

S-NOTATION: A COMPLETE MUSICAL NOTATION SYSTEM FOR SCRATCHING AND SAMPLE MUSIC DERIVED FROM “THEORY OF MOTIONS”

Alexander Sonnenfeld
Qbert Skratch University
alexandersonnenfeld@yahoo.de

Kjetil Falkenberg Hansen
KTH Royal Institute of Technology
Södertörn University
kjetil@kth.se

ABSTRACT

In this paper, we present and discuss the *S-notation* system for sample-based music, and particularly for DJ scratching and turntablism. Sonnenfeld developed the system from his *Theory of Motion* where scratch music is seen as constructions of concurrent musical gestures (motion parameters), and not only turntable actions. The detailed symbolic notation was inspired by traditional musical notation, and among its advantages it covers current musical needs, it can be read and played live in performance, it provides a tool for composers to convey musical ideas, it can be expanded towards new styles and techniques, and it is generalizable to other types of sample-based music. In addition to motion parameters, the new notation system involves an analysis of the sampled sound. Finally, S-notation is also applicable for documenting and for teaching situations.

1 INTRODUCTION

In this paper, we introduce the *S-notation* for sample-based music [1], and particularly within turntablism, which is a practice where disk jockeys (DJ) use turntables as musical instruments [2]. There is a growing need for musical notation that can handle performance and composition of turntablism. Since 1998 there have been attempts at creating such notation—and with varying aspiration—but none has been exhaustive. A possible explanation for this is the high musical complexity, which can be expressed as specific challenges:

1. To effectively write and read scores for music with high event density, as scratching averages 5.8 notes played per second [3].
2. To find means of transcribing playing position of the recorded sound that is to be manipulated.
3. To cover the musical diversity of DJ playing techniques including scratching, word play, drumming, beat juggling, and experimental techniques.

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This design task is complicated further as each style involves both hands alternately playing the audio mixer and turntables.

The S-notation system proposed here has been developed by Sonnenfeld since 1999 [4, 5]. It represents a reciprocation from the progressively simplified graphical notation systems to a more elaborate symbolic one that extends standard musical notation, see Figure 1. Although the appearance is similar to standard notation, there are a few fundamental differences, mainly related to pitch representation, sound to be played, and rendition of onsets.

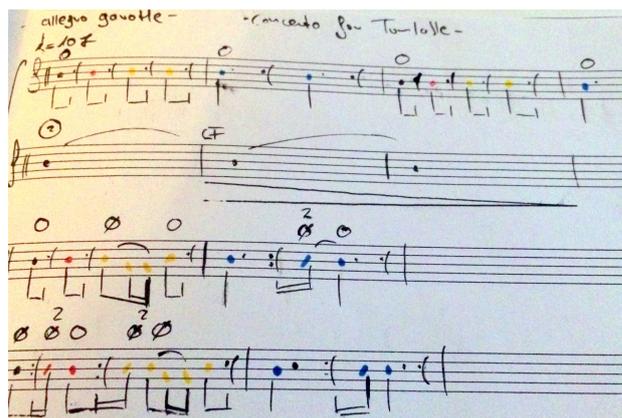


Figure 1. Excerpt from the handwritten S-notation sketches of Gabriel Prokofiev’s “Concerto for Turntable”.

Because of the balance between complexity and affinity to standard notation, S-notation addresses the above challenges and has a set of advantages:

- it provides means for conveying musical ideas,
- it provides means for transcribing music,
- it can with training be read and played *a prima vista*,
- it covers most of the foreseeable musical needs,
- it is expansible toward new turntablism techniques,
- it is generalizable to other sample-based music.

In the following, we will describe both how the notation derives from the *Theory of Motion*¹ and how the sampled sound material can be transcribed alongside score elements like pitch, note duration and dynamics. Because of their breadth, only a part of the S-notation system and Theory of

¹ Orig. *Bewegungslehre* (German).

Motion can be introduced.² We will also discuss possible further developments with some emphasis on tutoring. The emphasis of the notation format, however, is on the now classic performing tradition which dates back to the late 1970s.

