Positional Drum Notation

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Abstract—Sheet music designed for pitched instruments does not translate well to drum music. Our prototype drum set music notation is designed to allow efficient display of information and easy interpretation especially by novice learners. The notation maps the instruments in the drum set horizontally to match the usual location in the drum set, and adds easily distinguishable icons that visually resemble the instrument. Sections with identical music are consolidated and marked in a timeline for the musician to follow.

Index Terms—Musical Notation, drums, positional mapping, vertical orientation

Introduction

Musical notation has been historically designed for instruments with pitches. The higher the note is on the score, the higher the pitch. Notes are seen as an ordinal variable, as they can be compared. With drum sets, however, this distinction falls, as there is no (obvious) direct way to compare the sound of each drum. The bass drum may have a lower frequency compared to a crash cymbal, but they differ by many other factors that are not easily comparable. Drum sounds are much more "nominal" rather than "ordinal", as they are so different that they cannot be ordered quantitatively. At the current state, drum notation has been directly obtained by "adapting" the classical music notation to a drum context. Each line on the score corresponds to a drum part and the symbol of the note changes to show different ways to play the drum part (⊗ for open hi hat vs. ╳ for closed hi hat).

Drum notation is not related to the characteristic of each drum part, and often drummers don't use any notation at all (what Norman Weinberg has called "improvisatory frameworks" (1)). We have also witnessed different standards for drum notation, that usually confuse the reader. There is some evidence of this notational chaos in the literature. "Notation for drums and percussion varies considerably from arranger to arranger and from publisher to publisher. Many notators have created their own symbols in an effort to cater for the huge array of percussion instruments and techniques" (2) and again "an examination of the published resource materials and performance literature reveals that composers, arrangers, editors, authors and educators often embrace different views on the subject." (1).

In his analysis, Weinberg has "avoided a discussion of the conventions of normal musical layout" (1), whereas we are going to challenge these conventions. Notation should: "serve as a means of preserving music (although incompletely and imperfectly) over long periods of time, facilitate performance by others, and present music in a form suitable for study and analysis." (3). We think it possible to devise a new notation that would improve the interpretation by others.

Our idea is to map drum notation to a web interface where vertical position represents the time / timing and horizontal dimension represents the spatial layout of the drum set. We reasoned that it is much more straightforward for the reader to map the notation to a spatial position of the drum part rather than an arbitrary height on the score.

Our project outline is:

1. Define the characteristics of the new notation
2. Create a web interface to write down the notation
3. Implement printing from web interface
4. Implement interactivity with the software

1 Related Work

In this section we will present different notation systems which we have identified along with the main pros and cons of each one.

1.1 Traditional Music Staff Notation

It is the current standard for drum music notation. It is based on the same rules that govern notation for other instruments. Each line / space on the score corresponds to a specific drum component to play. Round notes are used for drums while other symbol are used for cymbals. Refer to fig. 1 for a common mapping. There is not one universally recognized mapping; this is sometimes the cause of misinterpretation in the notation.

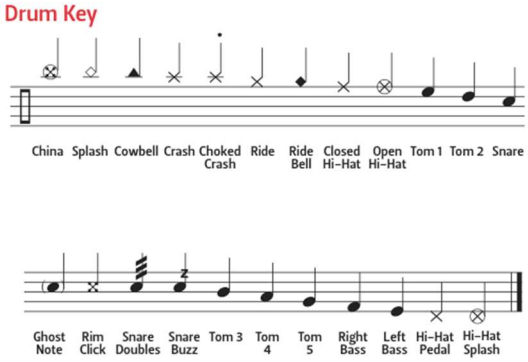

Figure 1: Common mapping of drum parts to music score (4)

1.1.1 Pros

This notation is friendly towards other musicians who already know how to read it. It encodes all the information commonly needed in a musical piece (time keys, duration of notes, bar subdivision…) and is applicable to any musical piece. As it is very old, it was meant to be written by hand, and is therefore easily sketchable.

1.1.2 Cons

The position of the drum parts on the score don't have a logical sense. There are no mathematical relationships between drums part (unlike the relationships in pitch with other musical instruments). In general drum parts that are positioned higher up in the drum kit occupy the higher lines, but a lot depends on the individual set up.

Drum parts are often made up of the same sequences which are repeated over and over again. This notation does not have an ideal way to convey that information, and often results in the same pattern of notes being written repeatedly on the score.

Finally, this notation is mainly meant to be static and non interactive, as it is meant to be printed and viewed on paper. Recently software has been developed to automatically scroll, though it is not widespread.

1.2 Notation Used in Music Games

In the past 10 years an array of musical games have been developed where the user plays a mockup simplified version of an instrument (guitar or drums). The game displays notes that fall from the top of the screen to the bottom of the screen. When they reach the lower part of the screen, the user has to play them. The most surprising aspect of this notation is that most players have no previous musical experience, but they still to play the (few) notes of the game. Refer to fig 2 for a screenshot of one of these games.

