



**KTH Computer Science  
and Communication**

# **The acoustics and performance of DJ scratching**

Analysis and modeling

KJETIL FALKENBERG HANSEN

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## Abstract

This thesis focuses on the analysis and modeling of scratching, in other words, the DJ (disk jockey) practice of using the turntable as a musical instrument. There has been experimental use of turntables as musical instruments since their invention, but the use is now mainly ascribed to the musical genre hip-hop and the playing style known as scratching. Scratching has developed to become a skillful instrument-playing practice with complex musical output performed by DJs. The impact on popular music culture has been significant, and for many, the DJ set-up of turntables and a mixer is now a natural instrument choice for undertaking a creative music activity. Six papers are included in this thesis, where the first three approach the acoustics and performance of scratching, and the second three approach scratch modeling and the DJ interface. Additional studies included here expand on the scope of the papers.

For the acoustics and performance studies, DJs were recorded playing both demonstrations of standard performance techniques, and expressive performances on sensor-equipped instruments. Analysis of the data revealed that there are both differences and commonalities in playing strategies between musicians, and between expressive intentions. One characteristic feature of scratching is the range of standard playing techniques, but in performances it seems DJs vary the combination of playing techniques more than the rendering of these techniques. The third study describes some of the acoustic parameters of typical scratch improvisations and looks at which musical parameters are typically used for expressive performances. Extracted acoustic and performance parameters from the data show the functional ranges within which DJs normally play.

Unlike traditional musical instruments, the equipment used for scratching was not intended to be used for creating music. The interface studies focus on traditional as well as new interfaces for DJs, where parameter mappings between input gestures and output signal are described. Standard performance techniques have been modeled in software called *Skipproof*, based on results from the first papers. Skipproof was used for testing other types of controllers than turntables, where complex DJ gestures could be manipulated using simplified control actions, enabling even non-experts to play expressively within the stylistic boundaries of DJ scratching. The last paper describes an experiment of using an existing hardware platform, the Reactable, to help designing and prototyping the interaction between different sound models and instrument interfaces, including scratching and Skipproof.

In addition to the included papers, studies were conducted of expressivity, description of the emotional contents of scratching, DJ playing activities, and the coupling between playing techniques and sample. The physical affordances of the turntable, mixer and samples, as well as genre conventions of hip-hop, are assumed to explain some of the findings that distinguish scratching from other instrumental sounds or practices.



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# Papers included in the thesis

This thesis is the original work of the candidate except for commonly understood and accepted ideas or where explicit reference has been made. The dissertation consists of six papers, and an introduction. The papers will be referred to by Roman numerals.

The principal contributions to all the papers, including study design, data collection, analysis, software implementation, and manuscript preparation were made by the candidate. Coauthors' contributions are stated below.

These papers are not contained in the electronic version of the thesis, instead, please refer to the examples' web page for electronic copies, or the author for reprints.

## Paper I

Kjetil Falkenberg Hansen. 2002. *The basics of scratching*. Journal of New Music Research, 31:357–365.

Johan Sundberg supervised the study and contributed to manuscript authoring.

## Paper II

Kjetil Falkenberg Hansen and Roberto Bresin. 2004. *Analysis of a genuine scratch performance*. Gesture-Based Communication in Human-Computer Interaction, 5th International Gesture Workshop 2003, Selected Revised Papers, Lecture Notes in Computer Science, 2915. Springer Verlag Berlin Heidelberg, 519–528.

RB contributed to the planning and the interpretation of results.

## Paper III

Kjetil Falkenberg Hansen, Marco Fabiani and Roberto Bresin. 2009. *Analysis of the acoustics and playing strategies of turntable scratching*. Submitted to Acta Acustica united with Acustica, in review.

KFH performed the main part of the work. MF wrote the Matlab code for data extraction, and wrote the corresponding part of the manuscript. RB contributed to the planning of the experiment, while both MF and RB contributed to the analysis, interpretation and discussion.

**Paper IV**

Kjetil Falkenberg Hansen and Roberto Bresin. 2010. *The Skipproof virtual turntable for high-level control of scratching*. To appear in *Computer Music Journal*, 34:2, Summer 2010.

RB contributed to the software design and the manuscript authoring.

**Paper V**

Kjetil Falkenberg Hansen and Roberto Bresin. 2006. *Mapping strategies in DJ scratching*. Proceedings of the 2006 Conference on New Interfaces for Musical Expression, 188–191.

RB contributed to the planning, design and manuscript preparation.

**Paper VI**

Kjetil Falkenberg Hansen and Smilen Dimitrov. 2009. *Using the Reactable as Experimental Interface for Instrument Design Prototyping*. Submitted to *Organised Sound*, in review.

The paper represents work by both authors. KFH focused on the DJ scratch model and interaction, and SD focused on the friction sound model and interaction. KFH prepared the manuscript with contributions by SD.

# Related Publications

Roberto Bresin, Kjetil Falkenberg Hansen, and Sofia Dahl. 2003a. The Radio Baton as configurable musical instrument and controller. In Roberto Bresin, editor, *Proc. Stockholm Music Acoustics Conference*, volume 2, pages 689–691, Stockholm, Sweden, August 2003.

Roberto Bresin, Kjetil Falkenberg Hansen, Sofia Dahl, Mathias Rath, Mark Marshall, and Breege Moynihan. 2003b. Devices for manipulation and control of sounding objects: the Vodhran and the Invisiball. In Davide Rocchesso and Federico Fontana, editors, *The Sounding Object*, pages 271–295. Mondo Estremo, Florence, Italy.

Roberto Bresin, Kjetil Falkenberg Hansen, Matti Karjalainen, Teemu Mäki-Patola, Aki Kanerva, Antti Huovilainen, Sergi Jordá, Martin Kaltenbrunner, Günter Geiger, Ross Bencina, Amalia de Götzen, and Davide Rocchesso. 2008. Controlling sound production. In Pietro Polotti and Davide Rocchesso, editors, *Sound to Sense–Sense to Sound: A state of the art in Sound and Music Computing*, chapter Appendix A, pages 447–486. Logos Verlag, Berlin.

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. 2000. Turntable music. In Leif Jonsson, Kjell Oversand, and Magnar Breivik, editors, *Musikklienskapelig Årbok 2000*, pages 145–160. Department of Music, Norwegian University of Science and Technology.

Kjetil Falkenberg Hansen. 2001. Playing the turntable: An introduction to scratching. *KTH Speech, Music and Hearing Quarterly Progress and Status Report*, 42:69–79.

Kjetil Falkenberg Hansen. 2002. Music besides grooves. In Frie Depraetere and Paul Willemsen, editors, *Pitch - Mutating Turntables: Argos Festival Catalogue 2002*, pages 136–146. Argos Editions, Brussels.

Kjetil Falkenberg Hansen. 2006. Musical structure: A translation of István Ipolyi's (1952) *Innføring i Musikkspåketets Opprinnelse og Struktur*. *KTH Speech, Music and Hearing Quarterly Progress and Status Report*, 48:35–43.

Kjetil Falkenberg Hansen and Marcos Alonso. 2008. More DJ techniques on the reactable. In *Proc. of the Conference on New Interfaces for Musical Expression*, pages 207–210, Genova, Italy. Infomus, Casa Paganini.

- Kjetil Falkenberg Hansen, Marcos Alonso, and Smilen Dimitrov. 2007. Combining DJ scratching, tangible interfaces and a physics-based model of friction sounds. In *Proc. of the International Computer Music Conference*, volume 2, pages 45–48, San Francisco. International Computer Music Association.
- Kjetil Falkenberg Hansen and Roberto Bresin. 2003. DJ scratching performance techniques: Analysis and synthesis. In Roberto Bresin, editor, *Proc. Stockholm Music Acoustics Conference*, volume 2, pages 693–696, Stockholm.
- Kjetil Falkenberg Hansen, Roberto Bresin, and Anders Friberg. 2006a. Principles for expressing emotional content in turntable scratching. In *Proc. 9th International Conference on Music Perception & Cognition*, pages 534–535, Bologna. Bonomia University Press. Abstract only.
- Kjetil Falkenberg Hansen, Roberto Bresin, and Anders Friberg. 2008. Describing the emotional content of hip-hop DJ recordings. In *Proc. of Neuroscience and Music III*, Montreal. Abstract only.
- Kjetil Falkenberg Hansen, Hilmar Thordarson, and Haraldur Karlsson. 2006b. How interactive are interactive installations? How musical are musical interfaces? Testing interactivity and playability in students' projects. In Jan Tro, editor, *Proc. of NoMute*, pages 23–27, Trondheim, Norway.

**Part I**

**Introduction**



# Chapter 1

## Background

The idea that a DJ can use his turntable to communicate thoughts that are this deep for me is showing just how unique the art is and just how far you can take it. You don't necessarily need a microphone and write rhymes to say something powerful through music. You can do it by scratching (...) it's not me showing off my skills or how good I am, it's me using my skills to say something.

*Interview with DJ Rob Swift, Super Happy Wax (2005)*

### Outline

This thesis present studies in two areas: (i) the acoustics and performance of DJ scratching, and (ii) DJ scratch modeling and scratch interfaces. It is organized in three parts. Part I presents a short background and description of the topic, the objectives and aims, an overview of some of the related work that has been done by others, and a summary of the six research papers included.

Part II focuses on the thematic contents of the six papers, providing an overview of aspects of the music, the DJ performance, and the instrument as well as alternative interfaces. Some results from additional topics to those discussed in the papers are presented. The part finishes with a look at possible future directions for scratch research. Where relevant, multimedia examples are provided: These are marked in the text as ♪:1 and can be accessed online at <http://www.speech.kth.se/~kjetil/thesis/examples.php?ex=1> (the electronic version of this document has active links). The examples include both experiment stimuli and commercially available material such as online videos ♪:1.

Part ?? includes the six papers. These will be referred to in the text as Paper I–Paper VI.

### 1.1 Scratching—what is it?

Scratching was first introduced in the middle of the seventies and has since then become the most recognizable musical feature of hip-hop alongside rapping. It is performed by a DJ, *disk jockey*, who uses one hand to change the playback speed on a turntable, and the



Figure 1.1: A scratch DJ in performance.

other hand to turn on and off the sound on an audio mixer; see an example of a performing DJ in Figure 1.1.

Scratching is only one among several DJ styles, and within each style, common playing conventions have developed during the years. DJs are familiar with these conventions and generally follow them. This is quite the same as for traditional instruments, but with the exception that turntables were not designed to be used as musical instruments. Consequently, without clear instructions on how expressive music can be produced, there have been no formalized methods for learning how to play.

Today, the most formalized style is scratching, and more specifically, accurate hand gestures constitute *scratch techniques*. These techniques play a major role in the thesis work and will be mentioned throughout. The term ‘technique’ will almost exclusively refer to a combination of a *record hand* and *crossfader hand* movement.

The crossfader and the turntable are the main components of the DJ instrument. The traditional DJ setup consists of two record players with an audio mixer placed between them. The crossfader sits on the mixer and is used to fade between the turntables. For scratching, only one turntable needs to be used, and the crossfader is set to work more or less like a switch, passing from sound to silence for very small movements, down to around one millimeter with the fader. The instrument is also described in Chapter 4.1, and illustrated in Figure 4.1 on page 29.

Recently, digital DJ tools have become popular among DJs. These are mainly either CD players that simulate how turntables work, or ordinary turntables that convert the rotation speed into a control signal that is sent to a software media player. New interfaces with new possibilities keep appearing, and DJs have increasingly more choices for piecing

together a performance set-up. The current trend for scratch DJs, according to discussions in the dedicated online communities, is to have conventional turntables together with one of the software media players that use the rotation control signal, and a normal mixer.

One of the challenges of new interfaces is to provide an effective set of controllers available to the musician. The new interface should either simulate the traditional instrument as closely as possible, or it should improve the interaction by giving the DJ more accurate, simpler, or extended control possibilities. New and alternative interfaces and their control parameters will be further discussed in Chapter 4.2.

Since 1995, the term *turntablism* has popularly been used when referring to music created with turntables, as opposed to mixing existing music together, and a *turntablist* is accordingly a DJ who treats the record players more like instruments than playback devices. Scratching is the most significant playing style associated with turntablism, and hip-hop the principal musical genre. However, turntablism also encompasses avant-garde DJ playing styles, which are discussed briefly in Chapter 5.2.

Scratching sounds different from many other instruments. This is partly due to how the tones are produced, and partly because the instrument was developed within a musical genre that outspokenly wanted to escape the conventions of Western popular and classical music. This makes scratching particularly interesting as it was not even intended to resemble any known instrumental sounds. In the presented work, I describe aspects of DJ scratching that can contribute to our understanding of the instrument and practices, mostly based on analyzing the acoustics and the performance, by looking at the musician–instrument interaction, and through modeling of the scratch techniques.

## Motivation

Many people ask me *are you a DJ yourself?* Since I am not, the question is always followed by *then why do you study scratching?* The reason why is also the motivation for this thesis: When techno and house music became popular, I generally found it uninteresting—except in a very few cases where I liked the music, without knowing why it sounded more attractive to me. That led to exploring different DJ styles and genres, including the classic hip-hop recordings, and it appeared that in all the parts I found intriguing, there was scratching. Since then it has been an ambition to understand what the musical function of scratching is and how a turntable can be played so expressively given its (to me at the time) limited instrumental qualities.

From the beginning, I have tried to embrace an ecological perspective. I have had a very close connection to the DJ communities, both in person and through the internet. This has allowed me to partake in daily discussions about hardware, software and playing practices. Also, it has given access to the DJ world “behind-the-scenes” at competitions, concerts, shows, clubs, trade fairs and in private rehearsals.

One other personal circumstance that is worth mentioning is that the time span from the start of the preceding degree project in musicology (Hansen, 1999) until the completion of this thesis provides a valuable perspective on how the DJ scene has developed. This perspective is naturally reflected in the papers which were written at different periods.

## 1.2 Objectives and aims

The objectives of this work can be associated with three main research areas: music acoustics, music performance, and musician–instrument interaction and modeling and design. However, these areas overlap, and it can be unreasonable to look at, for instance, certain aspects of performance without including the musician–instrument interaction part. As there have been very few studies about DJs in general and scratching in particular, each research area still has very few certain results to relate experimental findings to. Thus, an interdisciplinary perspective has been adapted for interpreting the results.

There have been three main aims for this thesis:

- To give a description of the acoustics of scratching and discuss how the sounds are constituted in music.
- To understand how the DJs produce expressive performances and convey emotional intentions.
- To explain how the DJs play their instrument, which movements they use and which sound parameters they can control.

The acoustic description of scratching was approached through analysis of audio and gesture data recordings of DJs. Gesture data were used to support the acoustic analysis. This topic is studied in Paper I, Paper II, and Paper III. The impact of scratching on music, and the role of the DJ as an instrumentalist, are discussed to varying extent in all the papers and Part II of the thesis.

How the DJs produce expressive performances, and convey emotional intentions, was approached through analysis of the DJs’ gestures and their use of expressive acoustic cues. The topic is covered in Paper III, and in Chapters 6.3 and 6.4 in the thesis.

With a musical instrument that is played fundamentally different from traditional ones, a crucial part of the description will be to investigate which control actions and sound parameters are involved in playing, and the coupling between these control actions and sound parameters. This musician–machine interaction is divided into two tracks: the study of the “traditional” instrument, and the study and design of new interfaces for DJs. The traditional instrument was approached in Paper I, Paper IV and Paper V, and also in Chapter 4.1. Modeling of scratching and control of these models are presented mainly in Paper IV and Paper VI. New and experimental interfaces are discussed in Paper V, Paper VI and Chapters 4.2 and 4.3.

Additionally, some of the other aspects of scratching relevant for this thesis are considered in Part II. This was either necessary to do, as in the case of finding descriptive emotional labels for expressive performances in Chapter 6.4, or because new possibilities were presented during the course of the work, as in the case of the scratch sample study in Chapter 6.2.

## Chapter 2

# Related work

In recent years, some academic studies on DJ-made music and several books about DJ culture have been published, but only a very few have a focus on scratching. In this chapter, an overview of research and publications up to now is presented. However, the thesis does not directly rely on methods or results from other studies of DJs, except where stated. Works by myself and colleagues will not be described here, but references to corresponding chapters in Part II where some of these topics will be discussed in more detail are indicated in the text. The aim here is to provide a comprehensive summary of the academic field, although the list of publications is not necessarily exhaustive, particularly for popular-science publications.

### General DJ culture and history

The use of turntables as a means of entertaining a crowd, and ultimately converting them into instruments, have had a significant impact on music culture, which is in turn reflected in the abundance of popular-science publications with varying academic ambition. Three directions stand out: the dance music track, the hip-hop music track, and the alternative music track. For the two latter, ‘turntablism’ announced a more theoretical approach to the art of DJing, and the designation was quickly taken up by writers.

The books by Poschardt (1998) and Webber (2007) give comprehensive overviews of the DJ culture and practices. Poschardt covers several dance music genres, from disco to hip-hop, and from techno to house. The perspective is mainly historical, but in a more philosophical chapter he also discusses avant-garde directions, technology and aesthetics. Webber’s book targets the beginner DJ and contains a short chapter on DJ history, interviews with ten central turntable musicians, a guide to the equipment (including drum machines and other instruments), and a section on how to develop instrumental playing skills.