2 BACKGROUND

DJ scratching and turntablism have been studied in detail, and are now part of higher education curricula [2, 6]. The musical style has been exposed to a wide audience since Herbie Hancock’s MTV video *Rockit*³ from 1984 until recently in 2011 when Gabriel Prokofiev’s *Concerto for Turntable* was featured in the BBC Proms concert series.⁴

The taxonomy of this music is well established [7], and some basic concepts are:

Turntablism Music made using turntables, played by *turntablists*. This does typically not include mere playback, although there is no strict definition. Similar practice with other controllers and other sound sources than vinyl can be considered turntablism.

Scratching The main musical output of turntablism. Performed with a combination of record movement and onset control using the audio mixer’s crossfader.

Beat juggling Switching between short phrases from each of the two turntables in the instrument set-up, creating new rhythms, melodies and chord progressions.

Drumming Playing rhythms from a small set of sounds such as a bass and snare drum beat.

The study of hip-hop DJing is to a large part the study of performing gestures, and the importance of such *techniques* is axiomatic. Even the story of the “birth” of scratching is, quite amusingly, the story of the *baby scratch* technique [6]. S-notation is based on Sonnenfeld’s Theory of Motion [4], which relates to current research on gestures [8]; in particular, scratching is seen as not only a performing action on the turntable, but as a construction of several concurrent musical gestures. It should however be mentioned that the Theory of Motions was developed outside academia, independently of ongoing research in the area.

Several writers have put forward the need for notation in scratching, and for different reasons. For instance, Taniguchi [9] claims that the audience appreciation will improve; Smith [10, 11] argued that turntable notation is necessary for communicating musical ideas, for documentation, for composition, for analyzing and understanding, and for making scratching a legitimate musical practice; Miyakawa [12] goes even further and says that notation methods are reflections of turntablists’ self-conscious efforts to be recognized as musicians; and Ouper [13] and Biederman [14] discusses how orchestral works with turntable soloists are transcribed.

² Full descriptions and examples: www.alexandersonnenfeld.com

³ Official video from VEVO: youtu.be/GHhD4PD75zY

⁴ Official BBC clip featuring DJ Switch: youtu.be/38atRejUORM

2.1 Scratch Notation Systems

Even if there are several notation formats for scratching, these have not been used to a large degree: only 23% of the scratchers in a survey had ever used notation [3, p. 41]. Scratch notation was first inspired by musical staff notation, and later based on graphic representation of scratch gestures. Doc Rice [15] and Hansen [16], and later Radar [17] and Webber [18] were among the first to use standard music notation (with additions and alterations) for transcribing scratching. These systems used symbols on the note heads to indicate which scratch technique to play.

DJ A-trak [17] and Raedawn [19] introduced graphical notation systems. DJ A-trak developed his system for personal use, based on sloping lines which represent record movement with crossfader cuts marked on these lines. Raedawn’s Turntable Transcription Methodology (TTM) specifically targeted the turntablism community, and was also long the most spread format. Position in the sample is plotted on the vertical axis as a function of time, which is ordered in grids corresponding to beat durations along the horizontal axis. According to interviews and comments from DJs, the system is intuitive and fairly easy; however, there are few reported cases confirming that it has been used.

2.2 Sample-Based Music

Making new music from sampled music is paradigmatic in contemporary music practices. *Paradigmatic* because the practice is everywhere [20]; because sampling music radically changed music industry [21]; because sampled sounds have cultural connotations [22]; and because musical sounds in general can be acoustically [23] and contextually [24] interchangeable. The term *sample* means in this context *the material the musician uses* [25], and is an inseparable component of the instrument, embodied in a tangible medium [26].

Time-coded vinyl, often called Digital Vinyl Systems or DVS, was a game-changer for DJs when introduced in 2001. Instead of playing music stored on vinyl, the record is imprinted with code that can correspond to playing position in a digitally stored file. In basic use, it is exactly like ordinary vinyl, but with computer processing, the possibilities are limitless. In this paper, we use “sample” as described above, and disregard other uses of DVS.