Figure 2:Screenshot of a music playing game. This game has four drum components, each mapped to a different color and position (5)

1.2.1 Pros

This is a very dynamic note visualization framework, with totally automated scrolling. The gaze of the user is always fixed on the screen and does not have to move very much. The notes "come to him" rather than having to move the eyes to follow the flow of the song.

In order to make the notes more easily recognizable by the user, each note / drum hit is assigned to a color. The position of the notes on the screen is linked to the relative positions of the drum pieces on the drumset (which is sold as one piece and therefore cannot be modified).

1.2.2 Cons

The notation has been created for the game, which is a very simplified version of real music. For this reason it does not carry information that is important to have with music like time figures or bar subdivision. It is also unclear what would be the results if applied to a real drum kit (which has more than 4 components usually).

It would not be ideal to communicate with other musicians, as there is no reference to the part of the piece which is currently being played. It is not meant to be printed, therefore there isn't a way to have a complete view / snapshot of the song. There is also no way to represent repetitive sequences.

1.3 Klavarskribo Notation

This notation was invented at the start of the 18th century to be more easily readable. It was conceived for organs, but it expanded to other keyboard and string instruments. It is characterized by a vertical score, mapped to each note of the keyboard. Music is read top to bottom. Black notes correspond to black keys, whereas white notes correspond to white keys. The direction of the stem indicates which hand should be used to play the note

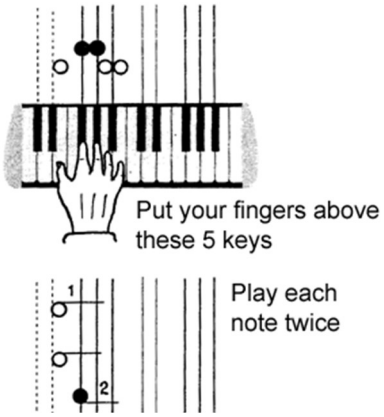

Figure 3:A klavar score, with an image of a keyboard to show mapping of notes (6)

1.3.1 Pros

The notes are mapped to their position of the keyboard with respect to the player's point of view. This yields a particular benefit when multiple notes are played simultaneously. There is no connection between the time and duration of the notes and the color / position of the note. It encodes all the necessary information from the standard notation.

1.3.2 Cons

When a whole keyboard is considered, the score gets very wide and is mostly empty. There are also no ways to show repetition of bars or sequences. The grid is very heavy, so there is a cluttered view, especially given the lines attached to the notes.

Some users may find it invasive for the notation to also encode finger and hand to be used to play a note. For more complicated songs, the user might prefer to have autonomy in deciding that.

When we consider drum notation, not all the encodings of Klavarskribo should be necessary.

1.4 Colored Music Notation

There have been numerous patents and systems which have been registered to teach music through coloring the notes (instead of having them only black). Through studies conducted by Rogers, this notation seems to improve the learning of music at initial stages, even though students tend to memorize only the colors instead of the position of the notes (7).

2 Methods

2.1 User Needs

We identified different user's needs. These relate to three categories.

2.1.1 Readability

The notation should be easy to read and ordered such that there will be a continuous flow of the gaze of the reader. Each symbol should clearly define one action to take and it should be codified in order to provide to provide no ambivalence, even to people with little experience with the notation. There should be only one unique way to interpret a specific transcription.

2.1.2 Practicality outside of playing

One of the main functions of notation is to be carried around and to be a communication medium between two different musicians. Traditionally music was written on paper (and still mostly is), however, we envision that most of music will soon be visualized on screens. Therefore, our notation should be both effective on a printed piece of paper and on a interactive computer / mobile device screen.

2.1.3 Transitionability

It would be easy to introduce a new notation to a world which doesn't have any. However, we have to consider that the current drum notation is the standard among musicians. They are used to reason in terms of traditional drum music, therefore, our notation will have to keep this into account and ensure that it is easy to transition from one to the other

Our solution might not be able to meet all of these needs, but it is important to aim to satisfy as many as possible.

2.2 Design Insights

A few key insights about drum music and about the way drummers read music from our testing inspired the design of our solution:

- Drum set music is very repetitive in most genres – there are many repetitions of the same 4,8 or 16 bar sections. Even inside these sections, the differences between bars is often only in the first notes (the beat at the beginning of the bar, when sometimes the cymbals or the ride is added). Examples of these sections include the intro, the outro, the verse, the chorus and the bridge.
- Reading drum music almost always involves recognizing the rhythm of the music and following along. When doing so, the most challenging part is recognizing when the rhythm changes or newer patterns of drumming are added on top of the existing rhythm. It is helpful to have such points of change pointed out.

In addition, we realized that the primary reason for the use of traditional sheet music notation was that many drummers were also musicians who could play other instruments and hence knew how to read sheet music. However, we also found that most drummers never wrote down their music or never used any kind of notation at all.

