the last ten years sounds with certain qualities have dominated. Only fragments of original recordings are being manipulated, often shorter than one second. Isolated musical incidents like drumbeats, guitar chords, orchestra hits or words represent the majority of sounds used. Especially the sung, spoken or shouted words from little known recordings, commercials and films are preferred. To simplify playing, and for obvious economical reasons, a number of popular sounds are compiled on one record pressed for DJ use, commonly called a battle record.
(copyrighting is of course an abiding but disconcerting question). The sound samples come without long gaps in one track. Longer sentences are scratched one word or syllable at the time. Short sounds can be given different onsets and offsets depending on the technique used by the DJ. Results of different techniques applied to these sounds will be analysed in the following.

**Material**

DJ 1210 Jazz, an experienced DJ, was instructed to perform some typical techniques, both independently and in a natural musical demonstration, and he also included more unusual examples. Further he was restricted to one frequently used sound, the breathy-sounding ahhh-sample (a multipart choir sings ahhh with a falling glissando in the end).

The sound material was recorded directly to DAT at 48 kHz by the author. All scratching was performed by DJ 1210 Jazz on a Technics SL-1210 Mk2 turntable equipped with a Shure M44-7 pick-up, and a Technics SH-DJ1200 mixer. The recordings lasted for about 30 minutes, out of which long sections (several seconds) of continuous playing of a single technique was extracted. About twenty different techniques were recorded in this session.

Recordings were analysed using Wav surfer and Soundswell software (see “List of Links” in the References section).

**Techniques**

**Basic movements**

Basic DJ hand movements are naturally distinguished in two separate entities; record movement and mixer (crossfader) movement. Most scratching techniques are derivatives from fast but rather simple movements. The two parts, record-control and mixer-control, depend strongly on one another, analogous to right and left hand in guitar playing. Both hands can operate both devices, and most players switch hands effortlessly, both for playing purpose and for visual showing-off purpose. Even techniques where both hands go to the same device are being performed. A general rule has been to have the strong hand on the vinyl, but with more intricate use of crossfader learners now tend to use their strong hand on the mixer instead. The volume controls (foremost the crossfader) are handled with fingertips and are often bounced swiftly between thumb and index. The record is pushed back and forth in every imaginable manner. Traveling distance for the vinyl varies from less than one centimetre in each direction to a quarter of a rotation, covering half a groove revolution.

Onsets and offsets are conditioned on the position of the sample when starting a scratch, the use of crossfader and the speed of the movement. There are basically three different onsets possible. First, a scratch movement can start before the sound sample, and the acceleration then completes before the sound cut in. The crossfader will have no effect. In the second kind of onset the scratch movement starts within the sound sample without use of crossfader; the record will speed up from stand still and produce a very fast glissando from 20 Hz to desirable pitch, often more than 1 kHz. A third onset category occurs when the crossfader cut in sound from within the sample, creating an insignificant crescendo-effect, as if it was switched on. Any sound can be deprived of its original attack by cutting away the start with the crossfader.

Figure 4 shows the four different possibilities of treating a sample with a push or drag motion.

![Figure 4. Four ways to start and end a movement over a sample’s borders.](image)

The grey box represents the sound, and the black lines represent the movement of the hand and record. There is a short silence both before and after the sample. In scratch movement types 1 and 2, the movement starts before the sound, and for movements 3 and 4 in the
middle of the sound. Movements 2 and 4 end before the sound is finished. In Figure 5 also the returning movement is shown.

![Figure 5. Eight ways to start and end a forward and back movement over a sample’s borders.](image)

The x-axis represents position in the sample. There are eight different forms of a forward-back motion. Movement types 1, 2, 5 and 6 start before the sound, and movements 3, 4, 7 and 8 start within the sound. Movements 1, 3, 5 and 7 have the change of direction outside the borders of the sound, while 2, 4, 6 and 8 change direction within the sound. Movements 1 to 4 end outside the sound border, and 5 to 8 end before the sound has finished.

Waveform and spectrogram of sounds produced by common hand movements, Figure 6a and b (these specific ones will be explained as baby-scratching), show some interesting features of the sounds. They are both illustrations of a very simple scratch similar to type 2 in Figure 5. The scratch is approximately four tenths of a second long and can in traditional musical notation resemble two eighths at about 150 BPM. The original sound (ahhh) has a noise band with a broad maximum, inducing the perception of a pitch. Arguably the first eight has a broad maximum around 1200 Hz and the second eight around 2400 Hz, or an octave higher, but it’s hard to establish a definite tonal phrase because of the glissando effects that can be observed in the spectrogram in Figure 6b. The first eight starts abruptly when the sound cuts in, evident on the amplitude level figure, while the second eight has a smoother attack with increase of both frequency and amplitude.