Music based on samples is fundamentally difficult to transcribe. This is especially true when the samples are manipulated in continuous pitch sweeps and not in incremental steps. Typically the DJ will use a short (less than 0.5s) sample to play, and according to previous studies [27, Figure 5] only the first part of a sample is likely to be played. Playing position and the character of the source sound determine both which techniques that can be used and how it will sound. For instance will playing through a source sound containing several syllables, like the commonly used phrase “making me rich”, generate more tone onsets than a sample like “ahhh”.

Although we focus on turntable interaction in this paper, sample-based music take on many forms that are related.

The same playing and transcription methodology would for instance apply to music generated using novel interfaces like two-dimensional surfaces [28–30], or in writing scores that include sampled material.

2.3 Playing Techniques and Gestures

As mentioned above, scratching as music has since the very start been defined by a number of *techniques* [16, 31], which also led to extensive collections disseminating these [32]. However, it was shown in a survey that half of the scratching DJs *know* less than ten such techniques or none at all [3, p. 46]. Thus there has been a research bias on techniques that is not incontrovertible.

Instead of looking at named techniques, it is thus more fruitful to consider playing gestures generatively. Each tone (or note) made by a scratching DJ consists of a synchronized movement of pitch control and amplitude control. In the proposed method, these gestures are systematically analyzed together with the playing position and contents of the sample. The theory behind the transcription methods in S-notation is called Theory of Motion, and includes *motions* or gestures in different domains. Common is that the motions are not directly corresponding to performance gestures (as in *forward-backward* movement), but to musical or acoustic gestures.

3 THEORY OF MOTION

Theory of Motion sketches a sort of classification of the DJ’s instrument set-up consisting of the audio mixer and turntable to understand how it influences specific musical parameters of the sound material.⁵ This systematic is the requirement to transcribe the performance through so-called *motion parameters* by using the S-notation. These motion parameters are grouped into:

Acoustic Motions Movement of the vinyl or control disk (changing the speed or direction) to change the pitch of the sound.

Dynamic Motions Line fader or crossfader movements to change the volume (i.e., for the most part to turn on or off sound).

Frequency Motions Movement of the fader or rotary dial to cut or boost certain frequencies (i.e., equalization, but the features on the mixers vary in this regard).

Panning Motions Movement of the panoramic (panning) dial to spread the sound across the stereo field.

Effects Motions Movement of the fader or rotary dial to change the intensity of applied audio effects (e.g., reverb, delay, distortion).

⁵ In this paper we focus on turntablism-style DJs. The theory of motions does however not exclude controllerism in general, which has implications on both the instrument set-ups (other control surfaces) and type of musician (i.e., not only DJs).

While the gestures and movements may be similar for e.g. Frequency, Panning and Effect motions, the musical intention is not. Since the musical intention vary, it is not certain that the actual gesture will be similar either, and therefore the motion parameters are specified. Another reason for having specific controller-based motion parameters is that there are many playing techniques that utilize one controller.

All parameters are further separated into *motion types*: ‘Single motions’, ‘integral motions’ and ‘groups of motions’. They constitute the fundamental principles of a composition—comparable to melody—and the theory of motion aims to represent them by notational symbols. This principle should also help the player to capture possible playing strategies on the instrument which cannot be defined in the context of classical, tune-based music.

Due to the fact that we cannot transcribe the musical output as ordinary pitched notes, we need to think a little differently about what “melody” is. In turntablism the least common denominators are individual gestures (forward-backward, left-right or up-down). When you make “groupings” of these movements you can conceptually handle a wide range of possible playing strategies. A sonic trademark of these groupings is the “integral motions” which means the connection of both fundamental “single motions” as one pattern. Such a pattern is for example in the *baby scratch* and *1-click flare* techniques. In S-notation we defined this important compositional design element as an “integral motion” and created a separate symbol and term.