We also realized that we could specifically look at the design affordances today's technology allows us that were not possible during the design of traditional sheet music:

- Color in inking
- Screens with pan and zoom, removing the limitation of having to fit on a piece of paper
- Moving visuals, tracking the music as it plays
- Interactivity on a touchscreen
- Connecting instruments for input
- Generating sound from notated music

2.3 Design Requirements

Based on what we learned, we settled on a few design requirements we found to be the most important:

- Easy to understand ('Intuitive') notation – icons and location for an action should correspond to the form or the instrument or the sound it makes, and to the location in the drum kit. [testable by showing drummers the icons and the corresponding drum kit and asking them to guess which corresponds to which]. This requirement might also allow novice learners to understand the different parts of a drumset without a teacher
- Icons that are easy to distinguish – icons that show a particular instrument must be easily distinguishable from those for another instrument or for a different action on the same instrument [testable by having a row of icons of one kind with one exception, and checking how long it takes for users to detect the different icon]
- Able to display different "hit" types (open Hi Hat, closed Hi Hat, foot Hi Hat, snare rim, ride cowbell, ride cup, etc.)
- Able to display timing of actions (beats) in a way that is easy to visually measure (with bars)
- Ability to Reposition instruments based on personal drum kit positioning
- Ability to print to paper so it doesn't need a digital device
- Ability to be quickly sketched by hand instead of only using a digital editor
- Display in a browser across devices so users aren't limited to a platform
- Allow scrolling the current view to follow music, ideally auto-scroll with music given a start time and a beats-per-minute setting

These requirements were used in evaluating our ideas during prototyping, and in designing tests during user evaluation.

2.4 Design Prototyping

One of the first design decisions to be made was to allow the instrument placement in the drum set to match the placement in the notation, and perhaps allow easier identification and decision about which hand/foot to use. This meant that timing had to be shown vertically, and the music read top to bottom. The alternative, following the current sheet music convention of reading left to right, would not allow this mapping from instrument position to notation position. However, we recognized that this meant the notation could possibly be drawn on sheet music turned sideways.

After the vertical scrolling was settled on, we needed to figure out whether to read from top to bottom (which is natural when reading) or from bottom to top (which would work better in a guitar hero-like auto-scrolling interface on a screen where you can see the notes come down to the present). We settled on the first option, as we prioritized being able to use it as a static image on a screen or as a print.

Initial prototypes used icons to mark each hit of an instrument and at the top of each column. This seemed to help recognizability of actions. However, the option of adding dots instead of icons to show hits and have the icon only at the top has the advantage of being much easier to write down by hand, and should hence be allowed as a valid alternative. Users experienced with the notation should be able to read the music from position alone.

Note duration/inter-beat interval – sheet music uses note length to show inter-beat interval, though in a percussion instrument the note length does not mean anything. We chose the alternate option of keeping the icon constant and using only vertical position to encode timing – this allows recognizability of

an unmodified icon, and allows easy reading of timing from top to bottom.

The icons were designed with the following goals:

- to be easy to distinguish from each other
- to be easy to draw by hand
- to be visually correlated to the form of the instrument and the action being taken
- to be small enough to fit in the scale, big enough to be clearly seen

We named this schema the Positional Drum Notation, because the position of the drums matching a drum set is a core feature of this notation system.

3 Results

We imagined our notation to have to possible outputs, either static (visualizable either as a hard copy printed on a sheet of paper or on a screen) or an interactive software usable to read and write the notation.

In order to evaluate the effectiveness of our design decisions, we performed some user tests using the static notation to gauge whether it was quicker for beginner drummers to learn a groove by reading positional notation compared to traditional notation .

3.1 Static Visualization

To prototype our design we transcribed the drum parts of the musical song "Starlight" by rock band Muse. Please refer to figure 10 in the appendix.

The header of the sheet music is the same as of traditional sheet music, showing the title, the artist and the beats per minute. On the left is the song progress bar, and on the right are all the sections.

3.1.1 Icons

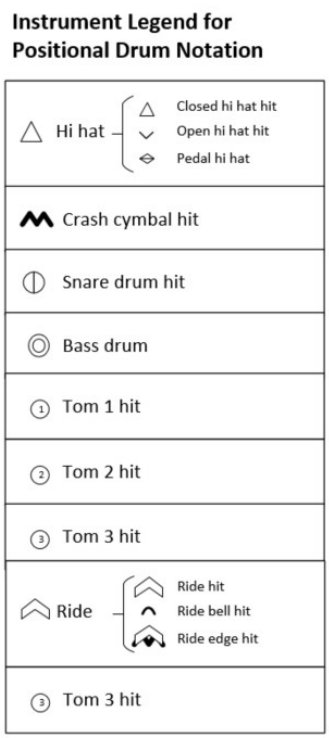

Figure 4: Mapping of icon to drum part

Icons indicate which drum part has to be hit. Each icon in the section is aligned underneath its legend position, to enable the viewer to map the horizontal position of the symbol with the drum part. At the top of each section there is the name and the color of the section, plus a mini legend to remind the user of the position and icon of each drum part on the score. The mapping of icon to drum part is available in the previous figure.