Many of the popular-science books with a general focus on hip-hop mention scratching as an important element of the culture, although without any detailed descriptions or analysis. The chapters about DJs normally give a historical account from the invention of the phonograph to modern DJing (Fernando, 1994; Toop, 1984), discuss different aspects of sampling (Neal and Forman, 2004; Rose, 1994) (see even below for more research about sampling), interview or portray DJs (Chang, 2005; Reighley, 2000), describe the role of

the DJ (Brewster and Broughton, 2006; Reynolds, 1998), or examine the turntablism phenomenon that solicited a discussion about the DJ as instrumentalist (Toop, 2000).

Creative uses of the turntable in contemporary music have a much longer history than hip-hop scratching. This music is representing a more esoteric tradition, and also fewer publications. Unlike in hip-hop DJ practice, the alternative turntable music has no conventions for how to play or which sounds to produce. Thus, the studies cover topics related to the (vinyl) medium to a larger extent than how the instrument is handled. Two papers by Palombini (1993, 1998) describe how Pierre Schaeffer used the turntables for creating the classic piece *Étude aux chemins de fer* in 1948, and thus start the *musique concrète* genre. Although earlier works by Cage and others also pioneered the use of turntables as more than playback devices, Schaeffer is usually acknowledged in DJ literature to be the first to manipulate the samples in a way comparable to modern turntablism. Holmes (2002) writes about the aesthetics of using media that demonstrate the degeneration of sound, especially in *musique concrète* and ‘tape music’. Ferguson and Marclay (2003) present the works of the avant-garde turntable player Christian Marclay, who from the late seventies embraced the vinyl format in his visual art, and also adopted hip-hop DJ playing styles. Marclay’s music has been very influential for the modern ‘alternative’ turntablism, even though the inspiration behind many of the works seems to come from the visual domain.

See also Chapter 5.2 which presents recently collected data on DJ roles. *Other contributions: Hansen (1999, 2000, 2002b)*.

## Theory and analysis of scratch music

From an academic perspective, the musical notation of turntable compositions and performances is an important (although highly debated) topic. Smith’s dissertation *The Compositional Processes of UK Hip-Hop Turntable Teams* (2006) has a methodological study on how DJ groups collectively write their compositions. The challenge of finding an appropriate musical notation for turntable performances is discussed, with an overview of some known notation formats (see also her related papers: Smith, 2000, 2007). Carluccio *et al.* (2000) published and distributed a manual describing a transcription system for scratching and beat-juggling: the *Turntablist Transcription Methodology* (TTM). The theories behind it are briefly described, and some examples of transcriptions are presented. The TTM is the most common notation system, and inspired the notation for instructing the DJs for Paper III.

The few theoretical studies on scratch music attend the philosophical side more than the practical side. Hertzberg (2002) discusses how hip-hop and especially how turntablism ‘theorizes time’ by breaking the sounds down in fragments, and how DJs ‘compose in sound’ by refusing to let the listener take part of the original recording. One observation he makes is how the meaning of the words ‘gramophone’ and ‘phonograph’ (the “talking machines”) is significant for turntablism, with regards to how DJs use the sound fragments almost as phonemes.

D’Arcangelo (2004) describes a framework for understanding the music created by preexisting sounds, and why there is an increase in the use of such recordings in turntablism and sampling. He argues for a new understanding of the familiar call-and-response audience experience as the knowledge that the played sample (call) is only a recording, and ‘*our response falls on deaf ears*’.

See also Chapter 5.3 which looks more into musical notation for scratching. *Other*

*contributions: Hansen (1999, 2001); Hansen and Bresin (2003a,b).*

## The instrument and organology

There have been more practical studies on the turntable instrument than on the turntable music, and mainly from a technological perspective. The work by White (1999) is the first organological study of the turntable, based on his previous master's degree (White, 1996). It includes a short analysis of the scratching in the song *My Adidas* by Run-DMC (1986), and a notion of six DJ 'techniques': backspinning, scratching, cutting, mixing, blending, and punch-phrasing. This is not the same use of the term 'technique' as adopted throughout this thesis; 'playing style' is a more comparable definition. White concluded that the turntable and the audio mixer might be akin to manual analog samplers, classified as GAMES 521.21 (Generators and Modifiers of Electronic Sound) in the extension by Bakan *et al.* (1990) of the Hornbostel-Sachs system for musical instrument classification (von Hornbostel and Sachs, 1914).

In his bachelor degree work in arts, Cross (2003) gives a historical account of how the audio mixer features have developed, and how the DJ playing styles have developed with them. One interesting discussion is how augmented features, at the time notably provided by the Vestax Samurai series<sup>1</sup>, could be regarded as *deskilling* technologies, helping the DJ in a way that peers perhaps would consider to be "cheating".

A philosophical discussion on the turntable as a musical instrument is held in Mudede (2003). Mudede bases much of the discourse on *The work of art in the age of mechanical reproduction* by Walter Benjamin (1935, trans. 1968), and argues that the turntable is no musical instrument, but a 'repurposed object' for creating 'meta-music'.

*Other contributions: Hansen (1999, 2002b).*

## New interfaces for scratching

The most active area for DJ studies is in the design of new interfaces. A growing number of conferences on computer music and interfaces have included publications of DJ projects and products. Some examples are the International Conference on New Interfaces for Musical Expression<sup>2</sup>, the International Computer Music Conference<sup>3</sup>, and various conferences organized by the Association for Computing Machinery<sup>4</sup>. Only a few papers present broader studies of new interfaces; the majority describe a novel system. The project-type papers are described in Chapter 4.3.

Beamish *et al.* (2004) and Lippit (2004) both investigate how DJs can benefit from augmenting the turntable with digital technology. Beamish focuses on multimodal interaction and haptic feedback, while Lippit looks at how the DJ could be able to control additional devices, for instance in order to record parts of a performance and manipulate those recordings in "realtime". Both Beamish and Lippit are active DJs themselves, and in the papers they also describe new performance interfaces.

Andersen's dissertation *Interaction with Sound and Pre-recorded Music: Novel Interfaces and Use Patterns* (2005b) studies how digital interfaces could reduce the DJ's

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<sup>1</sup>Vestax PMC-07 Pro, <http://www.vestax.com/v/products/mixers/>

<sup>2</sup><http://www.nime.org>

<sup>3</sup><http://www.computermusic.org/>

<sup>4</sup><http://www.acm.org/conferences>

cognitive workload, for instance by automatic beat extraction. Andersen also reported on tests with interfaces for browsing music on computers and mobile audio devices.

See also Chapters 4.2 and 4.3 which present overviews of digital scratch interfaces and experimental instruments. *Other contributions: Hansen and Alonso (2008); Hansen et al. (2007); Hansen and Bresin (2003b).*

## Sampling

Three main (but overlapping) themes can be defined in the studies of sampling in hip-hop: the aesthetic aspect concerning the musical statement or audio contents (i.e., choosing the right sound); the philosophical or musicological aspect of using prerecorded sound to create new music; and the legal aspects of using copyrighted material. Most published research on sampling has, perhaps not unexpectedly, been in the area of copyright issues. Many of these studies have however also perspectives of cultural theory, technology, ethnographic studies, or musicology.

Demers' dissertation entitled *Sampling as Lineage in Hip-Hop* (2002) describes how sampling earlier recordings in popular music developed with DJs' use of multiple turntables in the late 1970s. She defines a sampling "canon" that shaped the whole hip-hop culture, and the musical genre in particular. The thesis does not focus specifically on scratching or the use of turntables, but is relevant as it explains why the DJs' choices of samples to scratch are neither coincidental nor only an acoustical concern (see also Demers, 2003).

Oswald (1985) and Cutler (1994) discuss the sample as a compositional and strategic tool. Oswald explains the DJs' use of samples as a necessity in music-making when there are no other instruments that fit the music or performer, while Cutler sees the use of samples as a protest against the established music culture.

Hesmondhalgh (2006) argues that the current sampling laws discourage much of the musical creativity in the hip-hop genre for economic reasons, and thus the culture of many 'disempowered social groups'. The laws are even unfavorable for many of the musicians that are being sampled, as they often come from less-established music traditions that either are not covered by copyright agreements, or too powerless to go against the major record companies in a lawsuit. He gives examples from the popular album *Play* by Moby (1999) of how recordings from non-western music are not declared properly, and how ethnomusicology studies are being exploited.

Wilson (2002) compares the current use of samples in popular music with the definition of *de minimis* in practical law ("the law does not concern itself with trifles"). He discusses the problems producers (and courts) will face in lawsuits where the sample is possibly very short and hard to recognize, but used extensively, for instance in drum loops<sup>5</sup>. His recommendation is to demand that every sample used must be declared, instead of a 'fair use' definition which can be hard to interpret. Schumacher (1995), on the other hand, argues that sampling in rap music calls for new understandings of copyright and ownership of creativity (and that rap in itself is a critique of the ownership of sound). For an earlier study of digital sampling, see also McGraw (1989).

Self (2002) discusses how law impacts the practice of hip-hop DJs, and also presents a historical background on sampling. He argues that the law, instead of defending creativity, prohibits DJs from being productive.

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<sup>5</sup>Scratch solos are not mentioned particularly, but also the majority of samples used for scratching are copyrighted (and very seldom declared).

There are unwritten rules about sampling in hip-hop, and Schloss (2004) discusses how hip-hop producers conform to such rules. For instance, many DJs would never sample sounds from compilations, only from the original album. Schloss also explains the fine distinction between sampling and ‘biting’, where biting means copying, and can refer to both sounds and playing style. While sampling and reusing material is a cornerstone in hip-hop, biting is totally unacceptable<sup>6</sup>.

See also Chapter 6.2, which presents a study of playing a performance with different samples.

## Teaching material

Despite the fact that DJing and scratching have been widely popular since the 1980s, books on learning how to DJ have come at a late time. A speculation of the cause is that hip-hop was opposing the current ‘accepted’ culture, and not least opposing the social establishment, and a scholarly take on hip-hop would have risked being not well received. Since the advent of the internet, self-produced teaching material has to a large extent been published freely within the DJ communities. Other strong competitors to the books have been instructional videos, and later DVDs, from official competitions (e.g., Technics DMC World, 2005), accomplished DJs (e.g., DJ Q-bert, 2003, 2005; Scratch DJ Academy, 2003) and instrument manufacturers (e.g., Shure Incorporated, 2001; Vestax Corporation, 1997).

In recent years, a great number of handbooks or educational books have been published, confirming that the market has become more cultivated (see for instance, Brewster and Broughton, 2002; Frederikse and Sloly, 2003; Sloly and Frederikse, 2004; Webber, 2007). Such books sometimes give explanations on how to perform the most common scratch techniques, or they demonstrate how to mix. But to a large extent, DJ handbooks foremost give advice on general aspects of being a DJ: they explain what kind of equipment to buy, technicalities of the instrument set-up, and they prepare DJs for their future career, for instance with how to play longer sets, and how to solve practical and financial issues (for instance, DJ Chuck Fresh, 2004; Slaney, 2006; Steventon, 2006; Wood, 2006).

## Magazine articles

Other important sources for writings on scratching have been various periodicals and magazines. *The Wire Magazine* published an influential series of articles on scratching and turntablism, for instance Khazam (1997) and Shapiro (1997, 1998, 1999), and also edited collections with material from the magazine (Herrington, 2002; Shapiro, 2000). These articles brought turntablism to the attention of readers outside the hip-hop culture, and alternative turntable music to the attention of the hip-hop community.

Even internet magazines and websites have provided scholarly articles and interviews. For instance, the online DJ taxonomy by Beamish (2004) gives a thorough description of the DJ practice, including terminology, different interfaces, scratch techniques, playing styles, and common challenges the DJs encounter. Newman (2003) gives a historical

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<sup>6</sup>In an interview about sampling, the producer Pete Rock describes fondly and in detail how he searches old recordings to find the right drum beat to sample and use for loops, but to a later question what he thinks of his own worked being sampled, he replies very protectively that he does not appreciate it at all (Carrara, 2008).

overview of the turntablism genre, with focus on the artists, the music, scratch techniques, competitions (DJ Battles), and possible future directions. In a blog entry, Kramer (2009, October 16) describes how many of the early turntable compositions were made, from Darius Milhaud up to Pierre Schaeffer. These are examples of considerable works, if not academic publications.

Finally, online communities provide insightful discussions, articles and reviews of music and gear. During the thesis work, three communities have been particularly helpful: the Skratchlounge at <http://www.skratchworx.com>, the Swedish forum at <http://www.djbattle.net>, and the alternative turntablism forum at <http://forum.itchymuzik.com>.

## Chapter 3

# Contributions of the present work

In the following sections, the six included papers are summarized in the two main tracks of the thesis. Their contributions and connection to the other studies are discussed. After this, the additional studies of Part II and their relation to the papers are outlined.

### 3.1 The acoustics and performance of scratching

#### Scope of the studies

The focus of Paper I: *The basics of scratching* was on how turntables are used as expressive musical instruments. To gain information of the acoustic characteristics of the instrument, a DJ was asked to perform some typical scratching patterns. Recordings of these performances were analyzed, and it is suggested that features typical for vinyl contribute to the overall sound of the performance. One hypothesis was that the common scratch techniques are the foundations of the DJ sound.

Scratching was presumed to be one of the traits of *turntablism*, and the paper aimed to define current frequently played scratch techniques as performed by a DJ. Apart from instructions on how scratches are to be performed and informal descriptions of how scratching sounds, no studies of acoustic aspects of scratching had been published at that time.

Another aim was to describe the instrument used by DJs—the turntable and mixer—with a review of new interfaces that allowed DJs to scratch music in software or stored on digital media. This would provide the first overview of such new interfaces.

Paper II: *Analysis of a genuine scratch performance* describes the complexity of scratching by measuring the gestures of one DJ during a performance, and explores the preconditions for building a novel scratch interface. A 12-bar performance was recorded and analyzed. We recorded both the audio and how the record and crossfader were moved using custom sensors. The analysis was performed manually, mainly comparing the gesture combinations to known scratching techniques and identifying characteristics of the movements. In the discussion, it was postulated that including scratch techniques in new interfaces would be a way to produce convincing scratching.

One aim of the experiment presented was to gain understanding of scratch performances; it was already known that such performances are built up of scratch techniques. Another aim was to improve the scratch models implemented in a software called Skip-

proof<sup>1</sup> by recording and analyzing the DJ gestures.

Paper III: *Analysis of the acoustics and playing strategies of turntable scratching* describes some of the acoustic parameters of typical scratch improvisations and looks at which musical parameters are typically used for expressive performance. Audio and gestural data from recordings by three professional DJs were analyzed acoustically, based on gestures, and by regarding the instrument characteristics and known scratch techniques. Extracted acoustic and performance parameters from the data show the functional ranges within which DJs normally play. We observed differences and commonalities both between DJs and between emotional categories.

The primary aim of this study was to explore and describe the acoustic characteristics of scratching. Secondly, we were interested in finding physical or musical boundaries of different DJs' playing styles, and to investigate the musical parameters and codes used for expressive performances.

## Methods

Similar methods were followed for the three studies, where professional DJs performing on standard turntables and audio mixers were recorded. All the performances were done using only one specific sound sample (see also Chapter 6.2). Each recording featured gesture data, but provided by different sensors in each session, which affected the analysis methods.

For Paper I we recorded typical scratch techniques. The DJ was instructed to perform freely, and the techniques were recorded systematically from a list. The recording session was video-taped, but only the audio signal was analyzed. Results from the previous study of turntablism (Hansen, 1999) which collected descriptions and introduced notation of scratch techniques, were used in the analysis. Around 20 techniques were extracted from the recording session; at the time these represented a majority of the scratches that had been clearly defined and generally agreed upon.

For Paper II we recorded one DJ who played eight unaccompanied, improvised performances displaying the most common techniques. The recordings included both the audio signal, measurements of the record movement by a rotation sensor affixed to the vinyl, and the crossfader movement by reading the electrical output of the crossfader signal. One of the improvised performances was manually analyzed. Both record movement, crossfader movement and audio signal were considered. The performance was segmented in bars, tones and gestures. The gesture combinations of left and right hand movements were compared to known descriptions of scratch techniques.

For Paper III, three DJs were recorded, illustrated in Figure 3.1. The recorded data included the audio signal both directly from the turntable and after passing through the mixer, a background drum loop, an additional 25 kHz pure tone going through the mixer to read crossfader output, and the record movement measured by a high-resolution rotational sensor affixed to the vinyl. The three DJs performed on the same equipment and were asked to improvise freely over the beat, first without any emotional intention, then with instructions to express different emotions. More than 70 performances were recorded and analyzed.

An automatic feature extraction process using the audio and sensor data in combination was written in Matlab for the recordings in Paper III. The customized feature

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<sup>1</sup>Skipproof is an application for scratching that is described in Paper IV.



Figure 3.1: From the recording sessions for Paper III. The rotation sensor is centered above the record label and does not obstruct the hand gestures.

extraction method acquired more reliable estimates of the feature values than from either traditional extraction algorithms or the audible data alone. The extraction produced acoustic features (including sound level, timbre, pitch, attack characteristics, tone durations, inter-onset interval (IOI), and articulation), gestural features (including record speed, gesture timing information, durations and IOI), and performance features (including playing position in the sample, relationships between right- and left-hand gestures, and densities of tones and gestures).