Every type of motion is subject to a unique architecture which is defined by a set of motion criteria. These criteria are: *direction*, *time value*, *intensity* and *characteristic*. S-notation is a transcription methodology from which you can read all the motion criteria based on the principles of music theory. As in classical notation, the shape of the symbol and the position inside the staff determines the action the musician should take.

4 S-NOTATION

S-notation is a transcription method which uses an own repertoire of notational symbols to describe the techniques of a turntablist; currently, there are around 20 additional symbols in use, see Figure 2. S-notation basically follows the orthographical rules of classical music notation in order to be able to communicate with traditional musicians outside of turntablism and open doors for composition, education and research. There are also a number of different clefs that serve specific purposes.

The purpose of this type of written music is to enable a musician to repeat performances with consistency, which has two requirements. First, the sound itself must be the same each time. This means there must be a way to annotate playing position of a sampled sound. The second requirement is that the individual techniques on the instrument must be subject to an order, a series of principles which can be understood and applied correctly.

In classical musical notation both prerequisites are firmly

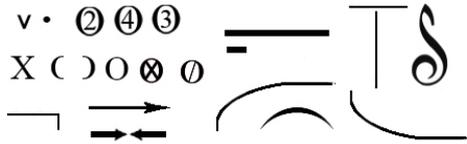


Figure 2. A selection of symbols added to conventional music notation for transcribing turntablism in S-notation. To the right is the “S” clef.

met because the movement on a keyboard or string is always linked to a certain tone or pitch. It is therefore possible to notate the tone based on the positioning of the note inside a musical staff. It is particularly difficult to capture pitch because of the broad pitch range produced by the motion of the disk, the characteristic of the sample, and the difficulty of playing steady-state tones.

4.1 Playing Techniques

S-notation describes only the manual motion on the disk and faders as a sort of gesture. For education and scientific purposes, a base formula allows detailed transcription of all the different playing techniques using a turntable and fader. To assist in this, audio recordings of particular scratches help the player to get familiar with the respective notated patterns.

S-notation provides its own repertoire of symbols to describe the direction of record motion and also the playing style, such as “hand mode” where the hand is in contact with the vinyl, and “release mode” where the record plays forward. It also includes a wide assortment of symbols to describe the velocity characteristics of the record motion (for example constant, logarithmic, exponential). Other parameters such as duration, pauses, articulation, etc., are based on traditional music notation.

4.2 Record Movements

Single movements on the record are divided into forward motion named *Note* with a standard note head, and backward motion named *Eton* which is the mirrored symbol of a Note (i.e. with a mirrored note head), see Figure 3.

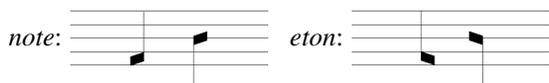


Figure 3. Notation of forward (note) and backward (eton) movements of the record.

Combinations of these two single motion types can produce complex patterns which we will refer to as “groupings”, such as the forward–backward–backward movements of a *tear* scratch, see Figure 4.

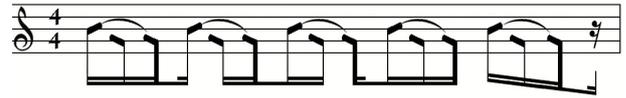


Figure 4. Notation of grouped gestures (forward–back).

4.3 Playing Position and Anatomic

To address challenges of working with recorded music as a sound source, S-notation allows to define all possible positions of the sample (or several samples) by using a given order of colored notes to represent the playing position.⁶ Figure 5 illustrates the different color positions on a record sample as played in a phrase, and the mapping between position and color in the waveform representation. The pre-defined coloring of the sample is part of an analysis of the recorded sound material, and is referred to as the *Anatomic*.

In using this coloring process it is possible to perform specific sound-material based on S-notation (see Figure 5), which is crucial because turntablists work with all kinds of recorded material. The *anatomic* analysis also includes basic values of musical parameters, such as duration, pitch, volume, etc. By using a colored template for the record (there are different methods possible) the player can play through the sound to recognize the colored areas corresponding to chronological positions of the sample.