3.1.2 Song Progress bar (Timeline)

This part of the visualization shows the order in which the sections have to be played in the song. As drumming is characterized by patterns which are often repeated, the song progress bar enables to specify the notes of each section only once and then tell the user where to play that section, which most probably will appear multiple times in the song. The sections are color coded to enable a quicker link between the side bar and the section content in the body of the visualization.

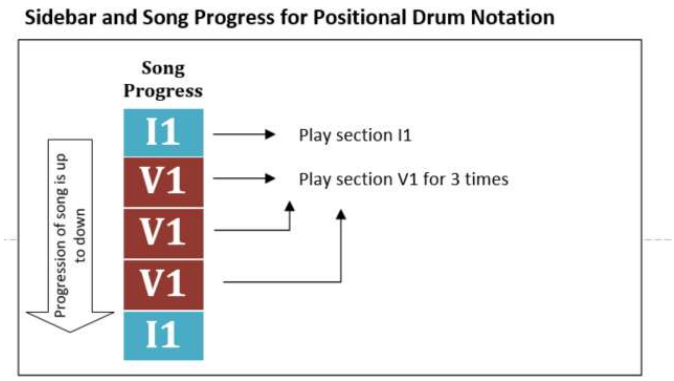

Figure 5: Instructions on how to read the progress bar

3.1.3 Sections

Each section represents a sequence of notes to be played. Each horizontal line represents a beat and the section progresses from top to bottom. Notes that appear at the same height have to be played together. Thicker lines represent the start of a bar. Notes that appear in the middle of lines do not fall on the downbeat. They could either be quarters or sixteenth notes. In order to distinguish between the two we have added thin lines behind the sixteenth notes, whereas eighth notes are positioned exactly between two lines.

We want our notation to be as compact as possible in order to minimize page turning which is always a cause of disturb for a musician. This is why we have inserted a "repeat previous bar" symbol, so that we will not repeat writing down bars which are the same.

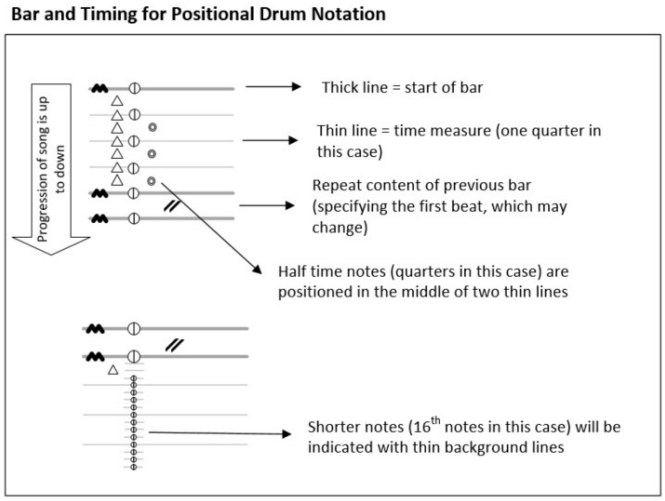

Figure 6: Timing and spacing in the sections

3.2 Interactive Writing Software

A web interface to create, edit, print and export sheet music using the Positional Drum Notation was implemented in html/css/javascript. The d3.js library (8) is used to visualize music data. This prototype interface is live at http://stanford.edu/~mishel/CS448B/.

The code saves the music in a javascript array (sectionList) which lists each section of music that is shown on a timeline ('Song Progress bar'), and expanded separately to show the groove. Each section object contains the name and length of the section, along with an array of instruments with beat timings for each. This object can be exported as a string and saved to file, as well as read from a json string to load previously saved music.

The page displays the timeline of sections at the top of the visualization, with the sections and the score for each section being shown underneath the timeline.

The interactions implemented are:

- Use the form at the top of the webpage to import/export music and to clear the music.
- A section can be added after its name and its length (in beats) is submitted. If the name is unique, it is shown both in the timeline and in the list of expanded sections. If it a repeated section, it is only shown in the timeline.
- A click on an instrument column adds a beat, snapped to the nearest time (right nor rounded to the nearest quarter note). The beat is added to the column with the icon for the corresponding instrument.
- Clicking again on a note will cycle through other actions for the same instrument. For instance, clicking on the Hi Hat column initially adds a closed high hat hit, as it is the most common. When clicked on again, it turns to an open Hi Hat hit, and then a Hi Hat foot strike.
- Right-clicking on a note removes it
- When a note is placed at a quarter note after or before a beat line, a horizontal strike is placed beneath it so it is easily distinguishable from notes that are a half note after a beat line.