## Results

### Paper I

An early observation from the data estimated that DJs use only a small movement range on the vinyl; for this particular study a span from around  $10^\circ$  to around  $175^\circ$  was seen. All the possible tone onset and offset combinations were described, as the same gesture can generate different-sounding scratches depending on the start and turning points. In all, eight variants are possible; however, not all are feasible to use for all sounds. By recording only audio, there was little possibility to elaborate different onset and offset types.

There are 14 techniques mentioned in the paper, divided into those that are done only with the record and those that involve the crossfader. Among the techniques including the fader, one type uses the crossfader to mute either the push or the pull vinyl movement, while another type uses the crossfader more actively. Not all techniques have a synchronized left-and-right hand gesture combination; the *transformer* scratch, for instance, is performed by turning the crossfader freely but rhythmically on-and-off while controlling the sample's frequency 'melodiously'.

### Paper II

From the analysis of Paper II it was shown that the scratch techniques were not always played in full, but interrupted and juxtaposed with other partially performed techniques. A distinction was made between sounding and silenced directional changes (where the

record was turned). It was found that the record changed direction 4.5 times/s (potentially producing 4.5 tones/s), and that 80% of the changes were silenced.

Record gestures were found to have an average span of  $90^\circ$ , and fewer than half of the movements were longer than  $100^\circ$ , which were considered to be “long movements”. Equally long movements in a forward–backward gesture pattern were unusual; only 30% of the paired gestures had the same span. It was found that backward movements in general were longer; possible explanations are that they facilitate difficult crossfader techniques, or are used for finding the sample’s start position.

Although the impression left by a DJ performing may be that of moving the record very fast, most of the movements were slower than the nominal record speed. Because of the circular movement of a record and the corresponding curved gesture trajectory, the majority of the movements had unstable speed.

Crossfader gestures were more frequent than record gestures. The crossfader was turned on–off 5.7 times/s, and the longest crossfader on-duration was less than 500 ms. The number of tones that are produced with a technique depends on the sample, the gestures, and the timing: 53.3% of the record gestures had only one sound, 24.4% had two sounds (thus one or two crossfader gestures), and 10.3% of the record gestures had more than two crossfader gestures.

Individual techniques are pointed out as they appeared in the recordings, including *forward*, *tear*, *chop*, *transform*, and *flare* scratch techniques, among others. Some techniques could be expected, as they are very common, but were absent in the recording; these include *chirp* and *baby* scratches. In addition to recurring techniques, some combinations of these were frequently found.

### Paper III

The analysis showed that only a very small part of the sound sample was used: 88% of the played sounds came from the first half sample which spanned a  $144^\circ$  sector. This observation should be compared to other findings: for instance, of the three possible onset types, using the sample’s onset accounted only for 19% of the tones. The bias on the first part of the sample also indicates that even though the sample’s pitch, sound level and timbre characteristics are changing, the sample position is not used actively as a control parameter to change these acoustic features.

The pitch was, overall, very unstable, even in short tones. The average tone had a pitch glide of 2100 cents (almost two octaves), while the average tone duration was only 93 ms. Four main types of pitch curve shapes can be defined: a constant pitch rise, a constant tone, a constant pitch fall, and a pitch rise-and-fall. The rise-and-fall shapes are produced when both the tone onset and offset come from a directional change.

Record movements had shorter span than what was found in Paper II; the average movement was  $36^\circ$ . This is in line with the discussion in Paper II where we argue that record gestures have gradually become shorter. Short movements are also a sign that the scratching playing styles are overall developing to be faster.

Event densities were high and relatively constant, in average 5.7 tones/s and 4.3 gestures/s. The tone density corresponded to a constant stream of sixteenth notes in 90 bpm. Two other measures of gesture activity were defined: the number of crossfader gestures per record movement, and correspondingly, the number of record gestures per crossfader on-time. This parameter was only partly approached in Paper II. Differences in these

gesture combinations represented one of the distinctive characteristics between the three DJs, suggesting that they had personal sets of techniques they used.

In order to determine if there were significant differences between the intended emotions of the performances, we assigned relevant features into either *activity* or *energy* features. This was a relatively speculative procedure, but also fairly conservative in the assigning. Energy features included sound level, spectral centroid, attack properties, pitch and gesture speed. Activity features included tone and gesture durations, and event densities. We found statistical differences between all the emotion categories, and correspondence with results from, among others, Juslin (2001). Also tone duration and onset type, and consequently sample position, were different for the emotions.

## Conclusions

It is hypothesized that the most characteristic feature of scratching is the range of techniques commonly used by the DJs, and that these need to be studied further to understand the music, and to design good scratch music interfaces. (To replace the turntable, all its aspects should be simulated, for instance built on physics-based modeling techniques, to give an acceptable result.)

Based on the recorded data and analysis in Paper II, it was suggested that future studies also need to look at more than techniques. Three possible applications of scratching with new hardware and software are discussed, including an approach where scratch techniques and patterns can be played like in a sequencer or sampler. The analyzed material was not sufficient for formulating general descriptions of the musical content of scratch performances.

The features provided by the customized extraction methods revealed acoustic and performance characteristics of scratching. These parameters could be compared both between DJs and between expressive intentions. The analysis in Paper III did not depend on scratch techniques or musical phrases, like in Paper I and Paper II. Although it is not feasible to draw any certain conclusions from data from only three performers, we could see trends of individual approach but also commonalities between the DJs.

Genre conventions of hip-hop are assumed to explain some of the findings that distinguish scratching from other instrumental sounds or practices, for instance how sadness is an infrequently encountered expressed emotion, and on the contrary emotions like anger and self-confidence are so common they almost constitute the ‘neutral’ expression (see also Chapter 6.3).

It is suggested that the findings can be used in software models of scratching, as well as alternative interfaces that for instance automate crossfader onsets and offsets. Systems that generate scratch performances could be made to sound more realistic by attuning the output to the characteristics described in the study.

## 3.2 Contributions of the papers

The first study got published at a time when the DJs’ drive for developing instrumental skills had a considerable momentum, and it was the first that offered a more detailed look at the produced sounds. In the period from late nineties to around this paper, much of the debate regarding naming and defining the various techniques was settled, and that the DJs really learnt and used these in a fundamental way was beyond doubt. The two most

prominent media for demonstrating and theorizing techniques were the online DJ fora and videotapes, reaching a conclusion with the encyclopedic DVD *Scratchlopedia Breaktannica* by DJ Q-bert (2007). Paper I was however the first academic study describing the techniques.

Paper II and Paper III followed up the analysis with new recordings that included gestural data. Many of the findings in the former paper were confirmed in Paper III, which had new measurement data and analysis. Some differences, such as the record gesture span that was measured to be shorter in average in the new study, can possibly be explained by changes in playing style as the genre developed rapidly during this period. Paper II was the first study to analyze DJ gestures and describe techniques in combination in a musical context.

The recorded data in Paper III have a higher quality due to better sensors, higher sampling rates, a better defined musical task, and also a 90 fps video capture. Although only three DJs were recorded, the material is sufficient for performing further studies, both practical and theoretical. For instance, several areas such as perception, emotional communication, scratch techniques, performance gestures, rhythmic structure, and instrument handling were not approached. This is also the first paper to provide a detailed analysis of scratch sound acoustics.

Results from all these papers, and especially the technique recordings from Paper II, have been used in the development of Skipproof, described in Paper IV. The very brief overview in Paper I of the emerging technology is still representative today; there are hardware performance problems yet to be solved, the interfaces mainly follow in the same vein, and the gaming industry seems by no means done with profiting from the DJ culture.

### 3.3 The scratch interface and DJ scratch modeling

#### Scope of the studies

Paper IV: *The Skipproof virtual turntable for high-level control of scratching* describes an application written in Pure Data (Pd, Puckette, 1996) that both emulates a turntable and a mixer, and also allows high-level control of modeled scratch techniques. Skipproof has been used in several projects during the course of the thesis work, including Paper V and Paper VI. The approach of using high-level control actions makes it possible even for non-experts to play expressively within the stylistic boundaries of DJ playing practices. Three use cases are described in the paper.

The aims of Skipproof were to implement the most common scratch techniques analyzed in Paper I and Paper II, and to create a platform for modeling and simulating scratch techniques. Other motivations for writing the software were to have a tool for studying how scratch techniques are used in expressive performances, to use the software as a virtual turntable, and to experiment with alternative performance tools for DJs.

Skipproof was intended to be controlled by any hardware that communicates with Pd through common protocols (such as USB, MIDI, OSC and TCP/IP), to allow experimenting with both custom-made interfaces and ordinary controllers. By writing the application in Pd, it is possible to connect Skipproof and other applications.

Paper V: *Mapping strategies in DJ scratching* looks into the mapping principles between the controller parameters and the audio output parameters of the traditional DJ equipment, and implications are discussed for the design of new interfaces with examples

of recent innovations and experiments in the field. It is commented that commercial manufacturers of equipment and instruments focus on existing control paradigms instead of exploring new possibilities at hand.

The aim of the study was to give an overview of mapping strategies found in commercial and experimental DJ products, and a more up-to-date report on alternative interfaces than in Paper I. Previous findings of the importance of scratch techniques, including the use of the crossfader, are discussed.

Paper VI: *Using the Reactable as experimental interface for instrument design prototyping* summarizes experiences from four short-term scientific missions organized by the European Cost Actions ConGAS and SID<sup>2</sup>.

The Reactable (Jordá *et al.*, 2005) was used as an intermediate interface for prototyping the interaction with scratch techniques and a physics-based model of friction sounds (Serafin, 2004). The interaction was evaluated by two experts and the developers.

The aims of the projects were to implement the models and interfaces on the Reactable, to control the friction model with scratch gestures, and to evaluate this high-level control interaction. In this paper, the appropriateness of using an existing performance interface during development, designing, and prototyping of new instruments is discussed. Another aim was to investigate the approach of using high-level control actions derived from performance analysis instead of traditional or direct mapping between musician and instrument.

## Methods

Skipproof was designed to have two modes: low-level and high-level control. In the low-level control mode, a standard turntable and mixer are simulated, allowing the player to change parameters like record speed, volume and sample. In the high-level control mode, the DJ gestures are modeled, allowing the player to execute techniques and change their parameters, like gesture speed, gesture size and gesture type.

The low-level control mode includes emulated functionality of the standard turntables and mixers, which are mostly parameters approximating the physical behavior based on measurements, providing realistic but not always exact models of these. The high-level control mode is based on analyzed recordings of scratch techniques performed by DJs. The recordings have also been analyzed in a musical context, in Paper II. The 12 included techniques are among the most commonly used ones in scratching. Record and crossfader movements were recorded and made available for manipulating in Pd. These control signals are used to change the playback of sound files.

The audio part of Skipproof is made to simulate how so-called skip-proof records work (see Chapter 4.1). All the sound samples in the application have a duration corresponding to one complete record rotation, or 1.8 s at 33 RPM. Furthermore, the samples' audio quality is a parameter that can be set, thus allowing a typical, deteriorated sound that can be statically assigned or dynamically changed.

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<sup>2</sup>ConGAS: Gesture Controlled Audio Systems, European Cost action 287, SID: Sonic Interaction Design, European Cost action IC0601. Four research visits were arranged: First, Marcos Alonso from the Music Technology Group at Universitat Pompeu Fabra in Barcelona visited KTH, then Smilen Dimitrov from Medialogy at Aalborg University in Copenhagen visited KTH. Finally, both Dimitrov and Hansen visited Alonso at the Music Technology Group.

Skipproof has a simple GUI that resembles a traditional turntable used for scratching, with an added volume slider and crossfader controls. Some visual feedback, for instance playing position, has been added to compensate the loss of direct tactile or visual feedback in the absence of a real vinyl and needle for the musician.

The Reactable was used as a hardware and software platform, with the functionality of Skipproof and the friction model implemented as *tangibles*. In addition to the software implementation, which was done in Pd, new tangibles had to be prepared, including selecting the physical objects and the rendering of visual feedback.

Evaluation of the interaction was performed by one DJ and one Reactable professional, who both performed three sessions on the Reactable and responded to questionnaires and interviews. The data, together with video recordings of the performances, were approached with qualitative analysis as the basis for statistical analysis was insufficient.

## Results and discussion

### Paper IV

Skipproof has been presented in a few public performances and in demonstrations. The paper describes a performance where the Radio Baton was used as a controller, and a performance using the Reactable as the interface. The Radio Baton experiment was the first public performance featuring Skipproof, and the first performance using the approach of higher-level control of scratching. The Reactable experiment is further described in Paper VI. Both interfaces were evaluated by the respective performers.

Other less performance-focused examples are mentioned: controlling a physics-based friction sound model with scratch gestures; using Skipproof as an alternative instrument in music therapy; and implementing scratch techniques on mobile phones.

### Paper V

The traditional turntable and mixer interface does not have a simple one-to-one mapping, but a somewhat more complex model, where for instance both the crossfader movement, the record movement, and the sound sample can be used for tone onsets. Three different record movement gestures are described, as well as different ways to manipulate the crossfader.

The mappings could be illustrated as in Figure 1 in the paper (see also Table 1, page 10 in Paper IV). The input parameters included in the overview were record speed, sound sample, playing position in the sample, the crossfader position, volume fader, and tone controls. The output parameters were pitch, tone onsets, durations, timbre, and dynamics.

Some new interfaces for scratching are described; these interfaces were selected from previous NIME proceedings and related journals, as well as from the commercial market. These are divided into groups: vinyl players, such as the *Vestax QFO* and *Stanton Final Scratch*; digital scratch players, such as CD and MP3 players; and augmented systems such as *Mixxx*, *D'Groove*, and *16padjoystickcontroller*.

### Paper VI

On the Reactable, the tangibles representing design variations of the models (with different mappings) could be tested side-by-side without interrupting the interaction. An interface

like this makes the high-level control approach very feasible, as the performer can generate music that would otherwise be impossible without substantial amounts of instrument practice.

The bow string interaction and friction sounds were less successfully implemented. Although the model could be controlled by scratch gestures, the model's parameters were not appropriately set to make a musically satisfying result. While the evaluation showed that the musicians had a low appreciation for the musical output they could produce, there were indications in the questionnaire data that operating on gesture models provided added possibilities for the player.

From the video recordings, we observed as expected different interaction strategies for the two musicians. The Reactable player approached the new tangibles and features from a Reactable perspective, exploring how the new objects diverged from the familiar ones. Similarly, the DJ approached the tangibles from a DJ's perspective and explored how the scratch techniques sounded.

High-level control interaction was found more acceptable than the low-level control. This can be explained by the system performance, limited by the video recognition. Also, a 2D interface like the Reactable imposes restrictions on the performer's gestures.

## Conclusions

From the experiences gathered from the various experiments, Skipproof appears to be a versatile application for allowing control of scratch techniques in different settings and with different hardware. The sound quality is not as good as the sounds made with real turntables, but the playing style of DJs can be simulated quite well. Higher-level control is a valuable approach that can be of use also in other areas, as it allows non-expert users to perform with realistic musical result.

When new interfaces for scratching are designed, the mappings between gestures and sound in the traditional instrument should be considered, but not necessarily replicated. Commercial products generally stay in the turntable paradigm without offering new possibilities, but DJs are, as seen in the studies, open to testing explorative interfaces. Meeting the strict requirements musicians have for low-level control has been technically hard for the commercial manufacturers of digital interfaces.

To decrease the number of iterations in prototyping a new interface, an established interface used as a design platform for interaction can be useful, as long as the intended musical output or gesture input is known and possible to implement. Especially, it is advantageous to reduce the input parameters needed to control the model, so as to allow non-expert users to produce "skilled" performances.

Paper VI concludes that although the Reactable was effective for the planned study, the interface is not an ideal hardware platform for all circumstances. This is to a large part because the Reactable has been commercialized since the experiments were done, leading to a closing of the software, and because the video technology limits the resolution of the gesture tracking.

Other possible benefits and uses of a hardware platform were discussed: for instance how it could be a tool in organology or other musical instrument studies to compare aspects of the interfacing and the music created.

### 3.4 Contributions of the papers

The papers describe a system for modeling scratch techniques and using these for controlling new performances. While the approach of higher-level control is common in synthesizer-based instruments—the most apparent example may be how MIDI instruments mapped to a MIDI keyboard will never sound “ugly” or be allowed to be played wrong (i.e. no squeaking clarinets, no failed Helmholtz motions, no bouncing drumsticks)—it has not found its way to DJ-related products in any considerable extent.

Paper IV describes the underlying application, called Skipproof, that has been used in several projects. Some example cases are described.

Paper V was the first work to give an overview of new interfaces for scratching, and also to describe the mapping in some detail. It included interfaces that had either been marketed commercially, or presented in the NIME proceedings and similar publications. Paper V was also presented as a poster with more examples. See Chapter 4.2 for a new, extended review.

Mapping was later also addressed in Paper VI, which used the Reactable for purposes it was not designed for. This paper offers a new angle in the discussions on design principles for new instruments, instrument mapping, and musical interface hardware prototyping.

### 3.5 Other included studies

Part II of this thesis includes a few studies which are either new or otherwise not covered by the six papers, and some of the topics in the papers have been extended. These studies add, in their own way, to the general description of what scratching is, although they were not initially planned to be part of the thesis. In the background sections of the papers, aspects related to the topics have due to formal restrictions been provided with only a limited scope. These aspects included notation, the use of samples, DJ playing styles, the traditional instrument and new interfaces, and more. The purpose of Part II is to extend these topics and present the new studies mentioned in the following.

