

# JAM TABS: A COLOR BASED NOTATION SYSTEM FOR NOVICE IMPROVISATION

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## ABSTRACT

Music improvisation, which is defined as creatively and playfully exchanging musical concepts, is often associated with expert musicianship and musical skill. While there are numerous methods for live scoring improvisation, there are not many resources aimed at assisting novice performance during improvisational activities. Jam Tabs is a notation system that helps coordinate idiomatic musical expression for novice musicians using color-coded instruments and a colored visual display.

Jam Tabs utilizes a seven-color notation system, LED cubes and a colored piano keyboard to assist novices in coordinating chord progressions—a common musical element used among improvising musicians in popular western music contexts. We have observed that novice piano players could follow chord progressions in tonal music note for note using color coordination while improvising. We found that seven colors in any key provide enough information for players to experience a satisfactorily expressive and creative jam session.

## 1. INTRODUCTION

### 1.1 Improvisation in Music Notation

#### 1.1.1 Music Notation

Music notation is defined as a visual notation containing images, symbols or codes used to represent musical sound or instruction for performance [1]. Though music notation has been used to depict many aspects of music throughout history, symbols that place emphasis on the relationship between pitch and time are common in popular western music contexts.

Music notation can be differentiated from music visualization, which is often expressed as a representation of music in real-time—produced with emphasis on aesthetic value, or to depict an aspect of the music. Music notation in the context explored, however, conveys information that allow players to refer to a common resource, synchronizing musical activity between musical agents.

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### Lead Sheet Example

Commonly Used in Jazz



**Figure 1.** Example of a lead sheet for Jazz style improvisation.

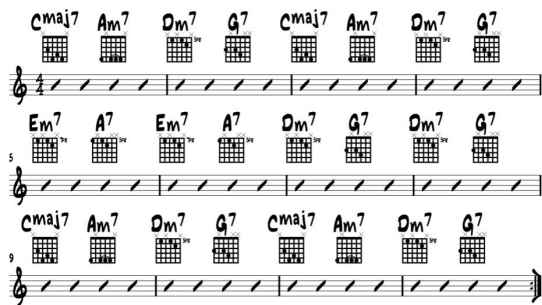
#### 1.1.2 History of Improvisation in Music Notation

Throughout world history music notation for improvisation has been utilized to convey broad or generalized musical information. One of the first examples of music notation, discovered in ancient Sumer around 1250 BC, contained: a poetic text of hymnic character, some lines of musical notation, a symbol specifying the genre of composition, the instrument tuning, and the composer [2]. It can be argued that these ancient scores were intended for improvisation rather than note for note replication of a piece—common in written scores of today. In the 13th century, and likely before then, India’s Raga music, a traditionally improvised classical music, was written and performed in the eastern world [3]. Also of note, western music composers like Mozart and others in the eighteenth century, utilized figured bass to indicate the underlying musical content for improvising over a cadenza [4]. In more recent years, musicians of many genres use lead sheets, chord charts, and other abstract notations to show only the essential components of the underlying musical material.

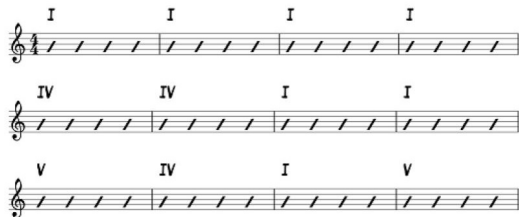
### 1.2 Current Use of Notation in Improvisation

Traditionally, jamming is a term used to describe a musical improvisation activity, implying real-time musical creation, often with an underlying theme or familiar tune.

Though jamming is more popular in genres such as jazz and blues music than in many other western music traditions, it is nevertheless a skill available to musicians in all genres of music [5]. A common form for representing music, both for performance and for jam sessions, is the lead sheet. A lead sheet usually consists of the chord root and quality contained within a bar of a given number of beats (see Figures 1 and 2). A lead sheet may also contain written music, but it is not an essential component of the notation. Additionally, instead of the letter name for a chord, a roman numeral is given instead to represent the chord in reference to the key or tonal center of the song (see Figure 3).