We also have a long list of features that we would like to implement in the future:

- Increase line thickness in the existing icon set so it is more noticeable against the background
- Pre-load icons so imported music loads faster
- Rearranging sections in the timeline by dragging
- Move notes in sections by dragging instead of deleting and adding them
- Deleting sections
- Adding bars to sections by duplicating existing bars
- Duplicating existing sections in order to modify them to create new sections
- Rearranging the order of instruments in the scale by dragging so users can map it to their own drum set
- Allowing users to mark certain bars or beats as "change in pattern", so they can be shown larger or in higher contrast
- Adding export/import of midi files or from sheet music formats like MusicXML.

We plan to open source the code so we can add features or have other interested developers take it from here.

3.3 User Testing

In order to validate our notation system, we set up a user experiment. The objective is to verify if our notation improves the speed at which a use learns to play a specified drum song more than the current standard notation.

3.3.1 Experiment Design

Figure 7: One moment of the user testing

We gathered 8 subjects who did not have any prior drumming experience. We divided them into two groups: those who already knew how to play an instrument (not drums) and read music, and those who had never had any prior music playing experiences.

For each individual, we taught a quick overview of the drumset, explained one type of notation, then showed 3 different grooves (increasing in difficulty) and recorded how many times the test subject had to start playing the groove before playing it correctly. Finally, each user was interviewed to gather feedback on the experiences with both notations.

From each group, we taught half the people how to read positional notation, conducted the test, then taught them how to read standard notation and conducted the test for the standard notation.

The grooves used were the same for both notations and are depicted in the appendix. S is one of the most basic and widespread drum grooves. B1 represents the first groove of the bridge of "Starlight", a song by rock music group "Muse". I1 represents the first groove of the intro, and is not very common as it requires to use both legs and both arms to be played.

3.3.2 Quantitative Results of Testing

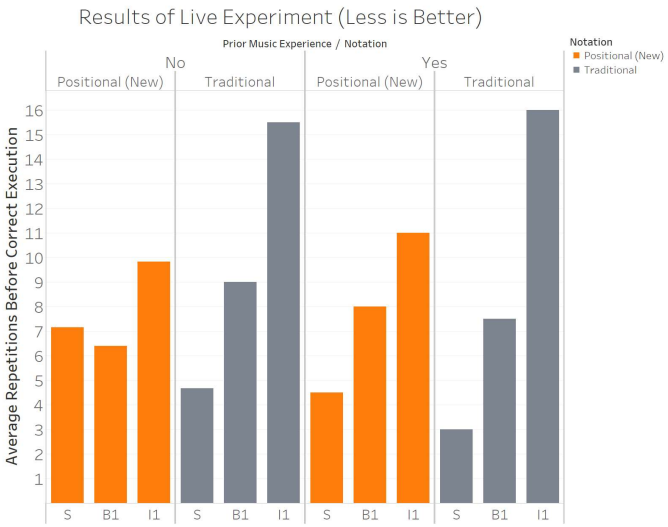

Figure 8: results of the experimentation. On the y axis is the average number of repetitions that the users had to go through before playing the groove correctly. The users are divided in 2 groups, each of which has results for positional notation and traditional notation on 3 grooves of increasing difficulty

The results seem to prove that positional notation provides a quicker learning experience for user who had no prior experience and for more difficult grooves. For people who had no prior experience, positional notation was better for grooves B1 and I1, especially for the latter. For users with experience, positional notation was better only for groove I1.

Positional notation caused a much quicker learning curve for both groups on groove I1. The groove had to be played on average 5 times less compared to the standard notation.

3.3.3 Qualitative results of Testing

Each user was interviewed after the test in order to gain more insight about how people process the visualization.

The symbols for the cymbals were appreciated, as they were perceived to depict the sound produced. Users reported that icons, instead of black notes, were easier to learn at the start, but that once the groove was mainly learnt, dots (traditional notation) were easier to follow. The icon chosen for the snare drum was confusing at first but became clearer once it was showed that the snare has a string rattler underneath it.

Some users reported difficulty in differentiating between the bass drum icon and the snare one. The depiction of the toms as numbers also was confusing. One of the users who knew music reported that it was much easier to read the traditional music, as it was easy for her to map the drum parts to a specific note.

3.3.4 Community Feedback

We posted an explanation of our static notation along with the starlight example on a drummer community on Facebook with around 35,000 members asking for feedback. Two users suggested to move the song progress bar to the left, which we did, in order to improve the followability of the song. In this way, you can see which groove to play and move the sight to the tab of that groove.

The same feedback suggested that positional notation would be much more effective if learnt during initial stages, something that our experiment confirmed.