#### **The DJ role survey**

There have been no available data on how DJs define their own musical practice, with regards to musical styles, instruments, and more. In order to acquire such information, a survey was sent out to DJ communities around the world, collecting answers from 123 participants. The results from this topographical study are used mainly in Chapter 5.2.

In all the papers, accounts of DJ preferences have been made based on observations from DJ communities and personal communication. This has emphasized the scratch DJs’ preferences. While the scratch DJ has always been the focus here, getting a more complete picture of the DJ practice is valuable.

#### **The emotional label studies**

In Chapter 6.3 an experiment is presented where the results were somewhat unexpected. The experiment had a different set of stimuli from the same recording session as the data later used for Paper III; we used composed performances instead of improvisations. The results led to an investigation of how to describe the expressive content of a performance

with words. For this, a library consisting of more than 200 scratch solos taken from commercial recordings was compiled. The library was used for an online listening test, where we asked 39 participants to describe examples from the library in words. This investigation is described in Chapter 6.4.

### Resynthesized performances

After the feature extraction procedure in Paper III, we had gesture data from the sensors that could be used to process any given sound to resynthesize the recorded performances<sup>3</sup>. Changing only the sample allows studying what influence the original sound has on a performance. Eight different samples were chosen to be used in an experiment in Chapter 6.2 where 77 listeners rated their appreciation of the music for the eight different versions and three different performances.

## 3.6 Contributions of the studies

Little is known about the DJs' musical world, and information can primarily be gathered from companies' sales numbers, and from individual reports (such as interviews and biographies). The DJ role survey is to the author's knowledge the first of its kind that has been published.

The label study is the only study of expressive music to approach hip-hop music specifically. The results can however be applicable to other musical genres as well.

Finally, the resynthesized performance experiment demonstrated one possible future direction for scratch studies. Although the results should come as no surprise—the original sample was preferred—it is noteworthy that we could show that even novice listeners had this preference. It has generally been assumed that there are differences between trained and untrained listeners.

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<sup>3</sup>This experiment could reasonably have been accomplished even with simpler means than resynthesizing analyzed performances: it is possible to log the record movements with several of the new interfaces described in Chapter 4.2.



Part II

Scratching



## Chapter 4

# The instrument

This and the two following chapters describe (i) the instrument, including alternative and experimental interfaces for DJs, (ii) the DJ as a musician and the music made by turntables, including musical notation, and (iii) aspects of the performance, including techniques, samples, expressivity and emotional labels. Multimedia examples (♫:1) are provided and can be accessed online at <http://www.speech.kth.se/~kjetil/thesis/examples.php?ex=1>.

DJs are often categorized according to a number of criteria—by choice of instrument, playing style, and type of music—just as, for instance, guitarists are categorized by playing electric or acoustic guitar, steel or nylon string, finger or pick, rhythm or solo, rock or flamenco. However, such classifications are not mutually exclusive for any instrument: it is customary to play different styles and use a combination of vinyl and digital tools.

An online survey was recently conducted for this thesis with the main aim of describing DJs and their playing activities<sup>1</sup>. We recruited 123 DJs from leading online DJ communities, open to all types of DJs. There was a quite even distribution in scratching (61%) and non-scratching participants. While not guaranteed to be representative for DJs in general, these data are used below to give some indication of how they define themselves as musicians. The survey had only five questions and a comment field; the first two questions had multiple choice answers, the last three allowed only a single choice.

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<sup>1</sup>by Hansen, 2009, see <http://www.surveygizmo.com/s/211789/the-dj-role>, last accessed December 2009.

- 1 Which fields do you work with?
  - mixing/club
  - radio
  - scratching/beatjuggling
  - playing with rapper
  - playing in a band
  - producing
  - competitions
- 2 What equipment do you DJ with?
  - vinyl
  - cd
  - time-coded vinyl + software
  - other digital systems
- 3 How many scratch techniques do you know?
  - less than 10
  - between 10 and 50
  - more than 50
  - I just scratch
  - I don't scratch
- 4 Do you ever use scratch notation (like music scores)?
  - yes
  - no
- 5 Would you use the term turntablist/turntablism about yourself?
  - yes
  - no

While the answer alternatives for question 1 were broad in order to cover most DJs, the survey was biased towards scratching and misses a few possible types, such as ‘bedroom DJ’, ‘internet radio DJ’, and ‘mobile DJ’. Also, the only equipment alternatives were derived from playing records.

## 4.1 The traditional instrument

The basic instrument set-up for scratch DJs have remained mostly unchanged since the early eighties. Turntables have had very few modifications at all. The mixer got many improvements until the first part of the nineties, after that only minor ones. The sound source, the records, were up until the nineties original releases, both singles, EPs and LPs, but today DJs use sound compilations to a large extent. These compilations accommodate different purposes: they can have hundreds of short samples presented in a constant stream; long sections with drum loops; sustained tones with stepwise incrementing pitch; one sample repeated for several minutes in a skip-proof section; or they can have a collection of offensive vocal samples for intimidating competitors in DJ battles (see below).

Figure 4.1 shows a standard turntable and mixer set-up used for scratching. The turntables are sometimes rotated to allow easier access to the controllers (for instance, the start-button and pitch slider). Scratching does not necessitate more than one turntable,

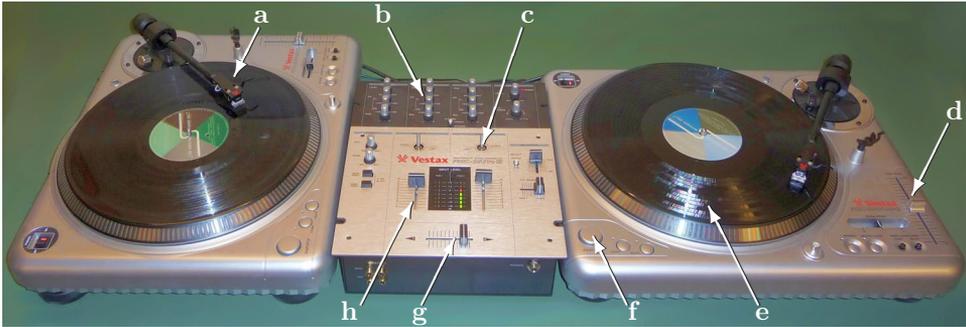


Figure 4.1: A traditional instrument set-up for scratching with the mixer placed between the turntables, and the left turntable rotated to keep the tone-arm away. The controllers most used for scratching are (a) the tone-arm and pick-up, (b) EQ, (c) line switch, (d) pitch control, (e) a skip-proof section with repeating grooves, (f) start-stop switch, (g) crossfader, and (h) line fader.

but it is most common to have two.

On the turntable, the main components are the pick-up arm and headshell, the pitch regulation, the pitch selectors, the on-off toggle and the power button. A slipmat is placed between the vinyl and the turntable platter to reduce and control the amount of friction. The turntables in Figure 4.1 also have sliders to set the amount of pitch variation, up to  $\pm 50\%$ . Turntables used for scratch have direct drive motors, as compared to the belt-driven platters of the consumer *hi-fi* sound systems. Special needles have been designed for scratching, with spherical styli tips, high signal output, and high skip resistance.

The audio mixer has more controllers than the turntable, but the most important ones for scratching are the crossfader and the line or channel fader. It also has a line selector, 3-band equalizer, a crossfader curve adjuster, a crossfader direction selector, and controllers for mixer volume, headphone volume, and headphone mode.

### Skip-proof battle records

A major reason why DJing with digital media (which will be discussed in the following sections) has become widely accepted, is that it can be hard to find appropriate samples on vinyl, both of economic and practical reasons. Often only one single sound is used from a whole record, and equally often, these records are rare. Therefore, sound compilations for DJs have been very popular. These are either collections of beats (the ‘breaks’) or collections of sound samples like the ‘ahhh, this stuff is reeeally fresh’, from the b-side of “Change the beat” by Fab Five Freddie (1982). This particular sample is the most frequent for scratching, and have been used in the recording sessions (see also Chapter 6.2).

These compilations<sup>2</sup> have developed greatly in recent years. To rectify the effect of jumping needles, ‘skip-proof’ sections were introduced on *The Skip-Proof Scratch Tool Volume 1* by DJ Swamp, where a sample with a duration corresponding to one revolution

<sup>2</sup>Often referred to as battle records, battle vinyl or battle wax as they are beneficial for competitions.

is repeated for a couple of minutes; thus, if the needle jumps out of its current groove in the record, it will probably stay in the same temporal location within the same sound sample. As an added benefit, the sounds in the skip-proof sections will be evenly worn, elongating the life of the record.

The skip-proof concept has inspired other battle vinyl designs. For instance, the ‘semi skip-proof’ section on *Book of Five Scratches. Book 2* by DJ 1210 Jazz has samples with one-half revolution durations. The first sound in each revolution is repeated like a skip-proof section, the second sound is changed like on a standard battle record<sup>4:2</sup>. The *Skratchy Seal Sealed Breaks* from Thud Rumble features a stream of drum samples (used for creating rhythms by scratching), where each type of sound (kick drum, snare, hi-hat) is placed in the same location in subsequent grooves<sup>4:3</sup>.

## 4.2 New scratch interfaces

Paper IV and Paper V suggested a categorization of new interfaces for scratching based on three variants of turntable interface designs: (i) the turntable controller, (ii) the turntable metaphor design, and (iii) other metaphors. A distinction between software and hardware interfaces could be made, as software interfaces often will provide the same options as the hardware interfaces, but necessarily by interacting with the computer using hardware that may or may not be appropriate to consider as scratch controllers. For instance a computer mouse can be used to push buttons in a graphical user interface for triggering scratch techniques, or its movement speed on the table can be converted directly to control signals; in the first case, the software will be the main performance interface, in the second case, the mouse will be the performance interface.

### The turntable controller

The most popular new interface for controlling the playback of digital files for scratch DJs is a standard turntable where the rotation speed is used as a control signal for software. In the DJ survey, 60% of the scratchers use a turntable for controlling software, and 29% of the non-scratching. An advantage of the technology, sometimes called ‘Digital Vinyl Systems’, is that it is used with normal turntables and pickups. This is achieved by playing a special vinyl with a time signal that is analyzed and decoded, and then converted to a digital control signal sent to the computer. Currently, some of the popular hardware and software products come from Stanton (*Final Scratch*, see Figure 4.2a), Rane (*Scratch Live*), Native Instruments (*Traktor Scratch Pro*), and Ms Pinky. An alternative to reading time-coded vinyl has been to get the record speed from sensors, for example the TT-M1 by Tascam (Figure 4.2b), or as described in the recording set-ups of Paper II and Paper III.

For these digital vinyl systems, there are no alternative crossfader or mixer controllers; instead, they are combined with a conventional mixer. There are mixers that can send MIDI messages, for instance from Roland, but these are uncommonly used for scratch purposes.

### The turntable metaphor design

The turntable metaphor designs use the concept of a disc that can be rotated with varying speed to change the playback speed of a sound file. Normally, the playback device is a CD



(a) *Final Scratch*  
©2004 Stanton



(b) *TT-M1*  
©2004 Tascam



(c) *DN2600-F*  
©2000 Denon



(d) *SL-DZ1200*  
©2005 Panasonic Corp.



(e) *DVJ-X1*  
©2003 Pioneer



(f) *Vinyl Video*  
©2001 VinylVideo Inc.



(g) *Spin*  
©2009 Vestax Corp.



(h) *Torq*  
©2009 M-Audio



(i) *Pacemaker*  
©2008 Tonium



(j) *DJ Control MP3*  
©2009 Guillemot Corp.



(k) *DJ Hero*  
©2009 Activision



(l) *Beatmania*  
©1997 Konami

Figure 4.2: Commercial interfaces for digital scratching. See Chapter 4.2 for details.

player with an integrated rotating disc. From the first models with small rubber or plastic dials, or ‘jog wheels’, to change speed (for example, Denon DN-2500F, Figure 4.2c), the development has more and more adopted the look, size and feel of vinyl records. Advanced CD players now have turntable-like motors rotating a 10” platter (for example Technics SL-DZ1200, Figure 4.2d).

CD players have to a large extent been taken up by DJs in other genres than hip-hop, and are not preferred by scratchers: 23% of the scratchers compared to 62% of non-scratchers use CD players. Turntablism has traditionally advocated the vinyl format, with many turntablists maintaining that the notion is restricted to vinyl. Without much speculation, the transition to digital format is more permissible with time-coded vinyl than CDs even if the CD technology should perform better.

As an extension of the CD scratching, scratchable DVD players have also been produced. They work like CD players, and output both the audio and video signal. The first DVD player was by Pioneer (Figure 4.2e), but video DJing (called VJing), has been ventured for a long time<sup>3</sup>. For instance, in Vinyl Video the video signal has even been pressed directly onto the vinyl<sup>3</sup> (see Figure 4.2f).

Other types of interfaces based on a rotating platter are less common in professional use, but are for economic reasons often highly interesting for the consumer market. These interfaces have different ambitions: from the ones that could be a replacement for vinyl, to the ones most suitable for home use, and to DJ interfaces for computer games. Unlike CD players and time-coded vinyl, these devices can even feature a crossfader, where the functionality is exactly the same as on an external audio mixer.

Some examples of products that target the semi-professional market are Vestax *Spin* (Figure 4.2g), M-Audio *Torq* (Figure 4.2h), and Tonium *Pacemaker* (Figure 4.2i), while Hercules *DJ Control MP3* (Figure 4.2j) is a product in a controller series for the home market. Spin, Torq and Hercules are all complete mixing consoles with two platters and a crossfader, connected to a computer and controlling software like the digital vinyl systems (some of these hardware and software products can be used in combination). Tonium’s Pacemaker is a hand-held DJ controller with a hard disk. It has a touch-sensitive display and offers many of the advanced functions of stationary or computer controllers, such as automatic beatmatching, timestretch and pitchshift, cue points, and added audio effects.

The recent *DJ Hero* version of Activisions’ *Guitar Hero* (late 2009, Figure 4.2k) has already been successful and well received by DJs, and other similar video games are announced. This kind of game based on ‘scratching’ a platter was first introduced in 1997 by Konami with the *Beatmania* arcade games<sup>4</sup> (Figure 4.2l). The gameplay is divided into song mixing, scratching, and tasks involving pressing buttons or moving the platter to match visual cues on the screen in time<sup>4</sup>.

## Other interfaces

Very few commercial interfaces have tried to challenge the instrument conventions seen so far. In Figure 4.3, different concepts which are all relevant for the scratcher are shown.

<sup>3</sup><http://www.vinylvideo.com/>

<sup>4</sup>Beatmania was the first game in the Bemani music-related game series. Later games included GuitarFreaks, which in turn inspired Guitar Hero ([http://en.wikipedia.org/wiki/List\\_of\\_Bemani\\_series](http://en.wikipedia.org/wiki/List_of_Bemani_series), ver. 2009-12-03; <http://en.wikipedia.org/wiki/Konami>, ver. 2009-12-16).



(a) *Attigo*  
©2008 Scott Hobbs



(b) *DaScratch*  
©2009 Stanton



(c) *Reactable*  
©2008 Reactable



(d) *QFO*  
©2004 Vestax Corp.



(e) *Controller One*  
©2005 Vestax Corp.



(f) *Faderboard*  
©2005 Vestax Corp.

Figure 4.3: Alternative interfaces for digital scratching (a–c) and augmenting the traditional instrument (d–f). See Chapter 4.2 for details.

*Attigo* is in principle a turntable simulated on a touch screen. The turntable controllers and a visual representation of the playing sound file are available to the musician who interacts by dragging the sound file on the screen. A big advantage is that the visual feedback can again be an integrated part of the interface, not moved to a computer screen. In a normal setting, two touch tablets and a mixer are organized like the traditional instrument set-up. The *DaScratch* (Figure 4.3b) is similar to *Attigo* in the sense that the visual feedback is in the interface, and that two units are coupled with a mixer, but the interaction is special. The round touch surface has several modes, including a virtual turntable mode. Additional touch sensitive areas can be assigned to other parameters in the accompanying software.

The *Reactable* is a new commercial music instrument, developed since 2003 (Jordá *et al.*, 2007). It is not a DJ controller as such, but the musical role of the player and DJing have much resemblance. In Figure 4.3c, a user is interacting with tangible objects on a projected screen. See also Paper VI. The objects can be programmed to control synthesizer parameters, and also playback of sound files.

## Expansion of the traditional instrument

There have also been few additional functions implemented in traditional DJ equipment. New functionality is primarily made available in the digital interfaces described in the previous sections. Vestax in particular has marketed a number of products that augment the typical turntable and mixer; three examples are shown in Figure 4.3.

The *QFO* is a combined turntable and mixer with a unique design, illustrated in Figure 4.3d. It was purposed exclusively for scratch DJs, and features only the controllers and functionality typically used for scratching. *Controller One* (Figure 4.3e) is more explorative: it has buttons for quickly changing the motor speed to preset values, thus making it possible to play tonal scale pitches on sound samples with long durations, much like a sampler. According to reports by DJ community members, there are diverging opinions towards the usefulness of such a functionality, but it offers for many an awaited possibility to play pitched tones in discrete intervals.

Vestax *Faderboard* (Figure 4.3f) came in the same period as the Controller One. It does not control scratching as such, but has ten faders and other knobs that can be assigned to various synthesizer parameters, such as tone pitch, scales, filters, and samples. The idea was that since DJs are comfortable with using faders, this interaction could offer added possibilities compared to a MIDI keyboard, mixer or turntable.