**Figure 2.** Example of how a lead sheet may appear. Contains chord charts or diagrams



**Figure 3.** Example of a lead sheet for Jazz or Blues style improvisation may appear. In this example roman numerals represent harmonic content

### 1.3 Music Notation for Improvisation

The traditional western music score has formed the basis for many other, less formal, western music notations. Many of these notations are used among musicians in recording studios, jam sessions, gigs and during practice for the purpose of creating flexibility in their musical output. Music improvisation, which entails some degree of freedom during a performance, requires less information in a notation than a musical piece that is more prescriptive and explicit in its intended expression. Therefore, music notation for improvisation is uniquely concise in its use of symbols—often displaying only a few musical descriptors.

### 1.4 Act of Improvisation

When improvising, the musicians in a group will often play notes that are present within the chord being played on the lead sheet. More advanced musicians may be able to incorporate other elements of music present in their improvisations, but nevertheless having access to this information while participating in a jam session or while practicing improvisation over a backing track is helpful for many improvisers. In order to fully utilize a lead sheet a musician must know:

1. What the symbols on the lead sheet refer to.
2. Where the notes are that are being referred to on their instrument.
3. Some musical vocabulary to use while referencing the music being played.

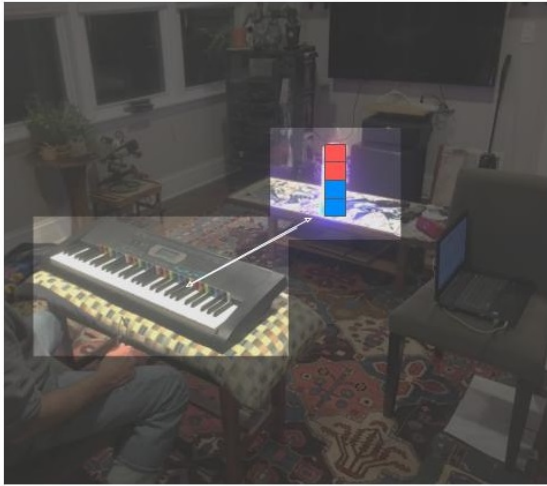
Depending on the instrument being played this task can be very difficult to achieve. Musicians improvising in real time can have timing constraints at approximately 30 milliseconds before sounding asynchronous [6, 7]. In the case of the piano keyboard, the task requires a minimum of 12 notes to be recognized from a pattern of black and white keys. If a note, or series of notes, is to be played at 60 beats per minute, in common time (four beats per bar), with a chord change occurring every bar, an improviser would have to locate a new and unique note on the piano every four seconds in order to reference this basic musical concept in the chord progression. An improviser who does not have knowledge of the keyboard would not be able to play notes in the chord progression with just a lead sheet and a piano keyboard. Therefore, without instruction or prior knowledge, an improviser would not have enough information to begin an improvisational activity.

### 1.5 Improvisation Pedagogy

Improvisation in music education has been researched in numerous western music genres. Some Jazz and Blues music educators have created exercises to bolster improvisation skills by breaking down solos, trading rhythmic clapping, scat singing, and utilizing multiple software tools to support the improvisation activity [8, 9]. There is also a rich history of improvisation pedagogy relating to cadenzas in classical music. For this type of improvisation education, musical passages are selected from famous classical improvisers, such as Mozart, and practiced in various ways—often in an effort to replicate the composers style without playing the music verbatim [4].

Stages of improvisation education have been outlined by Kratus for optimizing the growth of the improviser [10, 11]. These stages of learning can be best categorized as being a multi-leveled system with tasks that increase in behavioral complexity [12]. Pedagogical techniques in this system separate aspects of the music for isolated training, such as rhythm, style and technique. According to Huovinen, improvisation pedagogy can also be broken down into two methods: a music theoretic approach, and the other being a 'dramaturgical' approach. In this view the music theoretic approach focuses education on the chords and scales that an improviser should be playing during the improvisation, and the dramaturgical focuses on balance, variation and tension [13]. When analyzed for differences in improvement for variation in play, both methods have shown to increase complexity of musical concepts while improvising. Those who are taught using a music theoretic approach demonstrated higher variability in dissonance, while those taught using the dramaturgical method demonstrated an increase in rhythmic variability [13].

Extra-musical factors can also play a significant role in the effectiveness of improvisation pedagogy. Studies in children have shown that while learning to improvise, social context plays a critical role when ascribing meaning to improvisation. Learning how children ascribe meaning to improvisation can influence how they perceive what they are doing and how they can work to improve upon it [14].