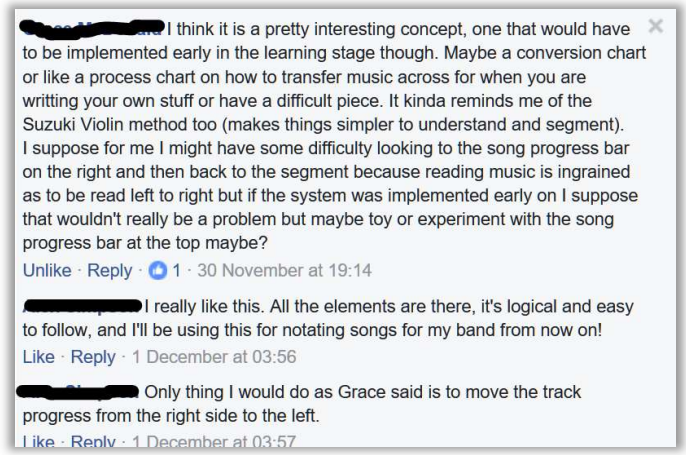

Figure 9: Facebook comments to post explaining positional notation on "Drummers" group

4 Discussion

Positional drum notation provides a new framework for beginners to read drum music without having to know traditional notation.

Positional notation has succeeded in making it easier for beginners to read drum music, especially for non-trivial grooves. We have observed reduced learning times for users who had never had previous musical experience. We have also succeeded in implementing a simple online interface to write and save positional drum music. The functions are basic but enable positional drum music to be open for use and shareable from now,

We have partially succeeded in providing a better reading experience to current musicians who have no prior drumming experience. Positional notation is easier to read, but only for complicated grooves. This may not be enough to motivate current drummers to transfer from the traditional notation to positional notation.

We have still to work on the icon selection, as they did not seem distinguishable enough and could potentially increase the readability of the notation. There are also a lot of features left to add to the notation writing software in order to make it comparable to software used to currently write traditional notation.

5 Future Work

5.1 Design

Qualitative user feedback has expressed concerns about some of the icons. It will be necessary to diversify the snare and bass drum icon, as some users confused them. It will then be necessary to find another way to distinguish between tom notation, as the numbers require the readers to process writing, which we would like to prevent.

In general, we plan on reviewing the thickness of the grid lines and shape borders in order to optimize the contrast. We will also change the color selection in order to take into account printability and color-blindness.

5.2 Software

There are many features that could be added to the online writing / visualization software. The main ones that we have identified and to which we will give priority are:

- Copying and pasting of notation

- Deletion of sections
- Exportation of midi files in order to enable the media playing of the written music

These would make the software comparable to other music writing software available. The next steps would be to leverage the characteristics of positional notation to make a better interactive experience for the user (automated scrolling for example)