### 4.3 Experimental scratch interfaces

Figure 4.4 shows examples of experimental DJ interfaces found primarily in academic conferences. They are mostly prototypes, and used to various degree by their creators. All are designed to be used with a computer (or portable music player), with very different applications. Some interfaces augment the traditional equipment, some give control over other performance parameters, such as graphical feedback, and some are designed to control playback of music files in novel ways.

Beamish *et al.* (2003a, 2004, 2003b) augmented a turntable with haptic feedback in order to guide the performer in mixing tasks with cues derived from analysis of the audio signal. In one of several examples of the system, called *D'Groove* (Figure 4.4a, each beat in the rhythm would be accentuated by a vibration ('bump') transmitted through the vinyl. Another mode guides the DJ in scratching tasks by adding force resistance in the vinyl. *D'Groove* also has an augmented crossfader which aids the DJ in similar ways.

Lippit (2004, 2006) developed interfaces that integrate with and augment his standard DJ setup, adding new control possibilities. The main functionalities of his *Lupa* and *16padjoystickcontroller* (Figure 4.4b) are to sample live performances and interact with them. To accommodate this, some workload and tasks are taken off the DJ's hands.

Fukuchi (2007) presented a system for multi-track scratching of sound samples represented graphically on a touch-sensitive display. In the prototype in Figure 4.4c, there are five simultaneous audio tracks, but no amplitude control except lifting the finger from the surface. The authors state that the interaction opens up to novel scratch techniques. *ColorDex* by Villar *et al.* (2007) allows mixing of six simultaneous tracks, designed by using a colored, cubic die as metaphor for crossfading (its orientation sensed by a 3D accelerometer). A hard disk drive is used as a rotary sensor to control record speed (Figure 4.4d). The musical aim of *ColorDex* is not scratching, but beatmatching (mixing).

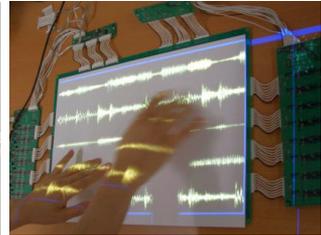
*Mixxx* by Andersen (2003, 2005a) is software that is designed to be controlled by



(a) *D'Groove*  
Beamish *et al.* (2003b)



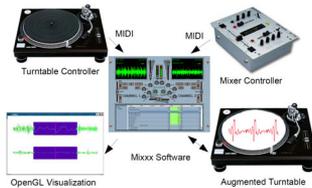
(b) *16padjoystickcontroller*  
Lippit (2004)



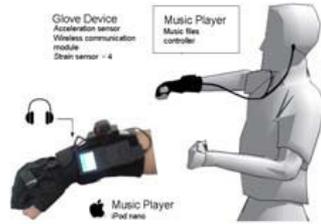
(c) *Multi-track scratch player*  
Fukuchi (2007)



(d) *ColorDex*  
Villar *et al.* (2007)



(e) *Mixxx*  
Andersen (2003)



(f) *MusicGlove*  
Hayafuchi and Suzuki (2008)



(g) *DJammer late prototype*  
Hans and Smith (2003)



(h) *Diskotron*  
Pashenkov (2004)



(i) *SpinCycle*  
Kiser (2006)

Figure 4.4: Experimental interfaces for digital scratching. See Chapter 4.3 for details.

conventional hardware such as time-coded vinyl and MP3 controllers like the Hercules (Figure 4.2j), but the scope is wider than digital vinyl systems, with for instance interaction aided by augmented visual feedback (Figure 4.4e). Pabst and Walk (2007) augmented similarly the turntable with display projected onto the vinyl, and added recognition of DJ gestures, such as the baby scratch technique, to control browsing of the music library. The system uses time-coded vinyl from *Ms Pinky*<sup>5</sup>.

The *MusicGlove* by Hayafuchi and Suzuki (2008) is a prototype for playing and manipulating music files using a sensor-equipped glove. Hand gestures, including typical DJ gestures, were mapped to normal playback control, and to scratch the sounds. MusicGlove has three modes, as Air DJ, Air Conductor and Wearable music (Figure 4.4f). Gesture recognition is used for control actions in each mode. *DJammer* by Hans and Smith (2003) enables users to interact and perform mixing with a sensor-equipped handheld device (Figure 4.4g). The device has optical and motion sensors, and communicates with a computer or MP3 player.

Pashenkov (2002) did a Master's thesis on optical reading of turntable rotation, using printed paper 'disks' (in a system called *Spinalcat*). The *Diskotron* (Figure 4.4h) by Pashenkov (2004) is a further development that lets the user add text commands on the disk, which will be processed as they are read, akin to a sequencer. In a similar approach, the *SpinCycle* by Kiser (2006) uses the turntable platter as a spinning, tangible interface, where colored objects are placed. An optical scanner tracks the color of the discs on the platter and converts them to control signals (Figure 4.4i).

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<sup>5</sup><http://www.mspinky.com/>

## Chapter 5

# The musician and the music

### 5.1 History

#### The early DJ sound systems

The history of the disk jockey is well documented (c.f. Chapter 2). What we consider to be a DJ today is generally the product of two merging branches: the person choosing and playing records in the radio from the 1940's (see Figure 5.1), and the person responsible for the music and sound systems for dance parties in Jamaica in the 1960's. The radio DJ's task was to choose and play records that fit musically. The first star DJs, Martin Block and Al Jarvis, would for instance mix the song order to give an impression of being at a ballroom dance (Poschardt, 1998). In Jamaica, DJs would travel around with large sound systems and play recent American music to public dance parties. One of these DJs, Kool Herc, moved to New York in 1967 and brought with him the equipment, the music, and the DJ style that would eventually lay the foundations for hip-hop (Newman, 2003).

In the Bronx, particularly, DJs started a practice of switching between two turntables with identical records to play one section of a song repeatedly. The sections were called *the breaks* and consisted often of a few bars instrumental part, preferably with a dominant drum beat. Both the terms "breakdance" and "hip-hop" allegedly come from this playing style where the DJs were *hip-hoppin'* between the breaks that were best for dancing (Fab Five Freddy and Braithwaite, 1992; Poschardt, 1998). This mixing style required turntables that could be spun backwards and accelerate quickly, and it required faders on the mixer that made it possible to change rapidly between two sound sources.

#### Hip-hop and scratching

Most references to the origins of scratching retell a story of how it was accidentally invented by DJ Grand Wizard Theodore, who tried to keep the record ready to play at a certain spot while the motor was running, and that he fancied the sound of backspinning the record that came out (e.g., Reighley, 2000). A less mythical theory is that it must have been quite common to be inaccurate when switching the sound from one turntable to the other, especially as the mixers were primitive at that time, and not all had a crossfader or allowed the DJ to cue the record (i.e., monitoring one channel in the headphones while



Figure 5.1: An early DJ from Radio Zurich in 1949. (Photo: © 2007 Keystone/Corbis.)

the other output sound). ‘A *scratch* is nothing but the back-cueing that you hear in your ear before you push it out to the crowd’ (DJ Grandmaster Flash<sup>1</sup>). The inaccuracy would either mean that the beat lost synchronization, or that sound from the record being spun fast backwards would leak out in the mix. Thus eventually, the sound of cueing records would be accepted as a characteristic DJ speciality, and therefore cultivated (Poschardt, 1998) and integrated as part of the music<sup>♯:6</sup>.

During the late seventies, scratching was mostly a novelty without an important musical function. The first rap records came in 1979<sup>♯:7</sup>, but scratching was not featured in recordings until 1981<sup>♯:8</sup>. From around *Rockit* by Herbie Hancock (1983)<sup>♯:9</sup>, scratching gained a more prominent place in popular music, and during the decade DJs featured as musicians on countless rap records. In the nineties, the development of scratching centered on playing skills, and also the involvement in other musical genres.

Up until year 2000, scratching developed very fast and in many concurrent directions. Also, around that time, digital DJ interfaces started to become widely popular, shifting the focus off turntables to some extent. While the progress naturally continued even after year 2000, discussions in the DJ communities commonly uphold that the development has been less remarkable in recent years as the instrument reached a more mature state.

## DJ battles

The so-called *battle culture* is omnipresent in hip-hop, and DJ competitions have been the main catalyst of the instrumental development. Official and informal competitions take

<sup>1</sup>Quoted in Toop (2000), page 65.

many forms and names, such as jams, battles and simple one-against-one showcasing of skills (Toop, 2000). The battle culture has also become an important part of the stylistic language, promoting (mostly good-humored) confrontational tactics that include bragging, gloating, and intimidating and ridiculing the opponent—a trend which is reflected in rap lyrics (Murray, 1998; Neal and Forman, 2004)<sup>♣:10</sup>. The battle aesthetics were even seen in the experiments, which had no resemblance to competition situations (see Chapter 6.4).

During the years, the New Music Seminar (1981–1994), the ITF (International Turntablism Federation, 1996–2006), and the DMC (Disco Mix Club, later the Technics DJ Mix Championships, 1985–present) have been arranging international competitions in several disciplines (Newman, 2003). The most prestigious battle, the DMC World Championships, focused initially on mixing for a dancing crowd, but quickly got more advanced with sophisticated scratching and beatjuggling in six minutes long sets, and now with three competition disciplines<sup>♣:11</sup>. The competition style can easily be compared to artistic sports where the judging is based on the technical, aesthetic and original sides of the programme.

## 5.2 Musical roles

In the following sections, numbers will refer to data from the DJ survey. It is customary that a DJ takes on many musical roles, and none of the below are mutually exclusive.

### The mixing DJ

The most typical task for disk jockeys is mixing records, and the majority of DJs do this (93%). Normally, professional employment will be playing in discotheques, night clubs, bars and events, but also playing for radio (12%) or making mixtapes<sup>♣:12</sup>. Although mixtapes are first and foremost compilations of popular music, they are also an important medium for DJs to showcase their scratching and mixing skills in more or less official releases.

### The producing DJ

The line dividing a producing DJ and a mixing DJ has always been thin, and even more now that many turn from vinyl to digital instruments. In previous years, analog samplers and drum machines were used in parallel with vinyl, foremost to produce beats used when mixing records or backing for rappers. With all the software available for sound editing, this musical role has become much more affordable, and 37% say they produce music.

### Playing backing music for rappers

From the beginning, the DJ made announcements through a microphone while playing. This task was taken over by the MC (master of ceremonies), leaving the DJ with only the musical responsibility. As the announcing got more elaborate, the MC became an integral part of the music too, by rapping to the beat. Soon, the rapping was considered the main performance, while the DJ made the accompaniment<sup>♣:13</sup>.

When backing a vocalist, there is less room for detailed turntable work, and thus rap music would not be the obvious style where scratching could continue to develop. DJs backing a rapper (11%) will to a large part both produce music and play this live, either

with turntables or by adding samplers and sequencers. In many cases, the DJs and rappers have formed balanced groups, for instance DJ Jazzy Jeff & The Fresh Prince, Erik B & Rakim, and the Beastie Boys with DJ Mixmaster Mike<sup>♣:14</sup>.

### Playing with a band

In the early eighties, many people were first exposed to both hip-hop music and DJs with the DJ as a band member: the video for *Rockit* by Herbie Hancock (1983) became one of the first music video superhits (Wiederhorn, 2002). The video featured a scratching Grandmixer D.ST<sup>♣:15</sup>, and is widely cited as the inspiration for becoming a DJ. Nowadays, the typical image of the DJ one may have is that of a solo musician standing behind a booth in a club. This impression is confirmed in the survey, where 5% answered that they were playing with a band.

The low number is not surprising, despite the fact that several mainstream bands have had DJ members in recent years. Unlike most other musicians, the DJ is expected to play alone; this is the musical function of the disk jockey. Nonetheless, DJs with a band have often been more commercially successful than solo DJs, and scratching has taken an important position in many bands' sound (among others, Portishead, Limp Bizkit, Sugar Ray, Uri Caine, and Ozomatli<sup>♣:16</sup>). A special kind of band is the all-turntable groups that were pioneered by The Invisibl Skratch Piklz<sup>♣:17</sup>. In turntable groups, the musicians take on different instrumental roles, such as bass, drums and vocals.

### The turntablist and battle DJ

The term 'turntablist' appeared during the nineties and signalled that DJs were instrumentalists like other musicians. Turntablism represented a strong movement that aimed to demonstrate how DJ music was not only a novelty of hip-hop, but a serious instrumental practice.

The turntablists use scratching, beatjuggling and other advanced playing styles to a large degree in their performances (38% of all the DJs say they scratch). Most often, this is done playing alone, for instance in competitions, but even in turntable groups or together with other instruments with a band. Although turntablism is less used as a musical description now, many DJs still identify themselves as turntablists (22% in total, and 57% of the scratching group).

'Battle DJ' is another common term for turntablist, and it is mainly scratch DJs who participate in competitions (7% in total, and 13% in the scratching group). There are also competitions without a focus on scratching.

### The experimental DJ

While the playing styles described in this thesis are formalized and hence follow quite strict rules, the origins of using the turntable as an instrument involved for the most part experimenting with the playback system. The first examples of such experiments were to use the turntable as a sampler to play sounds not possible otherwise; Darius Milhaud, Paul Hindemith, Ernst Toch, Edgar Varèse and others were known to experiment with phonographs during the 1920–30s. Later, John Cage used several turntables simultaneously, more like a synthesizer, in *Imaginary Landscapes #1* (1939)<sup>♣:18</sup>, layering sounds

and changing their parameters. In *Étude aux chemins de fer* (1948)<sup>♯:19</sup>, Pierre Schaeffer explored recorded sounds with the help of a turntable, laying grounds for *musique concrète* and *l'objet sonore*, a whole new direction in contemporary music.

Around the same time as the turntablism distinction was taken up by DJs and writers, more attention was given to finding the possible roots of the musical genre. It can be argued that composers using everyday devices for creating contemporary art music paved the way for popular culture to some degree. Another viewpoint is that the turntable got used for art music during the Futurism period just like the ‘telharmonium’, ‘intonarumori’, or prepared piano did, and that its importance was as a novel device for experimenting with sound, not principally interesting as an instrument (Griffiths, 1994).

Modern, alternative uses of the turntable as an instrument have typically been to make physical alterations to one part of the playback system. Such alterations include placing other physical objects than vinyl records on the turntable, augmenting the pick-up system with other objects than the needle, using other mechanical devices than the turntable’s motor system, and preparing the vinyl by for instance assembling a new record from splinters of shattered ones or drilling a new, off-center hole so the record will not spin circularly<sup>♯:20</sup>.

Manipulations that do not involve making radical physical changes to the instrument set-up include techniques like repeatedly changing position with the pick-up, creating a skipping loop or locked groove, handling the pick-up directly by scraping it sideways or drumming it down on the vinyl, and playing with feedback sound in the mixer. There are naturally innumerable more ways to experiment, and it is quite common for DJs to use such techniques together with more conventional ones.

Most cases of experimental DJ work have however been hip-hop DJ guest appearances in non-hip-hop recordings. In the first years, it was enough to do normal scratching when the sounds were sufficiently novel, while in later years, DJs have started to experiment more with their scratching style in these situations.

### 5.3 Musical notation

There are a few notation formats for scratching and other DJ styles, but they are not used to a large degree (77% of the scratchers in the survey have never used notation). These systems are either inspired by musical staff notation, or they are based on an individual’s conventions for graphically representing scratch gestures. Smith (2006) counts five main functions of turntable notation: 1) for communicating musical ideas, 2) for documentation, 3) for composition, 4) for making scratching a legitimate musical practice, and 5) for analyzing and understanding.