**Figure 4.** Jam Tabs system containing notation and colored piano keyboard.

### 1.6 Color in Music Notation and Instruments

The use of color in music has been used many times over the course of history. Colored notation has been utilized by composers such as, John Cage, Olivier Messiaen, Alexander Scriabin and Gyorgy Ligeti to enhance the musical content of their scores in a variety of ways [15]. The use of color has also been demonstrated to make music notation easier to read for young children [16] and has been used in piano instructional books from many popular publishers. These instructional books are often accompanied by a set of stickers that are to be applied to the instrument. A variety of stickers can be found in stores, including: black and white letters of the musical alphabet, pictures of musical notes as they appear on a score, and colors of various shapes.

More recently, color and light have been used to supplement music education by lighting notes that are to be played on the lit instrument. Piano companies such as Casio® and Yamaha® have lit keyboards, and guitar companies such as Fretlight® have LED embedded guitar necks to guide learning guitar players to the correct notes.

## 2. MOTIVATION

Skilled musicians often describe being in a pleasurable state, achieving flow [17] and bolstering creativity [18] when improvising. While there are numerous methods for live scoring improvisation [19, 20], there are not many resources aimed at assisting novice performance during improvisational activities using notation. Many resources are available for players that have an understanding of scales, chords, time signature, and their instrument. These visualizations often display various chords or scales while a musical piece is played and are aimed at an audience that has already spent a significant amount of time with their instrument.

Several resources are available for novices by augmenting instruments so that they are easier to play [21, 22]. Many more resources are available for novices to experience music in novel ways through collaborative musical in-

struments and interactive musical systems [23, 24, 25, 26]. These methods, however educationally useful, can neglect desirable aspects of participating in a traditional jam session, such as playing a traditional instrument or maintaining control of one's musical contribution.

The proposed system was designed to coordinate players of both traditional and non-traditional instruments as well as accommodate music improvisation at more difficult levels of play. The system was designed to assist in making collaborative musical experiences easier for novice musicians of any instrument by providing an optimal amount of visual information.

The following design problems were identified as the most pressing issues to address in novice music improvisational settings:

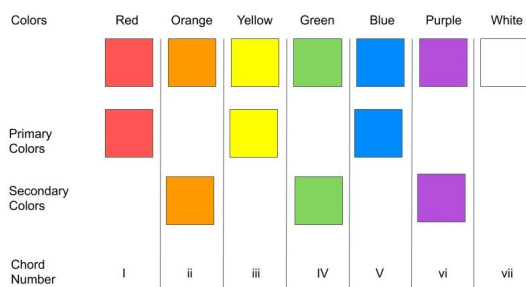
1. Providing information regarding the root note of a given chord on a visible notation.
2. Providing a series of root notes that clearly represent an order or progression.
3. Demonstrating a time signature, or how many beats are present per chord.
4. Including features that allow musicians to recognize where in the progression they are at any given time.
5. Providing a reference to the instrument itself in order to aid in the interpretation of the notation element.
6. Maintaining visibility of the notation from any angle in the jam session allows musicians to focus attention on a single common notation when in a group.

Information about the chord progression ties all members of the jam session together and is often the main content of a lead sheet. This information is available to musicians either visually or auditorily. Aural information, however, does not persist in time. An intermediate level of aural skill (auditory musical element recognition) is generally required in order to follow along in a jam session. This observation coupled with the fact that current systems of visually displaying music are beyond the interpretation of a novice player, suggests that a new method of visually displaying relevant chord progression information is needed in order to increase the number of novice musicians who can participate in improvisational activities.

This paper presents a system that addresses these design constraints and also provides additional benefit to the novice improviser. The design solution was developed through numerous observations of jam sessions using various relevant technologies.

## 3. JAM TABS DESIGN PROCESS

In order to make improvised musical activities less stressful and creatively productive for novice musicians, Jam Tabs utilized a seven-color notation system, addressable LED lights inside of an acrylic cube (LED Cube, see Figure 10) and a color-coded piano keyboard to coordinate the essential content of a lead sheet—the chord progression, a



**Figure 5.** Color selection and reference to relevant harmonic content

common musical element used among improvising musicians. A color-coordinated notation in addition to color-coded instruments enables novice musicians to quickly identify the salient notes in a chord progression on their instrument (see Figure 4).