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7 Appendix

7.1 Example of Positional Drum Score

7.1.1 Positional Drum Transcription

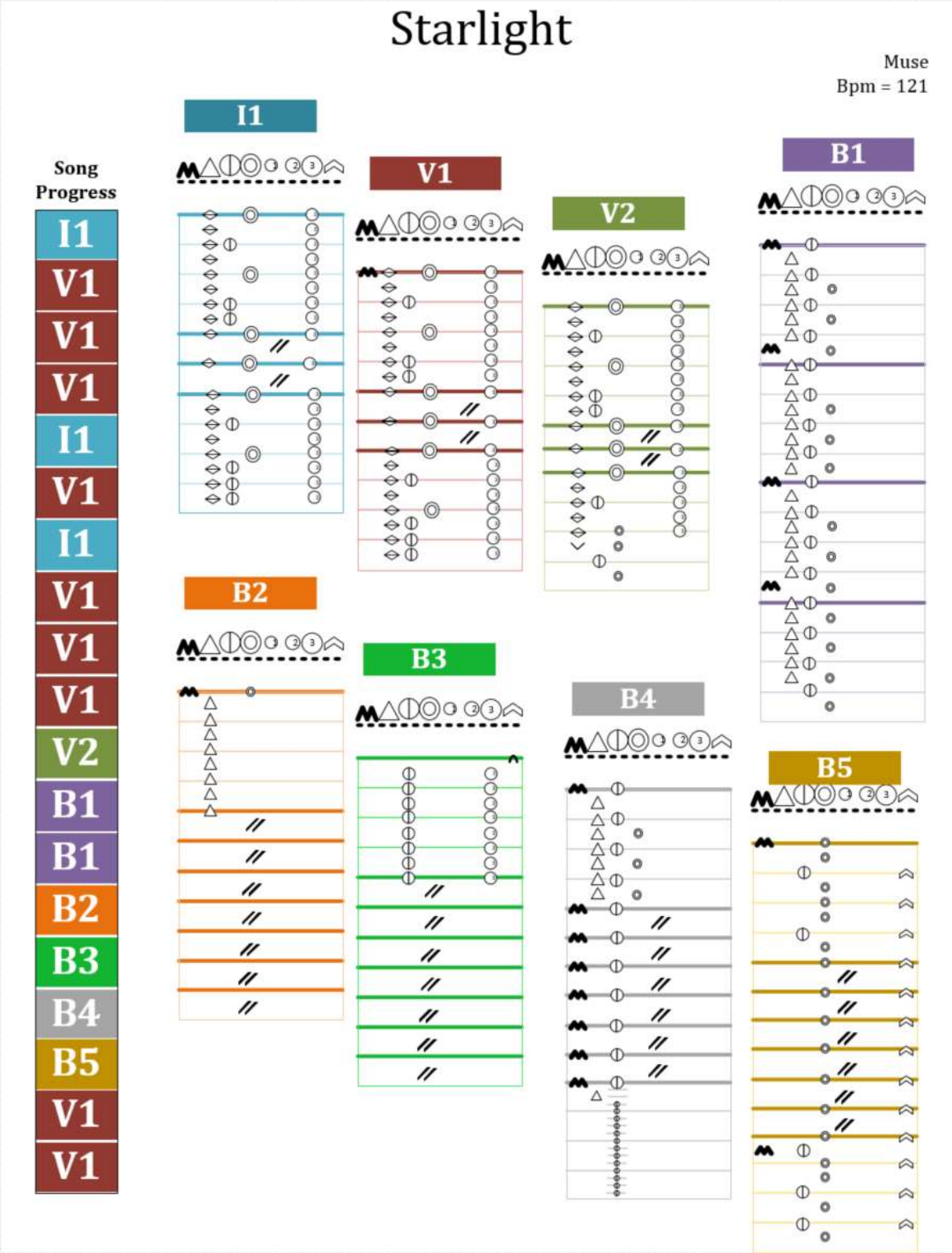

Figure 10: Starlight positional drum music transcription

7.1.2 Legend for Positional Drum Music