Doc Rice (1998), Hansen (1999), Radar (Thud Rumble, 2000), Webber (2007), and more recently Sonnenfeld (2009), have all made use of standard music notation with additions to and alterations of the note stems and heads, and new articulations. Hansen’s system (similar to Doc Rice’s, although both were unaware of the other) was used for theoretical descriptions of different scratch techniques. Radar’s system was used for writing the DJ part of the score for “Concerto for Turntable and Orchestra” by Yáñez and DJ Radar (2001)<sup>♯:21</sup>. Sonnenfeld has developed a format that, unlike the others, aims at offering a complete set of notation rules for turntable playing. This will necessarily result in a rather complex notation; see Figure 5.2 for notation of a performance by DJ D-Styles<sup>♯:22</sup>. Webber’s system, while adapted from traditional Western notation, uses



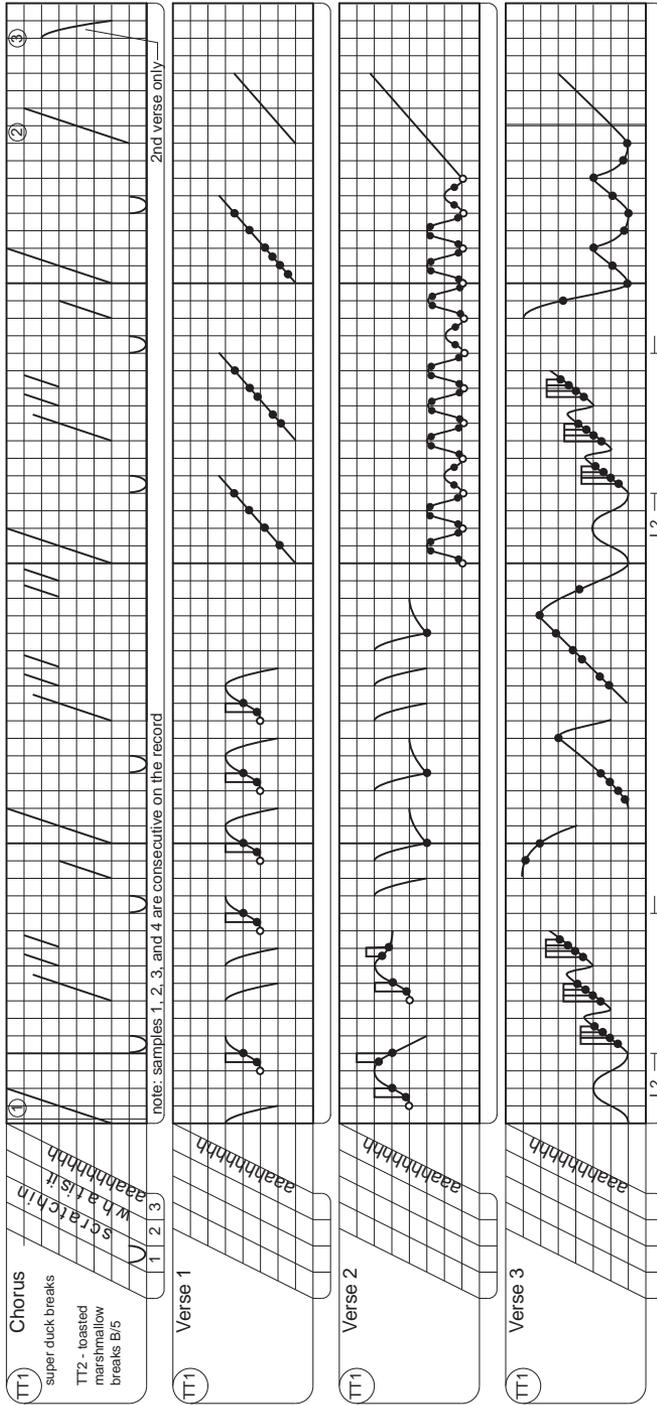


Figure 5.3: The first part of *Skratchin* by Rob Swift notated in the TTM system (from TTM website). The sloping lines represent record movements, and each grid unit corresponds to a  $\frac{1}{16}$  note. Crossfader on-off clicks are noted as filled circles, sample (tone) onsets are noted as open circles, and the absence of a line in the diagram corresponds to a closed crossfader.



# Chapter 6

## The performance

### 6.1 Scratch techniques

Scratch techniques are the building blocks of scratch music performances. There are several sources for describing how they should be performed. The currently most comprehensive and ‘official’ is the encyclopedic DVD “Scratchlopedia Breaktannica” by DJ Q-bert (2007); it describes one hundred techniques. Other comprehensive lists are either online collaborative documents, such as Wikis or part of the notation projects discussed above<sup>1</sup>.

Much of the work in Hansen (1999) involved classifying the different techniques as they were described in various sources at the time (e.g. in videos, internet communities, and by performers). The classification was based on looking at which controllers that were operated in the combination of hand movements. Basically, there are single-handed and two-handed techniques, where two-handed means one hand controls the crossfader and one hand the record movement, and single-handed means controlling only the record movements. A few techniques have two-handed record movements, where both hands are placed on the vinyl. Some less common techniques can even have two-handed mixer movements, or one hand operating both the record and a fader on the mixer.

Based on findings reported in Paper I and Paper III, a typical (two-handed) technique

- has precisely defined gestures,
- consists of a forward–backward movement of the vinyl record in combination with a synchronized crossfader movement,
- has a duration corresponding to less than an eighth-note,
- has the sound turned on–off a couple of times,
- silences the record direction change with the crossfader,
- has a record movement span of 30–40° ,
- manipulates a single-onset, vocal sound sample,
- plays the sample from the start.

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<sup>1</sup>For example, <http://www.tonspielzeug.de/> and <http://dj.wikia.com/wiki/Scratching>.

Interestingly, the definition or naming of a technique is never dependent on what sample is chosen, on the playing position in the sample, on the size of the record movement, on using the crossfader, line fader or line switch, or even on the duration of the scratch. Instead, failing to attune these parameters will render a sound that cannot be recognized as the aimed-at technique. On the other hand, producing a sound that resembles a technique, but doing so by other means than the defined gestures (such as using a multi-onset sound to produce tone attacks instead of using crossfader movements), is not an acceptable way to play the technique.

Earlier it was generally believed that DJs had a very wide range of precisely defined techniques in their repertoire, not least because of the frequent and ardent discussions between DJs in online communities (Hansen, 2001). Now, there is less controversy, and it is accepted that a technique is named or performed with some modification. The DJ survey revealed that of the scratching DJs, only 11% know more than 50 techniques, and 40% know between 10 and 50 techniques. As many as 26% know fewer than 10 techniques, and 23% answer that they just scratch without considering what the techniques are.

From the extraction procedure in Paper III, three different tone onsets and offsets types were defined (see Figure 3, page 8), and in Paper I the possible variations of starting, turning and stopping the record movement in relation to the sample position are shown (see Figure 2, page 6). Control over these parameters, and especially knowing the duration and position of the sample, is fundamental for producing acceptable scratch techniques. In Chapter 6.2 below, it is shown that a performance with “wrong” tone onsets and offsets caused by changing to a different sample is not appreciated by listeners.

## Technique examples

Three techniques are described below to give examples of how the DJ must learn a precise gesture control. One is a single-handed technique, the *clover tear*, and the others are two-handed techniques, called *faderless crabs* and *echo scratch*.

The clover tear produces four onsets by dividing a forward-and-backward record movement gesture in two forwards, then two backwards<sup>♯:24</sup>. This gesture is done with the crossfader on, also during the direction change. The direction change should happen before the end of the sample is reached. If several of these tears are performed in a series, the position of the next direction change (from going backwards to forwards again) will determine the onset speed. If starting the movement before the sample’s start, the timing must be accurate. Depending on the onset and offset types that are generated, the clover tear will sound very differently, but normally it should have only directional type onsets (as described in Paper III). Then it would produce, in a short time, four tones with a several octave pitch rise-and-fall pattern and no sharp attacks.

In a regular crab scratch, the DJ makes 3–4 fast clicks with the crossfader during one record gesture. The faderless crab uses record onsets instead of crossfader onsets, by drumming the fingers of one hand against the direction the other hand is moving the record<sup>♯:25</sup>. This drumming produces minute stops in the sound, comparable to the fader clicks (and sometimes called phantom clicks).

The echo scratch is simple—the aim is to produce an echo effect using the mixer’s line fader. The DJ is free to vary the echo, but typically, a short sound is played 3–4 times in a row with stepwise decreasing amplitude<sup>♯:26</sup>. Depending on the interval between onsets and the gap between the tones, there are two ways to produce it. Almost any technique

can be used in an echo scratch, and also samples with multiple onsets, but often it is just a repeated stab scratch (where only a part of the forward record movement is heard, the rest cut out by the crossfader). With fast movements between the crossfader and the channel fader, it is possible to do a stab, return the record, decrease the volume, then repeat the procedure several times. If the onset interval or the gap between the tones is intended to be short, the echo can be performed only using the channel fader by doing a stab with the line fader at full amplitude, returning the record, then a stab at a lower amplitude, and so on.

## 6.2 Sound samples

Although DJs can choose recordings from a virtually endless reservoir to cater for their musical need, a canonical set of samples has been established. Listeners will soon start to recognize phrases like ‘ahhh, this stuff is reeally fresh’, from the b-side of “Change the beat” by Fab Five Freddie (1982)<sup>♯:27</sup>, and ‘all that scratching is making me itch’ from the “Buffalo gals” single by Malcolm McLaren And The World’s Famous Supreme Team (1982)<sup>♯:28</sup>, and many others. These samples approximate a neutral set of sounds, comparable to presets on a synthesizer, and appear on the many specialized DJ records or so-called battle tools. Among the 228 scratch solos collected for the emotional label experiment (see Chapter 6.4), 176 of the manipulated samples came from vocal samples. In total, 35 samples were variations of the ‘ahhh’ sound, and 37 were variations of the ‘fresh’ sound (both originally from the Fab Five Freddie sample, but acquired from many different sources with similar sounds).

Naturally, the sampled material will not be without connotations, as the sound can inherit or communicate a meaning or emotion from the original recording. Thus, an important influence to acknowledge from the hip-hop culture is the humoristic and extensive referencing to both acclaimed and obscure recordings, TV shows and films (Demers, 2003). The reason why DJs widely use this referencing strategy has been explained as partly to create a connection to the listener by initiation (Cutler, 1994), to add to the narrative (Murray, 1998), to pay respect to their history or use it as a political statement (Demers, 2002; Rose, 1994), or to counteract the sometimes overly hostile attitude developed by modern rappers which otherwise takes the focus off music (Negus, 1998).

In Paper III we discuss how different sound samples can affect the performance: the tone attack, pitch, duration, and timbre all depend on the sound source. It is understandable that the playing is adjusted to fit the current sample, such that for instance there will be only short movements when the samples are short, less use of crossfader if the sample itself has several onsets, more muted backward movements if the sample has a fast decay, and so forth. In an experiment, we wanted to see whether expert and inexperienced listeners would accept a performance being played with a different sample than the one used in the original performance.

From the data in Paper III where sample position, record speed, and crossfader movements were extracted, we could resynthesize performances using other sound samples. Resynthesized versions of three randomly chosen performances from the recording session in Paper III were produced using the sound samples from Table 6.1<sup>♯:29</sup>. These samples were also taken from the skip-proof section of the same record as the original ‘ahhh’ sound (DJ 1210 Jazz, 2001), and have the same duration as the ‘ahhh’. The performances with the original sample were also resynthesized for the experiment.

Table 6.1: Sound samples used for generating performances in the experiment. Sample type is either single-onset (S) or multi-onset (M).

Sample	Type	Description
ahhh	S	Vocal ‘ahhh’
chord	S	Orchestra chord
drum	M	Drum beats
fresh	S	Vocal ‘fresh’
hm what	M	Vocal ‘hm, what?’
sine	S	Pure tone 500 Hz
watch this	M	Vocal ‘watch this’
yo go	M	Vocal ‘yo go’

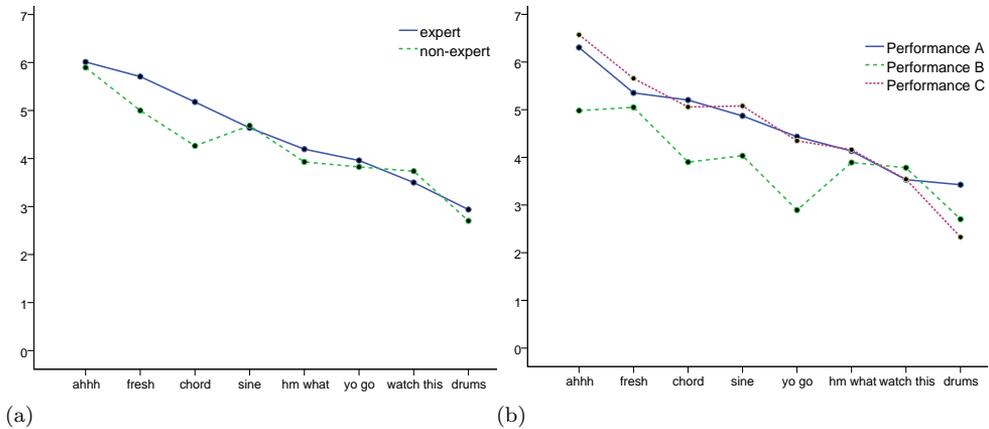


Figure 6.1: Results of changing the sample for appreciation of performances. The first four samples (ahhh, fresh, chord, sine) are single-onset sounds, the last four (yo go, hm what, watch this, drums) are multi-onset sounds. a) Expert and non-expert scores for three performances. b) Scores for each performance.

The 77 participating subjects (58 experts, 19 inexperienced) listened to the eight different versions of the three performances, and were instructed to rate how good the performance sounded on a scale 1–10. To test for statistical differences, univariate analysis of variance tests and independent sample T-tests were performed. The results show that listeners are sensitive to changing the sample, as seen in Figure 6.1. There were no significant differences between experts and non-experts, even for appreciating the performance. The experts show a slightly higher appreciation than non-experts, but only if the sample is a single-onset sound (see Figure 6.1a).

Performance B was significantly different from the other two (in a Tukey’s HSD post-hoc test). Although Performance B was less appreciated than the others, there was little

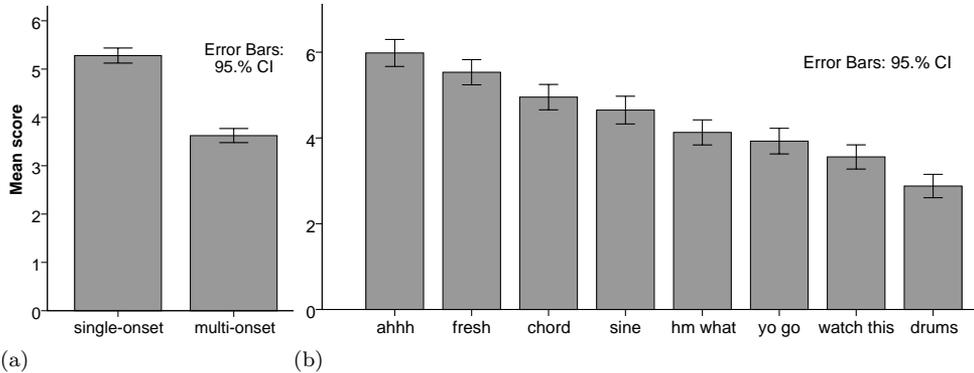


Figure 6.2: Ratings of appreciation of performance from all participants and all performances. a) Difference between single-onset and multi-onset samples. b) Ratings for each sample (the first four samples are the single-onset sounds).

effect from performance on the sample score in the data; the trend was quite similar (see Figure 6.1b), except that the sample ‘yo go’ got much lower rating.

It seems that the “DJs” choice of sample can explain the differences in listeners’ appreciation for this data set. It could be expected that a performance played using a single-onset sample would not work well when the sample is changed to a multi-onset sample, and this was also the case; single-onset samples were significantly more appreciated. However, in Paper III it was shown that mostly the beginning of the sample is played, which challenges that explanation. Also, both experts and non-experts preferred the original sample, not just any random single-onset sound (see Figure 6.2b).

### 6.3 Expressivity

One of the hypotheses in this work is that the DJ instrument can be played expressively like any other musical instrument. This means that DJs are able to communicate emotional content in performances—even to inexperienced listeners. Also, it implies that DJs follow the same rules for expressive performances as other musicians.

A pilot listening test was set up to investigate expressivity in scratching, however the results were nonconclusive, and two other experiments were conducted to get more answers. The pilot experiment, described below, involved matching an emotionally intentioned scratch performance to an emotional label (Hansen *et al.*, 2006). The second experiment, described in Chapter 6.4, aimed at finding appropriate labels to be used in scratch music experiments (Hansen *et al.*, 2008). The third investigation was the analysis of expressive scratch improvisations in Paper III.

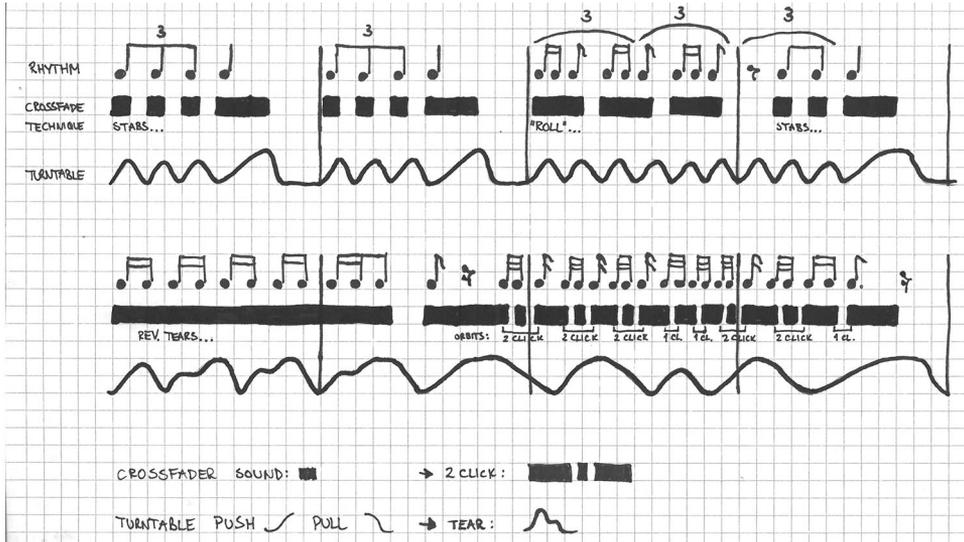


Figure 6.3: A scratch composition sketched in a custom notation format, with notated rhythm, crossfader position, and record movement. It is notated in  $\frac{2}{4}$  time, with tempo=96 bpm. Each horizontal grid unit corresponds to a  $\frac{1}{16}$  triplet.