Just as (most) other music instruments have visual or tactile cues or guides to help the player orientate to find correct pitch (the keyboard layout, buttons, frets, key-holes, etc.), it is important in this context to create a visual aid for the DJ or composer to apprehend the sample. The notation in Figure 6 shows a drum scratching performance by differentiating between a bass drum and a snare drum part.

The black notes (notes 1–4 and 7–12) indicate the record motions of the bass drum; the red notes (notes 5–6 and 13–14) indicate the snare. Round note heads indicate a special playing technique which refers to the so-called *release mode*. The symbols above the staff indicate the crossfader movement and define the wide range of possible playing strategies on faders. The turntable and mixer as being one instrument is defined through the interaction of Acoustic Motion and Dynamic Motion.

4.4 Dynamic and Acoustic Motions

The duration of a Dynamic Motion determines the length of time for which the sample is audible. Normally it is equivalent to the duration of the Acoustic Motion (the movement of the control disk), which is why the time value of the Acoustic Motion matches the action of the crossfader. As the motion durations varies, so do the methods for manipulating the sound material. In each of the examples in Figure 7a–d, a quarter note is cut four times by applying a different playing technique.

The graphical waveforms in in Figure 7 show us the resulting divisions of different techniques on the same sound

⁶ The actual coloring scheme is currently under evaluation for maximizing readability, to ensure that for instance color confusion is avoidable through layout settings and templates.

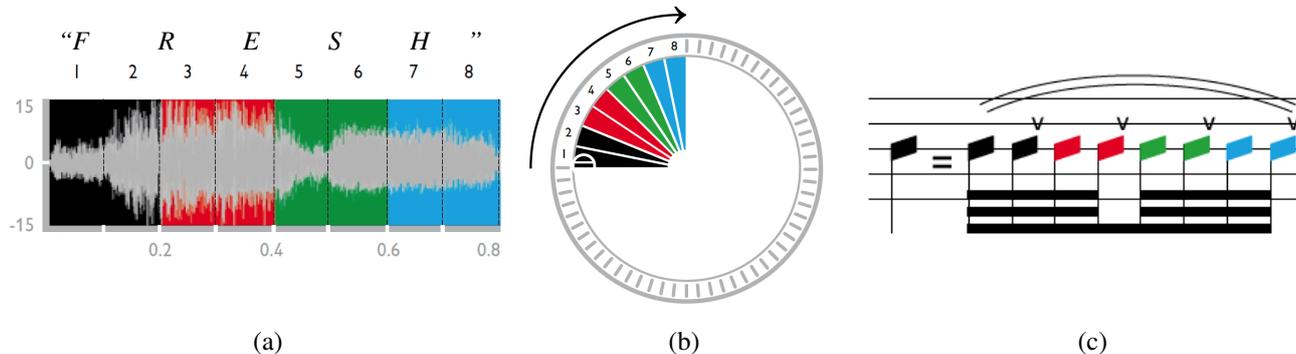


Figure 5. Three representations of a segmented quarter note, sectioned by the colors black [1-2], red [3-4], green [5-6] and blue [7-8]. (a) shows the analysis of a 0.8 s sampled sound (“FRESH”) in a waveform plot. (b) shows a corresponding visual representation of the playing position in relation to a 90° record movement. (c) shows a musical phrase using the same coloring scheme. The double slur indicates that the *forward Notes* should be played in one motion.

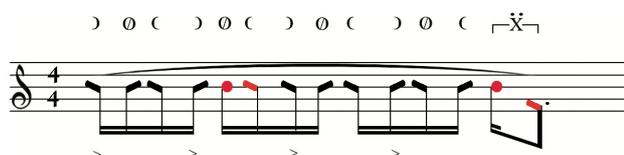


Figure 6. Notation of drumming. Black note heads are bass drum sounds, red note heads are snare drum.

sample (“fresh” of the sentence “ahhh, this stuff is really fresh” [33]). In an accompanying video recording⁷, one drum-scratching pattern was repeatedly played using all basic fader techniques that are mentioned with Figure 7.