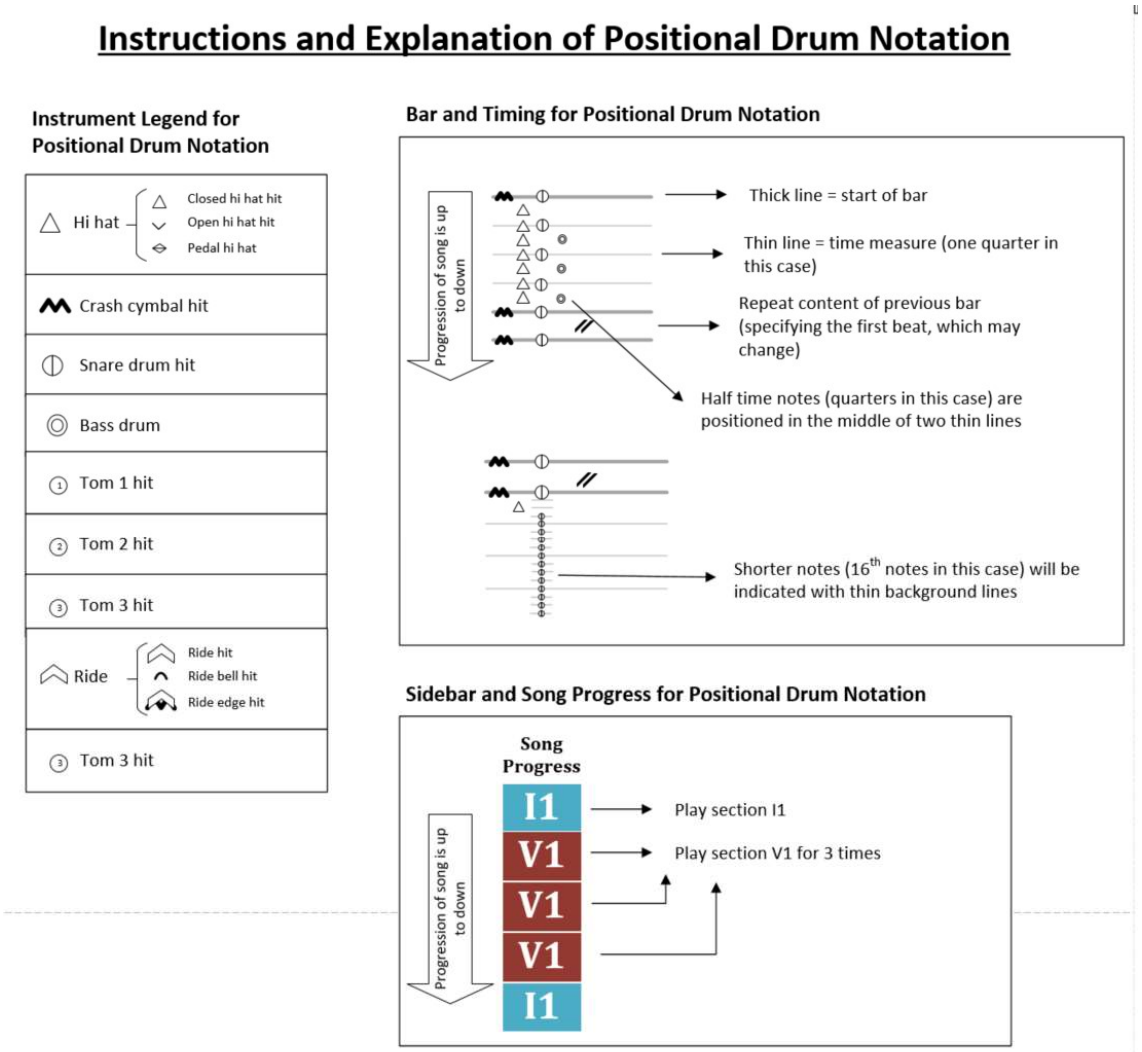

Figure 11" Instructions for Positional Drum Music Interpretation

7.1.3 Traditional Music Transcription

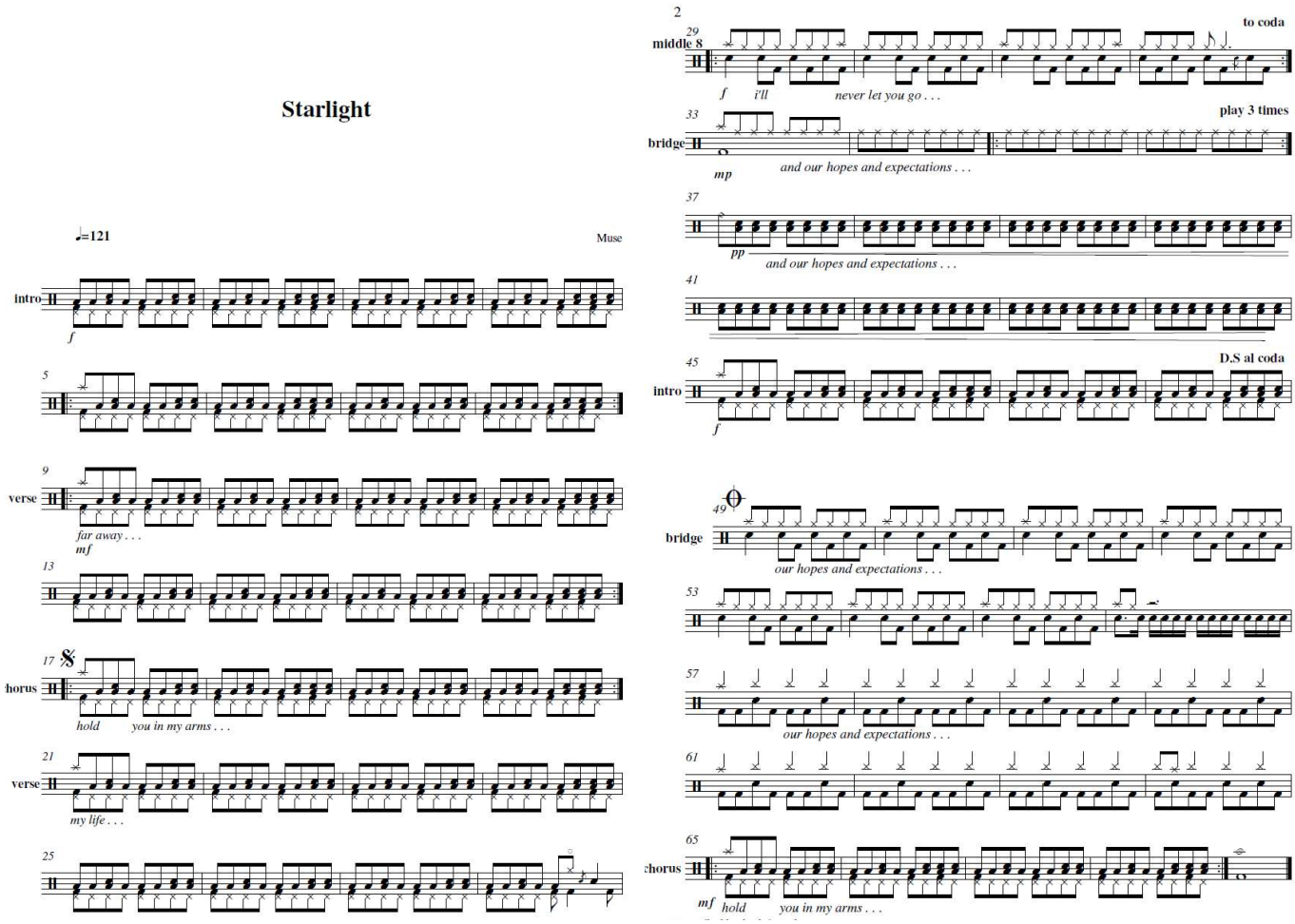

Figure 12: Starlight traditional music transcription