## Method

The recordings that were used in Paper III included only improvisations, but in the recording session we also asked the DJs to perform a specially composed short piece in order to reduce the experimental variables<sup>4:30</sup>. Both improvisations and compositions were recorded under the same conditions: the ‘ahhh’ sound sample, the background drum loop, seven different emotional expressions (sadness, happiness, disgust, anger, coolness, self-confidence, romance), and a ‘neutral’ performance. The sessions were organized with a warm-up and practise on the composed phrase, performance of composed phrase, and performance of improvisations.

The composition was drafted by combining a few well-known scratch techniques that were both easy to perform and allowed for varying the gestures to some degree. A DJ practiced on and modified the notated draft version until the composition was acceptable, then a score (see Figure 6.3) was distributed to the recording participants. We noted that the DJs had some problems playing the composed piece. All commented that the piece in itself was technically uncomplicated, but that playing a composition represented an unfamiliar task. With sufficient practice, they all succeeded in performing it.

In the listening test conducted on these stimuli, 16 scratch-inexperienced participants were asked to match the emotions the DJ communicated by assigning a label to each performance. The listening test had first a training section with improvised performances, and then the compositions with the background muted.

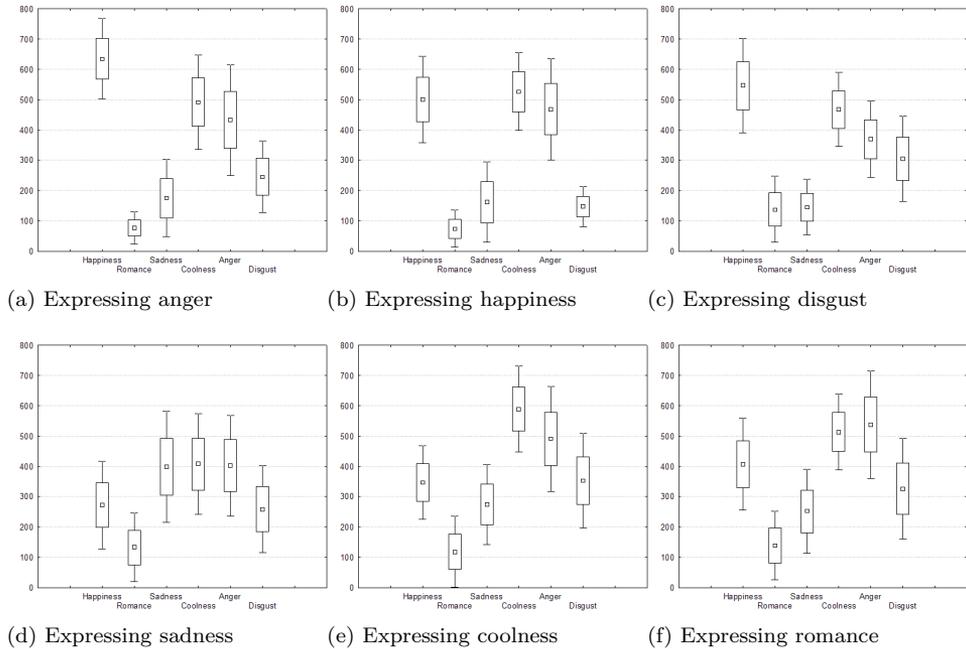


Figure 6.4: Improvisation stimuli in the first part of the experiment expressing six emotions, with rated score for each emotional label: Happiness, romance, sadness, coolness, anger, disgust.

## Results and discussion

The results indicate that listeners could not recognize the intended emotional expression from audio alone, or that the DJs could not produce the emotion. The ratings were not consistent with the expected outcome. This was only a pilot test with 12 subjects, too few for facilitating statistical analysis. In Figure 6.4, the results from the first task, where six improvisations by DJ A were rated, are plotted. The first three diagrams, for angry, happy and disgusted performances, show higher ratings for ‘happiness’ than sad, cool and romantic performances. For the cool performance, ‘coolness’ is correctly top rated, and for sad performance ‘sadness’ is higher than in the other examples. Apart from this, there seem to be few matches between intended and rated emotion.

An example of the ratings (neutral and sad performances) of all three DJs can be compared in Figure 6.5. It shows that, for instance, the response differences are very small for DJ C between the emotions. In the later study, Paper III, we postulate that ‘neutral’ is not performed without any particular emotion, but with an emotion being recognized as closer to agitation, self-confidence and happiness. Therefore, a bigger difference between Figures 6.5c and 6.5f was expected (as seen for the other two DJs).

DJ C got a peculiar increased rating for ‘happiness’ in the sad performance. For DJ A and DJ B, the ratings differ more between emotional performances, but not much so. Both

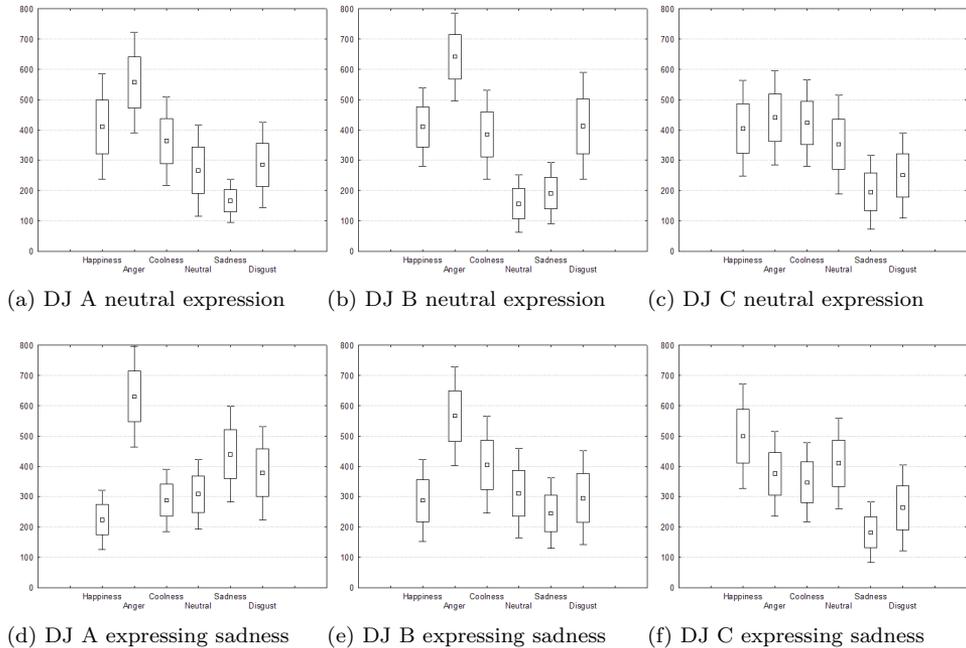


Figure 6.5: Three DJs express ‘neutral’ and ‘sad’ for the second part of the experiment, with rated score for each emotional label: Happiness, anger, coolness, neutral, sadness, disgust.

sad performances have high ratings for ‘anger’ compared to neutral performance, but only DJ A has a higher ‘sadness’ rating for the sad performance.

Happiness, anger and coolness were rated very highly in general. High coolness can possibly be explained by both the playing style and overall expression of DJs. The general impression many seem to have of hip-hop culture is as ‘cool’ (this was also reported informally by the participating listeners)<sup>2</sup>.

In these rating tasks, the participants to the listening test had very little or no experience of scratching, and presumably never had to consider how performances of such music can be categorized by emotional labels. All reported that the task was difficult. Nevertheless, hip-hop music is today a genre that one hardly can avoid being exposed to, and the songs of the genre are likely composed and performed to express similar feelings as other pop music. The musical nuances of expressive scratch performances are however perhaps still too arcane to the average listener, or the DJs did not express emotions univocally; at least the pilot results indicate this.

<sup>2</sup>The meaning of the word ‘cool’ is not universal. For this and the following experiments, our interpretation was explained to the DJs and the participants (epitomized by one DJ as ‘*cool like Fonzie [in Happy Days]*’). The hip-hop understanding of ‘cool’ seems to be quite accepted (see for instance <http://www.urbandictionary.com/define.php?term=cool>).

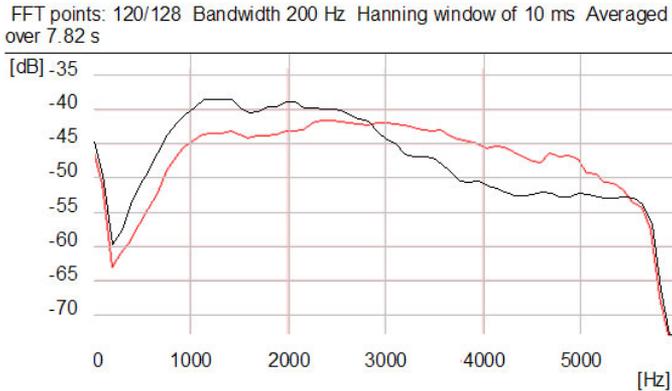


Figure 6.6: Long time average spectrum of performances expressing anger (red line) and happiness (black line). Performance with the ‘anger’ condition produced more energy in the 3–5.5 kHz range due to higher gesture speed.

In the acoustic domain, there are some differences between the expressive performances. For instance, in the long time average spectrum, there is more high-frequency energy for the angry performance, as shown in Figure 6.6. This could be expected (and was also found in Paper III) because the gestures are generally faster, producing tones with more high-frequency energy, which are both typical cues for expressing anger (Dahl and Friberg, 2004; Juslin, 2001).

The shape of the curves and the pitch level in spectrograms of the recordings (see Figure 6.7) are directly relating to the record speed and the gesture. Steeper curves mean that larger gestures were made in that period of time. There are more arched pitch curves for the performance shown expressing anger than happiness, as discernable in Figure 6.7. DJs seldom acquire sufficient skills to control pitch in a way that resembles traditional instruments, which would have been seen as less arched tones in the spectrogram (the last tone in each spectrogram in Figure 6.7 was produced by releasing the record and letting it play with the motor speed). Accurate pitch control has neither become a stylistic ideal<sup>3</sup>.

Listeners commented that they tried to imagine the DJ in action, and one assumption is that the imagined movements are more important than the actual sounding result to an untrained listener. Scratching possibly leaves an impression of fast movements and high velocity, which generally are associated with the emotion ‘anger’. The big pitch shifts, although in reality caused by relatively small movements, will in turn possibly leave an impression of large hand gestures, and thus with emotions like ‘happy’. For non-DJs, at least, pitch and timbre may serve as ambiguous cues in scratch performances.

<sup>3</sup>The Controller One by Vestax (see Chapter 4.2 and Figure 4.3e) was an attempt at providing a tool for producing discrete tones with a turntable.

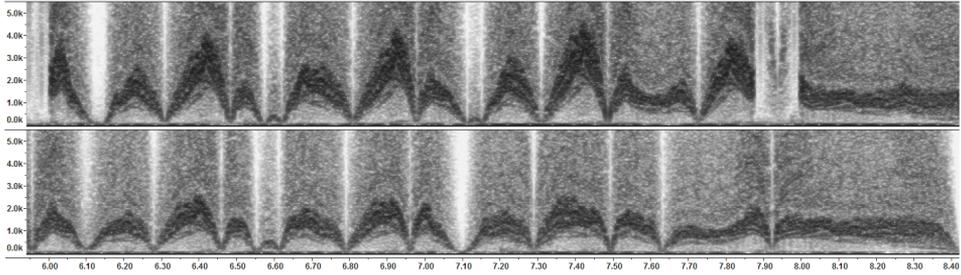


Figure 6.7: Spectrograms of the same performance excerpt from angry (top) and happy conditions. The excerpt corresponds to bars 5–6 of the composition in Figure 6.3 (on page 50) with mainly *reverse tear* scratches, which produce record onsets and have no crossfader onsets.

## 6.4 Emotional labels

In the pilot experiment described in Chapter 6.3 it appeared that listeners were unsuccessful in categorizing and describing variances in expressive scratch performances, or possibly, the performers were unable to play with given instructions on the target emotional expression. Another possibility could be that it was problematic to use a forced-choice method experiment with a set of selected labels for describing expressivity in music. Studies conducted in music mood taxonomy and communication of emotional content in music rarely include stimuli from narrow music genres like turntablism.

An experiment was designed to find emotional descriptions for scratch music, and to compile a list and recommendation of terms that are useful for describing expressive music in this and possibly other genres (Hansen *et al.*, 2006). The new list can be used when conducting experiments involving for instance DJs, and differs to some extent from the labels of emotion found in previous studies (e.g., Juslin and Laukka, 2003, 2004)<sup>4</sup>.

Many of the previously used methods in music emotion studies may not be applied to scratching, as they are most often based on the analysis of a discrete tonal and rhythmically structured melody (Gabrielsson, 1999, 2003; Widmer and Goebel, 2004). This difference applies not only to melody, but to other musical aspects as well. For instance, it appears to be less use of tonality, dynamics and tempo changes to produce expressive performances in turntable music. Also, without the melody line, rhythmical timing rules will be harder to formulate. Finally, the tempo is constant in loop-based music. In effect, many of the most important acoustic cues in computational models for music expression that are used (e.g., Friberg *et al.*, 2006; Todd, 1985, 1992) might not be suitable for scratching. Kallinen (2005) concluded from a study with different music styles that the emotional connotations are less established in modern than in more tonal music.

<sup>4</sup>Several papers discuss if such basic emotions exist, what the distinction between emotions and other phenomena like affect and cognitive states are, what qualifies a basic emotion, and how many basic emotions there are (e.g., Barrett *et al.*, 2006; Ekman, 1992, 1999; Ortony and Turner, 1990). Here, we use the basic emotions that have become common in research on musical expressivity (Juslin, 2001).

Interesting comparisons can be made with studies involving emotional expression and musicians using a limited set of acoustic cues or features. Laukka and Gabrielsson (2000) investigated how performances of drumming could communicate emotions by using only tempo, dynamics and timing as cues. It was found that the communication was overall successful and that some emotions (happy, sad, fearful and angry) were easier to communicate than others (tender and solemn). Behrens and Green (1993) made a different observation in a study where timpanists, violinists, trumpet players and singers were instructed to convey the emotions sad, angry and scared through short improvisations. There, correct identification of expression was found to be highly instrument dependent, and for the timpani, only the angry emotion was accurately communicated. Baraldi *et al.* (2006) investigated how musicians would use an explicitly limited set of acoustic cues to play with expressive intentions on a piano. Ultimately, only variations of the rhythmical density and tempo were allowed. Still, a systematic cue utilization for different emotional intentions was found, supporting the view that manipulating only a minimal number of musical features can be sufficient for communicating emotions.

## Experiment method

A library of scratch music excerpts was compiled from around one hundred commercially available recordings between 1982 and 2007. In all, 228 scratch solos were identified, and eight stimuli were randomly selected for an online listening experiment<sup>4.31</sup>. There, 39 participants were asked to ‘list adjectives that describe the music excerpt’, and to describe ‘which feelings/emotions/moods that are expressed’ for each of the eight sound examples. The open form answers allowed single words, compound words, expressions, or even short or long phrases. In total, 1100 responses were entered by the subjects. Among those, there were 671 unique words or descriptions.

## Semantic analysis

The semantic analysis procedure was mainly manual, involving four expert judges. This had practical advantages, but also imposed some restrictions as the judges would have to make interpretations to process the data. One advantage was that unusual words, slang, or purposely misspelled words, which are all frequent in hip-hop terminology (Fab Five Freddy and Braithwaite, 1992), would not necessarily be lost as might have happened with automated analysis procedures.

Five broad categories were defined based on what we assumed to be probable candidates that could encompass most or all of the words. These were *Motional*, *Emotional*, *Quality*, *Musical mood* and *Musical sound*, and for unclassifiable words an *Other* category. They were chosen more or less intuitively and were considered common for describing music throughout literature, for instance in Gabrielsson (1982), and in daily language. A correlation analysis was performed at a later stage in the analysis that validated the approach of having the five broad categories. For instance, *Musical mood* and *Emotional* categories are often not considered to be separate, but either used in parallel (Baum and Rauber, 2006), or exclusively as connected to a certain research discipline (Downie *et al.*, 2007). This study, however, supports Gabrielsson (1982) in that *Musical mood* and *Emotional* categories should be treated separately.

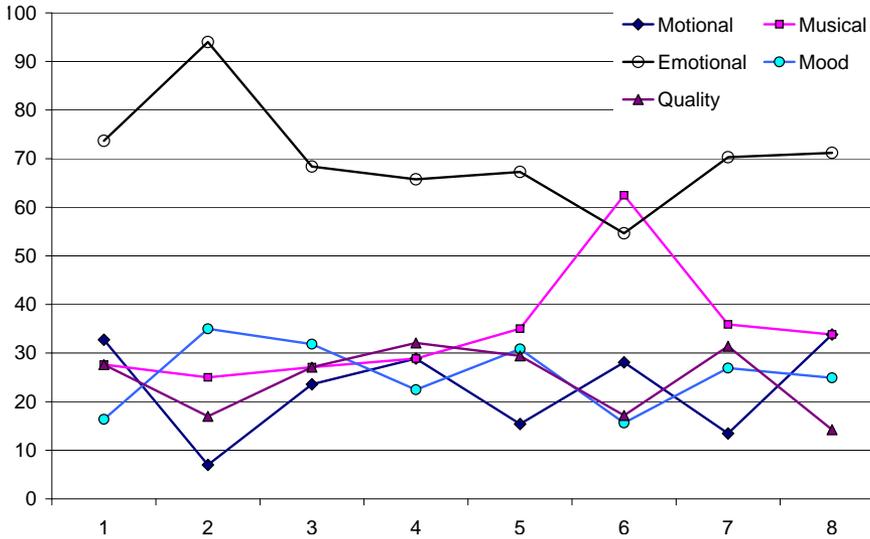


Figure 6.8: Distribution of responses in percent for each music example (1 to 8 on the horizontal axis) and category. For Example 2, the categories are, from top to bottom: *Emotional*, *Musical mood*, *Musical sound*, *Quality* and *Motional*.