![Figure 6. Waveform (a) and spectrogram (b) of simple forward and back motion, called baby-scratching.](image)

Ending of tones can equally be divided into three categories, with the quick slowing down to a halt perhaps being the most interesting one. During a scratch performance a big portion of the onsets and offsets are just the record changing direction within the boundaries of a sound sample. Figure 7 shows a combination of movement type 5 followed by type 3 from Figure 5. It means that the eighth tenth of a second long scratch is built up by four eight-notes in 150 BPM. The first eight has an abrupt attack, while the second and fourth eights have a more smooth attack. The third eight has a faster attack than the second and the fourth, but the sound is still achieved in the same way. The explanation to these differences lies in the speed of the turn of record direction. In the example in, the turn when going from forward to backward movement is quicker than the turn when going from backward to forward again – the initial move from the body is faster than the initial move towards the body. All the endings except from the last one are results of slowing down the record to change the direction, producing a fast drop in frequency.
The pitch we perceive from the broad maximum of the noise band is determined by the original recording and by the speed by which it is played back. A recording of a sustained flute tone will of course not imply any diffuse noise band, but such tones are unusual. Normally 33 1/3 RPM is used for scratching, but also 45 RPM. These numbers can be adjusted a certain percentage in both directions depending on the product: a Technics SL-1200 Mk2 manages 8 percent tempo increase and decrease. Eight percent make a span of almost a major sixth (from 30 1/3 to 48 1/3 RPM, a factor of 1.58). Even the force on the record in the strokes of course decides the speed of the sample. There are no musical restrictions to which audible frequencies that can be used, and the normal pick-up have a range from 20 Hz up to 17-20 kHz. For a 500 Hz tone to reach 15 kHz, however, playback at 30 times the original speed, or 1000 RPM, is required, which of course is impossible for a human to accomplish (recordings can of course exceed the pick-up’s range).

**Hand motion**

Each DJ has a personal approach to moving the record, even though the aim is a well-defined technique. There seems to be an agreement among the performers as to how it should sound, but not so much as to how it is accomplished. Since the record has a large area for positioning the hands and fingers, and the turntable can be rotated and angled as preferred, the movements can be organized with great variety (Figure 8). The characteristics of the hand movements associated with different types of scratches will be examined in a future investigation.

![Figure 8. Different hand positions taken from a performance by DJ 1210 Jazz.](image)
Without crossfader

The most fundamental technique, also known as “the first scratch”, is done by pushing the record back and forth without using the crossfader. When done in a steady rhythmical pattern of for example eighth-notes or triplets it is called *baby-scratch*. Movement types number 2 and 5 and the combination of 5 and 3 from Figure 5 are most frequent in baby-scratching. How fast the turntablist turns the record direction influences both attacks and decays. A long slowdown or start gives a noticeable glissando-like sound. Also the frequency-drop will make the listener experience amplitude decrease, thoroughly explained in Moore (Moore, 1997). This can also be extrapolated from equal loudness contours and *Fletcher-Munson* diagrams (Fletcher & Munson, 1933).

Another fundamental technique is the *tear-scratch* that divides one stroke, usually the backstroke, in two. The division is kind of a halt before returning the sample to the starting point. It is not usual that the record stop entirely in the backstroke, but the fall in frequency will give an impression of a new tone attack. Figure 9 shows how the simple division inflicts the sound.

Two techniques take advantage of a tremble-motion on the record. Tensing the muscles on one arm to perform a spasm-like movement is called a *scribble-scratch*. Dragging the record with one hand while holding one finger of the other hand lightly against the direction make a stuttering sound called *hydroplane-scratch*.

![Figure 9. Waveform (a) and spectrogram (b) of tear-scratch.](image)

Both hydroplane- and scribble-scratches produces continuous breaks in the sound, and on a spectrogram of a hydroplane-scratch, Figure 10, it is possible from the tops and valleys around 1 kHz to see how the finger bounces on the vinyl. Diminutive slowdowns at a frequent rate, here about thirty per second, produces a humming sound. The broad maximum makes jumps of about 1 kHz in these slowdowns.

![Figure 10. Spectrogram of hydroplane-scratch.](image)
With crossfader

The volume controls can cut a sound in or out at will, which also triggered the experiments of Pierre Schaeffer in the fifties (Griffiths, 1995). A cut off bell might sound like a church organ, for instance. Normally the turntablists let the crossfader abruptly cut the sound, in this way cutting the transition. The sound can easily be turned on and off several times a second, making the scratches sound very fast. This is probably one reason why scratching sounds so recognizable and inimitable. Some techniques are just baby-scratching with varying treatment of the crossfader. Others use longer strokes with excessive crossfader cutting.

Forwards and backwards, chops and stabs all hide one of the two sounds in a baby-scratch, either the forward push or the backward pull. In chirps only two snippets of sounds are heard from a very fast baby-scratch. On every movement forward the fader closes fast after the start, and backwards only the last bit of the sound is cut in. At these points of the scratch, the vinyl speed is high and so the broad maximum of the noise band is high, 2 kHz in Figure 11. The drawn line, adapted from the baby-scratch spectrogram (Figure 6b), shows the probable broad maximum curve of the forward and back movement with $\frac{1}{10}$ of a second silenced, hiding the turn of record direction.