5 EVALUATION AND DISCUSSION

Like other notation systems for scratch performances described here, S-notation has not been formally evaluated. Indeed, no system to date has been used very much. These matters are further examined below. There is a growing incentive from composers for notation, however, whose opinion is valuable. Until now, there has been little reason for DJs to learn notation. While not a proper evaluation, the actual appropriation of S-notation in new works will function as a proof-of-concept and aid development.

5.1 Appropriation for Composition

As mentioned earlier, the British composer Gabriel Prokofiev wrote “Concerto for Turntable” which has been played worldwide, including a performance by Mr. Switch at the BBC Proms. The notation first used to write the score left however too much room for interpretation for the soloist, and therefore the concerto has now been transcribed using S-notation.

The soloist works in this piece with an orchestral theme sample which was produced by the composer and then pre-recorded for scratching with by using a timecoded DVS. The sample was analyzed with Anatonie for transcription, which was important to match pitches and onsets with

the orchestral part. All relevant information to the DJ is printed in the score, including tempo (bpm), turntable speed, sound-file names, sample lengths, and pitches.

In the fifth Movement, the sample consists of four transients or onsets: three tones and a reverse tone. To mark all the relevant cue points which are used for performance (generally done by DJs in the DVS software), the wave spectrum is color-coded and transferred onto the notation.

As all motions in the section seen in the sketch in Figure 1 and in the finished score in Figure 8 are in the release mode (sounds are played by letting the record play forward) the note heads are round. The pitch control slider is at 100% turntable speed, so the notes are placed on the middle line. Based on the coloring of the note heads and the position within the bar it is possible to anticipate the arrangement of tones, like one would expect.

5.2 Challenges for Teaching

Few turntablists are educated in traditional music theory or have a musical background outside DJing. Thus, the systematic notation can be challenging to learn and understand. Without tutoring, and compared to students who play traditional instruments that have more formalized learning situations and didactics, the ambition to learn or work with notation can be hard to motivate. A particular hindrance can be the format of scores: it is unlikely that DJs will ever put up a note stand and read printed music, and the computer screen, which is commonplace in today’s gear setup, is already saturated with necessary information to the performer.

Turntablists mostly play and practice in solitude, and seldom in groups; ensemble performances would otherwise have a positive effect towards using notation. The process of education is commonly autodidactic by means of following tutorials or imitating performances from other artists. Nevertheless, many understand the importance of learning music theory because it enhances the possibilities of being more creative and collaborative in making music with this instrument. Having a common notation is critical for the party of teachers that grows with the flourishing music style.

⁷ youtu.be/H2dcSpukf6c

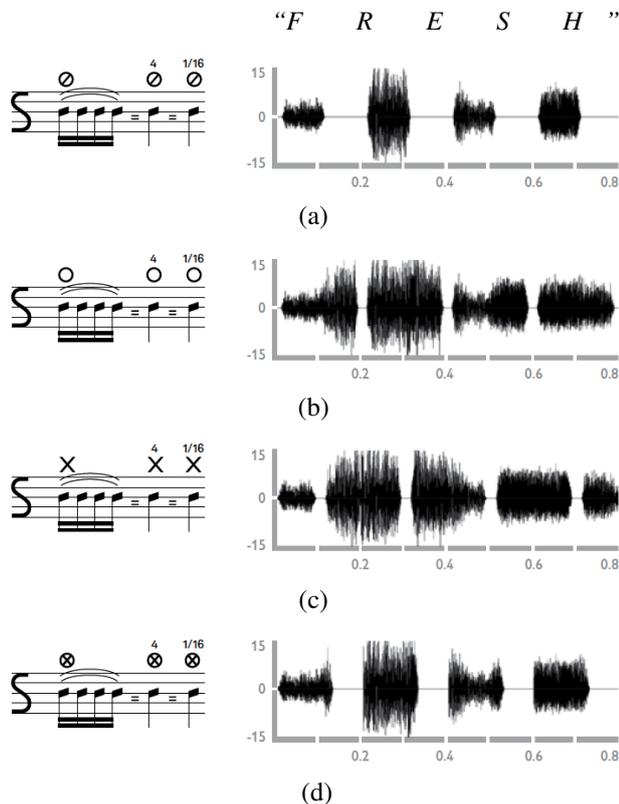


Figure 7. On the left, the breakdown of the patterns is shown in the staff. In order to reduce and simplify notation, the number of cuts or durations are written above the symbols. The resulting sound will depend on the cutting technique used (open–close or close–open with the fader).