All the words were categorized manually by the judges into one or more of the five predefined categories. Entries that could not be placed in any category were sorted as *Other*. The condition for inclusion in further analysis was that at least three judges put the word in the same category. The entries in *Other* were not analyzed further.

Each judge was instructed how to interpret the categories. *Motional* is a description of physical motions or abstract musical motions. *Emotional* is a description of emotional expression in the music or the emotional content conveyed by the performer. *Quality* is a description of often more evaluative character. *Musical mood* is a description of the musical expression that may not necessarily be possible to use as an emotional description; for instance ‘90ish’ or ‘nostalgic’. *Musical sound* is a direct description of either sounds or the music.

Almost twice as many words were put by the judges in the *Emotional* category than the second largest category, *Quality*. *Emotional* had more than twice as many compared to the *Musical sound*, *Musical mood* and *Motional* categories.

All categories had many words where the judges disagreed; only *Emotional* had a high rate of agreed-upon categorization, where 66% of all the descriptions were common for all the judges. Figure 6.8 shows the distribution of categories for each music example used in the test. It is interesting to see how Example 6 generated many more responses connected to *Musical sound* than the rest, and that this example also had the lowest number of *Emotional* responses. We will later see that subjects coincidentally related this extract to a specific musical characteristic. Also, Example 2 stands out, with the highest number of *Emotional* responses and lowest *Motional* responses, although we could not give an explanation for this.

Table 6.2: The table shows manually clustered descriptions for each category, ordered by popularity.

Mus. sound (195 descriptions)	%	Mus. mood (156 desc.)	%	Motional (133 desc.)	%	Emotional (435 desc.)	%	Quality (148 desc.)	%
Uptempo	16	Cool	29	Fast	22	Cool	14	Skilled	25
Eventful	16	Amusement	15	Calm	19	Agitation	13	Good	22
Futuristic	14	Sadness	9	Agitated	16	Amusement	12	Dull	20
Noisy	8	Agitation	8	Moving	16	Happiness	11	Bad	15
Melodious	7	Dark	8	Dancing	12	Sadness	8	Rough	9
Oldschool	7	Tenderness	8	Energetic	11	Cocky	7	Basic	7
Uplifting	6	Happiness	6	Dizzy	3	Tenseness	6		
Aggressive	5	Dancing	4			Alert	6		
Rhythmical	4	Dreaming	3			Passion	5		
Tranced	4	Groovy	3			Carefree	5		
Messy	4	Tranced	2			Suffering	4		
Downtempo	3	Mysterious	1			Tranquility	4		
Repetitive	3					Mysterious	3		
						Dizzy	1		
						Uncool	1		
Other	2	Other	3	Other	0	Other	2	Other	2

Next, entries in each category were grouped into clusters created from a combination of suggestions from a linguist, from synonyms, and from other studies reported in the literature (for instance Collier, 2007). Often, the most frequent word was used as the basis for a cluster. Each category had an ‘Others’ group. Table 6.2 shows the results for all the categories.

For the *Musical sound* category, 195 descriptions were clustered into 13 groups. As seen in Table 6.2, the word group clustered as ‘futuristic’ was very prominent, but it was only found for Example 6. Some entries in the data set that were excluded because of the judging criterion would in retrospect have confirmed certain findings: for instance, the excluded entries ‘space age’, ‘space trip’ and ‘alien’ were used particularly to describe Example 6. This is one example of the difficulties of subjective categorization of words taken out of context, and how the judge agreement limit could seem strict.

For the *Musical mood* category, 156 descriptions were clustered into 12 groups. One group alone, ‘cool’, covers nearly one third of the responses. For the *Motional* category, 133 descriptions were clustered into seven groups. *Motional* can be interpreted in several ways, for instance as a movement connected to discrete human action or to a higher level of movement, such as ‘fast’. For the *Emotional* category, 435 descriptions were clustered into 15 groups. Again, ‘cool’ is an expected popular description.

For the *Quality* category, 148 descriptions were clustered into six groups. It is somewhat uncertain how helpful such descriptions are<sup>5</sup>. However, it is clear that the participants gave corresponding descriptions. All examples but one were considered to be ‘skilled’, possibly interpreted as ‘with virtuosity’ or ‘played fast’.

<sup>5</sup>In other studies (e.g. Gabrielsson, 1973) evaluative descriptions were excluded.

Table 6.3: Selection of examples for listening test. *Scratch style* and *Mood* came from an ad-hoc classification, while *Description* is the result from the analysis.

Ex.	Scratch style	Mood	Bpm	Description
1	Classic	Neutral	80	Agitated, Energetic, Fast
2	Melodic	Humorous	101	Amusement, Sadness, Passion
3	Melodic	Gentle	89	Cool, Calm, Melodious
4	Classic	Neutral	96	Moving, Energetic, Tenseness
5	Classic	Melancholic	98	Cool, Eventful, Tranquility
6	Weird	Happy	105	Futuristic, Energetic, Happiness
7	Fast	Happy	89	Melodious, Eventful, Cool
8	Fast	Melancholic	98	Cocky, Dark, Agitation

Table 6.4: The 15 most frequent labels to describe scratch music and expressive content of the recordings. The rate is in percent of the total number of responses.

Rank	Label	Rate	Rank	Label	Rate	Rank	Label	Rate
1	Cool	9,9	6	Tense	4,9	11	Cocky	2,9
2	Agitation	9,4	7	Sadness	4,6	12	Futuristic	2,6
3	Amusement	7,1	8	Skilled	3,5	13	Dancing	2,1
4	Fast	5,7	9	Eventful	2,9	14	Carefree	2,0
5	Happiness	5,4	10	Calm	2,9	15	Passion	2,0

## Results

It was possible to find a ‘best fit’ description for all examples based on frequency of responses (Table 6.3). There is a slight emphasis on labels that describe high activity (agitated, energetic, ...) and a positive valence (amusement, cool, ...). Some examples have consolidating descriptions, while others have more contradictory labels.

Word groups were removed if the distribution across all examples were even, which made those labels inadequate to explain differences in emotional content between stimuli. As an example, ‘good’ was used repeatedly for all the examples. Most of the removed labels were from *Musical sound* and *Musical mood* categories.

The groups listed in Table 6.4 were most frequent in the study. Compared to other studies (e.g. Lindström *et al.*, 2003), the results were not very different, as common labels like ‘happiness’, ‘agitation’, ‘sadness’ and ‘tenseness’ were present. The list also includes some more unusual descriptions like ‘cool’, ‘skilled’, ‘futuristic’, ‘eventful’ and ‘cocky’. Basic emotions, except for ‘agitation’, do not rank especially high on the list. Not surprisingly, ‘cool’ and ‘cocky’ were rated high here, as were terms connected to virtuosity and high energy or tempo. ‘Fast’ tempo, as will be discussed below, is most probably associated with fast playing techniques, not necessarily a high bpm (beats per minute).

Some words or groups were overlapping or were redundant. The list presented in Table 6.4 was constructed by grouping many different synonyms into clusters of words, producing only one label for each group. That possible source of ambiguity must be

considered when interpreting the results. One conclusion is that for the studied musical culture and genre, some labels that represent otherwise basic emotions were missing or less frequent, while other labels representing subtle nuances of specific emotions or emotions that normally are not considered basic, were well represented.

## Discussion and conclusion

The results of the study support the suspicion that the selection of emotional labels in the pilot experiment in Chapter 6.3 led to an unexpected low matching of intended and perceived emotional expression in listening tests with scratch music performances. Anger or agitation seems to be the emotional intention that is communicated most strongly, and together with ‘cool’ it was the most common description both here and in the pilot experiment. ‘Cool’ is indeed a stereotypical apprehension of what hip-hop is, along with certain personality associations such as self-confidence and a desire for social recognition (Rentfrow and Gosling, 2007). That does not automatically make ‘cool’ an efficient label for distinguishing between emotions in scratching: as seen, the listeners perceived all the performances to be expressed with agitation, even when the musician aimed at conveying sadness. Even though all possible kinds of emotional coloring can be expressed, the dominant ones here seem to be those of being or acting cool, being competitive, showing off (skills) and being agitated. These traits are reflected in the whole hip-hop culture in general (Rose, 1994) and in rap music especially (McClary, 1985; Murray, 1998).

Coupling between emotional descriptions and tempo or references to tempo, was not found in this data set. Possibly, it is an effect of the awkwardness of playing prolonged tones, which may cause scratching to always sound ‘fast’, or it could be that the meter or pulse is not the same as the bpm<sup>6</sup>. Words describing slow movements were also unusual.

Scherer (2000) discussed the view that assessment of emotion, whether induced or expressed, is culturally conditioned, but that this does not imply the emotional mechanisms are different. Hip-hop, as a cultural construct, may indeed suppress feelings and emotions of certain types. One possible example is the emotion ‘sadness’, which seems to be rarely encountered in turntablism. Only a few subjects used that exact word to describe a stimulus, but synonyms like ‘melancholy’, ‘mellowness’, ‘unhappy’ and ‘moodiness’ were found, which when grouped made ‘sadness’ a common emotional label. Subjective decisions made in the categorization necessarily influenced the results and call for interpreting the results accordingly.

The influence of referencing to known or unknown recordings through sampling will probably, intentionally or not, induce a sense of amusement even in performances that are not intentionally humoristic, if the subject recognizes or is surprised by the sample (see also Chapter 6.2). A study by Schubert (2007) showed that felt emotions affect the perception of emotions. Samples can therefore amplify or work against the intended effect on the expressive content. DJs can counteract the influence of the sample to some degree. As discussed earlier, some sounds have become standard sounds in the repertoire and are thus comparatively neutral for any performance.

Tempo in hip-hop is by tradition not very diverse, and even though tempo is distributed from 60 to 192 bpm in the collected scratch solo library, there is a prominent peak between 90 and 100 bpm (mean=96.5 bpm, SD=16). This corresponds perfectly with the *Afro-American* category in a study of popular music rhythms and tempi by Moelants (2003). It

<sup>6</sup>It is for instance usual to play with a triplet pulse in a slow tempo.

can be argued that expressivity is less dependent on tempo choices than what is normally found in literature (Gabrielsson, 1999). Also tempo variations are expected to be less important for emotional coloring, especially as used in classical music, mainly because of the static loop or drum machine rhythms.

The label ‘futuristic’ has probably been added by the subjects due to some specific acoustic feature of that example (see Table 6.3, example 6). Although these traits were not apparent when examining the stimulus selection, it seems likely that a strong reference to science fiction films or sounds can explain why ‘futuristic’ was used so consistently. If this music example deviates from the rest of the library, it is hard to defend that particular label’s position in the label list. On the other hand, it might be that stylistic ideas taken from science fiction culture are in fact so important in hip-hop that such a label can describe a genuine expressional intent.

It is interesting to note that some of the words that came out of this study can be hard to place in the two-dimensional activity–valence space (Russell, 1980). ‘Cocky’ and ‘cool’, for instance, could be situated along a possible potency dimension in a variation of the emotional space (Osgood *et al.*, 1957), while being more neutral in the valence and activity dimensions, see also Figure 9 in Paper III. Other synonyms that appeared, like ‘alert’ and ‘interested’ are arguably more related to cognitive states than emotions.

The final list reported in Table 6.4 will therefore for many reasons appear to be a compromise between basic emotions, cognitive states, affective reactions, expression and moodstates (as described in for instance Ekman, 1999; Scherer, 2004; Terwogt and Van Grinsven, 1991). It has yet to be proven through experiments how well the items in the list can be used as descriptions for emotional intentions in music.

## Chapter 7

# Conclusions

This thesis set out to describe what scratching is, based on analyzing scratch techniques in performance recordings. The topics which have been touched upon cover a wide research area and several disciplines. While not providing a complete picture of the instrument and its practice—that would have been a rather ambitious goal—the work describes several aspects that have not been investigated until now.

The acoustic analysis showed that the tones in this music bear little resemblance to the tones of other traditional instruments of Western music. They are very short, they have a particularly unstable pitch with big frequency glides, and sounds with a broad noise spectrum are preferred over periodic sounds. Such tones are not suitable for melodic music, and consequently there is no tradition for notating music, for compositions or for tune-based songs. Instead, improvisations dominate the musical output. The tone density is overall high, which makes the scratch DJ a demanding member to include in an ensemble. By tradition, the DJ is also accustomed to embrace all musical roles at once, and it is hard to separate the rhythmic and melodic function in a scratch performance.

Scratch techniques still have a prominent position for the musicians, as they represent a collection of cultivated, successful gesture combinations more than being just genre-specific dogmas. The recordings have shown that the DJ's individual expression lies in how these techniques are blended, more than how each technique is performed. The sample that is manipulated has some impact on how the techniques are played, but it is more that the combination of techniques is varied, as in the study in Chapter 6.2, than that there have been defined different techniques for different samples<sup>1</sup>.

For the most part, expressive performances are produced by abiding by the same rules and principles as other instrumentalists do. These principles include pitch, tone duration, articulation, tone density, timing and more. The performance parameters of scratching are tightly bound in many cases: for instance it is not possible to get a high pitch by slow movements (unless the sample is such), or a stable pitch with the slow record onsets. Therefore, the DJ must make compromises between tone stability, onset features, and other parameters. Apart from the acoustic cues of expressive performances that might be unfamiliar, hip-hop has general characteristics developed for instance from the battle culture which can interfere with the interpretation of the emotional contents of

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<sup>1</sup>Like for example a tone scratch must be performed with a pitched tone sample and the transformer with a long sample.

an expressive performance. The studies of expressivity and emotional labels conducted in this thesis (see Chapters 6.3 and 6.4) suggest this.

Scratching is hard to learn and master, but technology can be used to assist the player in achieving “correct” techniques. By modeling DJ gestures and mapping these to interfaces that are easier to control than the turntable, the playing style is made available even to non-experts. Modern interfaces are, however, not focusing on this type of user, but on the (semi-)professional DJ who wants to control a digital music collection instead of vinyl records. The interfaces are for the most part replicating the functionality and behavior of standard turntables.

There is no doubt that DJ culture has had a big impact on popular culture. In music, we have many examples of instruments imitating the scratch sounds. In consumer media devices and software players, every opportunity is provided for being your own DJ. In a broader perspective, the reusing of recordings is reflected in many art forms, used in a way inspired by the DJ practice.

## 7.1 Future work

Studies of DJ scratching have only just started. Considering the odds against the instrument’s survival and its now at least 40-year history, there are many justified questions: how could a musical instrument evolve from a playback device, mostly without change; how could the instrument continue to exist even after the vinyl medium was totally overtaken by CDs (and commonly announced dead); how could a non-melodical solo instrument succeed in a steadily more tune-based pop music culture; why do kids spend hours of practicing without support from music schools to master an unruly instrument. . .

Also the result and discussion sections of the experiments in this thesis indicate that there are many issues remaining to be investigated. For instance, none of the studies included here or in Chapter 2 provide comprehensive results on

- perception of scratch sounds,
- the effect of hand and finger settings on the vinyl and crossfader,
- the description of performance gestures apart from control actions,
- comparisons of performance quality with traditional and new interfaces,
- applicability of scratching or DJing in other situations, such as in music therapy or music training,
- how scratch techniques are performed in different perspectives (such as regional, historical, gender, musical background and genre perspectives),
- how scratch techniques are adapted to a specific sample,
- how scratch techniques are affected by using the other volume controllers (line fader and line switch),
- how scratch techniques are affected by the hand position on the vinyl, and
- how tempo influences the performance.

Without speculating in the future of scratching, there is an open attitude towards new technology among DJs, as seen in Chapter 4.2 where 87% say they use some kind of digital technology (and 74% of the scratchers). It will remain a challenge to design

new interfaces with appeal to DJs, and also to improve the interfaces in use today. An interesting observation has been made about new interfaces: These technologies, from CD players and time-coded vinyl to Tonium's *Pacemaker* 'are designed to replicate the analog, vinyl experience, that's already an acknowledgment that it isn't the DJs coming to digital tech, it's digital tech coming to the DJs' (Fintoni, 2004).

Yet, we can also depict a scenario where the DJs come to digital technology, in which the increasing user friendliness of sensor-based building toolkits and open controllers will enable (and inspire) DJs to design custom instruments fitting their own playing gestures. This tendency has been observed in the growing use of augmenting technology like the Korg Kaoss pad, guitar effect pedals, and software processing of sound with for instance Max/MSP.

Speculating a bit further in the future of scratching, on the other hand, I have several times during the thesis work come across comments (even from DJs) that say the instrument and genre has nowhere left to go, "there is only so much you can do with a turntable". Now, it is clear that in 2010 the DJ industry and instrument market is still flourishing, perhaps even more so than 10 years ago. Digital vinyl systems have sustained the interface DJs love while overthrowing the drawbacks of an imperfect storage medium. The musical output has reached a mature stage, with plenty of room to evolve, and thus the prospects of scratching are only limited by the availability of instruments, the DJ's creativity, and the listener's openness.



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