![Figure 11. Spectrogram of chirp-scratch.](image)

The most debated technique is the flare-scratch, with all its variations. Basically flaring means cutting out sound during the stroke, but discussions among the performers concern how many times and how

regular these cuts should occur. In a relatively slow forward movement that starts with the sound on, the sound is quickly clicked off and back on by bouncing the crossfader between thumb and index finger. The names of the various flares are defined by number of such clicks. A two-click flare is one stroke with two clicks, or sound-gaps, producing a total of three onsets. An orbit or orbit flare is the same type of scratch on both forward and backward strokes. In a two-click orbit flare there will be a total of six onsets; three on the forward stroke, one when the record changes direction and two on the backward stroke. These terms are not decisively accepted, though, and the flaring-technique generates lots of other techniques.

Twiddle and crab further take advantage of the possibility to bounce the light crossfader between thumb and other fingers, making a rapid series of clicks. The superficial similarity with the flamenco-guitar picking technique tremolo is clearly evident. Figure 12 comes from a twiddle, where the index and middle fingers on the left hand thrust the crossfader on the thumb. The short gaps are easily audible even in a very short scratch.

![Figure 12. Waveform (a) and spectrogram (b) of twiddle scratch.](image)

Because the numerous clicks are done in one single stroke, the frequency of each attack or tone will be quite stable. Roughly speaking, flutter-tongue playing on brass instruments and flutes produces a similar sound (Meyer, 1972).
The old technique transformer-scratch is often compared to strobe lights, as the crossfader is pushed back and forth as quick as possible during relatively long and slow strokes, or even at original playback speed. Figure 13b shows a spectrogram of a typical transformer-scratch section. Transforming generally attain greater tonal variety than the techniques where rapid fader clicks is the main musical purpose, as for instance in the twiddle-scratch.

Relevance in music

Techniques are seldom played individually for longer periods, but are blended and intertwined for greater expression and musical substance. When hearing, for instance, a 2-click flare-scratch and a twiddle-scratch in rapid succession it might be difficult to distinguish the techniques from each other. That is not the intention either. Turntablists often refer to the different playing styles and scratch solos in terms of flow, and the whole seem to be more important than the components. Mastering one single scratch should be compared to mastering a scale (or rather being able to take advantage of scales) in tonal improvisation. Without the sufficient skills, it will not sound good, at least to appreciating and accustomed ears. But aspiring DJs must devote hours to training every day to get the timing right.

Scratch-equipment based on digital technology

Expensive equipment and hard-to-learn playing techniques are motivations for developers of turntable-imitating hardware and software. Several scratch simulators have emerged during the last ten years, but none have proven to be successful among the professionals. This is bound to change, and one of the promising products today is the Pioneer CDJ 1000, developed for CD-scratching. What it really does is loading some seconds of music into its memory. This memory can easily be accessed via a so-called “scratch pad”, and the vinyl record simulation is good enough for more than just the basic scratching. Numark (CDN-88), American DJ (Pro-Scratch1) and Denon (DN 2600 F) make other scratchable CD-players. MP3 and MiniDisc players can be based on the same technology of buffering sound, for example in American DJ ProMix MP3 and Soundgraph DJ Pad 2020. Other experiments include the FinalScratch concept where a
The turntable is used for controlling recorded sound in different formats (for wave and MP3 on the BeOS platform).

The scratch-simulating software without a physical controller is interesting mostly because of the low expenses. TerminatorX for Linux and OTS JukeDJ for PC are already introduced, but they have yet to prove to be useful for more than simple entertainment. People seem to like the idea of scratching in software, and a lot of games profit from this, both in advanced arcade games (Konami’s Beatmania, recently even adapted for Sony Playstation) and banal Flash- and ShockWave applications (ScratchIt Old School and New School, ScratchDeLux, DJ FU Wax Attack). For references, see Manufacturers and software in the List of Links paragraph.

Reflections

It is not obvious to see whether models of scratching will hold a comparison to vinyl technology. All simulators have in common its digital approach, which is quite natural, but there are benefits and catches with vinyl that is either overlooked or even side-stepped. One specific example of a vinyl-typical feature is the deterioration of the vinyl; a few minutes of dragging the needle back and forth over the same spot on the record has devastating consequences for the sound quality, and the needle even seem to respond differently to movement on that spot. The Pioneer player will not wear out any spot of sound the same way a record does, and this might take the edge off a performance the same way a producer in a recording studio can polish a rough performance to the nearly unbearable.

To simulate every aspect of the turntable, the vinyl, the needle and the more remote aspects like wearing, will probably turn out to be the only suitable option for making a replacement for today’s instrument set-up. An approach built on physical-modelling-based technology seems therefore appropriate and worth to experiment with in the future (Rocchesso et al., submitted).

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Shure V15 VxMR cartridge
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