5.3 Reception by the Community

By definition, turntablists consider the combination of the turntable and audio mixer as a musical instrument, and typically support the idea of music notation (although with few using scratch notation). Some reactions suggest that notation discourage improvisation, and even taking away the *soul* of scratch music due to the systematical approach of the Theory of Motion; after second thoughts, however, DJs tend to realize that this theorizing constitutes nothing more than the common and essential knowledge which forms the basis for effectively communicating with all types of musicians, a practice that already exist.

Opponents of any notation argue that the best method of analyzing and memorizing a scratch is by studying available recordings. To such learning scenarios one might use waveforms to indicate the acoustical result of a pattern in detail. But S-notation was developed to describe the motions on the turntable and mixer for the purpose of faster comprehension. While one could analyze videos or audio recordings, a more efficient way would be to learn a system that can describe any scratch technique.

5.4 Future Work

The upcoming work with Theory of Motions will tackle the analysis and transcription of other motion parameters such

as frequency, panorama and effects motions, and how they influence the musical output. In addition to that, the focus will be on compositional methods, a curriculum based on S-notation, and special techniques such as *beat juggling* or tone playing.

Furthermore, the Theory of Motions will be applied to visual controllerism (often called video DJing or VJing) in order to find new ways of creativity for video performers. The relationship between the current status of technology and live performance of audio and video leads to novel artistic forms which are valuable to explore.

One problem with transcribing scratch music is the rhythmic complexity in terms of onset density and timing. Depending on playing position in the sample, tones can have onset timing that might deviate from the performer’s intention, and the acceptance for timing imperfections. A possible approach to analyzing performances could be to use an appropriate automatic transcription method [34].

S-notation was developed with a needs-based—partly *ad hoc*—approach. The design builds firmly on traditional notation: one advantage is that the development process can be quick, and design choices are unlikely to critically contravene established practices. However, the format should be evaluated and harmonized with (contemporary) guidelines for musical notation, and in particular SMuFL [35]. At the moment, S-notation has not been implemented in existing software like MuseScore or LilyPond, but this work is projected.

Design choices concerning how to represent the different motion parameters should be carefully assessed, for instance within the *cognitive dimensions of notation* framework [36]. In this process, the selection of parameters to include should be validated against recent DJ practice studies [e.g. 37]. As the presented system mainly extends standard notation, the need for evaluation is thus arguable. The Theory of Motion is on the other hand more exploratory and will be approached with inspiration from contemporary research on gesture.

6 CONCLUSIONS

Theory of Motion was employed as a theoretical and methodological framework for creating a new notation system for sample-based music, *S-notation*. According to this theory, performances can be transcribed using a set of parameter motions, including acoustic, dynamic, frequency, panning, and effects motions. In addition to the motion parameters, the new notation system involves a time-based analysis of the sound source, named *anatomie*.

The S-notation system was particularly developed for DJ scratching and turntablism, and was designed and implemented with both the musician and composer in mind. Although it is a complex notation format, it can be learned and potentially used in performance. Correspondingly, although turntablism is a complex musical form, S-notation can provide a detailed tool for composers to convey musical ideas. Finally, S-notation is also applicable for documenting and for teaching situations.

Audio Sample: „CFT Snow Time”
Length: 1,6 sec

Allegro gavotte
Speed: 107 bpm/100 %

Pitch

3

5
Length: 7,2 sec

7

Variation

15

Figure 8. Finished score of the first 10 bars or *Movement V – Snow Time* of Gabriel Prokofiev’s “Concerto for Turntable and Orchestra”, see video <https://youtu.be/38atRejUORM>.

Acknowledgments

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