### 3.1 Color Selection

Colors for the LED cubes were selected in order to provide seven distinguishable colors to display. Primary and secondary colors were used to distinguish the first six colors. The seventh color chosen was white also because it is easily distinguishable from the other six (see Figure 5). Additionally, by using the sequence and colors of the rainbow, an inherent order is given. Doing so enabled the LED cubes to be easily distinguished from each other while simultaneously providing an order to the colors. Pitch information is notated through color because it does not have spatial restrictions. This allows color to be used on the cubes and any visual instrument. Color also has the capability, if not confined to a shape, to be omnidirectional.

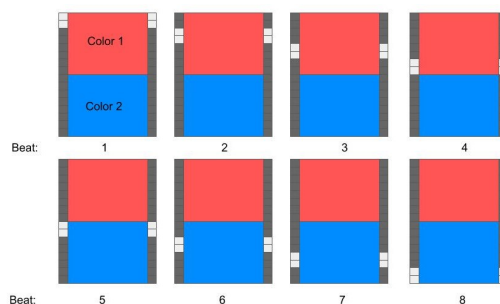
### 3.2 Time Signature

The LED cubes, similar to lead sheets or chord charts (see Figure 2), indicate a full measure of music. The cubes indicate a time signature (number of beats present per cube in a bar of music), through a series of neopixels located on the edges of the cube (see Figure 6). For example, if the chord progression is in common time (four beats/bar) the neopixel strip will show a white light that moves from one neopixel to the next lower neopixel. This occurs four times in one cube and then the following series of lights in the cube initiates.

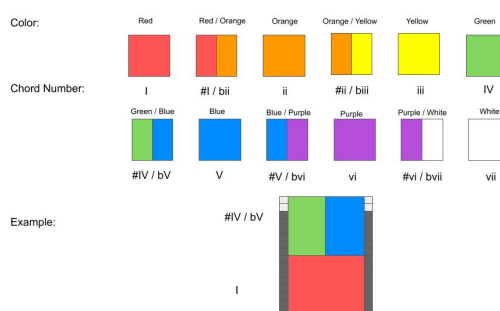
### 3.3 Accidentals (Sharps and Flats)

Notes that are outside of a given key are displayed as a combination of the adjacent colors. Each cube is separated into two parts in order to retain the capability of showing the seven colors used to represent the major scale as well as the five notes that are in between the seven notes (see Figure 7).

Splitting the bar had two notable benefits. First, increasing the number of colors to twelve spread the spectrum of color and took away from the ability to distinguish them. Second, the colors that are found in between are perceived



**Figure 6.** Beats per minute demonstrated by a moving LED on either side of the colored face of the cube. Number of lights per color/section indicate the number of beats per bar of music. This example indicates a 2-chord progression (I-V), each played for a duration of four beats (common time) at a given tempo.



**Figure 7.** Demonstrates how accidentals are portrayed in color. Accidentals (sharps and flats) are shown by splitting the neighboring colors in half and merging them into a single section.

as being some combination of the surrounding notes. This is similar to the already familiar concept of sharps and flats in classic music notation. This, among other features, allows for players to recognize notes that fall outside of the key quickly and easily. For these reasons, only seven colors were included in the final design.

### 3.4 Backing Tracks

A jam or backing track, defined as a minimalistic instrumental track that provides the background for a small jam session, consisting of a drum beat and at least two other instruments, can be played to support the players. This type of support is not often used in group jam sessions but is often used by musicians to practice their soloing skills [27]. Musicians will often utilize resources such as YouTube®, Band-in-a-Box® software, iReal Pro® and other forms of generated or recorded jam tracks for this type of practice, regardless of genre. It has also been demonstrated that children as young as five years of age can experience positive effects during music improvisation sessions when using harmonically relevant backing tracks [28, 29].





**Figure 8.** Piano bar color arrangement



**Figure 9.** Vinyl piano bar placed behind the keys of a digital piano keyboard instrument.

### 3.5 Piano Bars

Vinyl piano bars, colored in the same colors as the LED cubes, are used to demonstrate the relationship between the notation and the instrument. Piano bars easily fit behind the keys of most piano keyboard instruments making color associations nearly instantaneous. The colors can be moved from one key to another to demonstrate key changes and are also accurately spaced to retain the relative spacing differences between keys (see Figure 8 and 9).

## 4. HARDWARE PROTOTYPE

The Jam Tabs system consists of LED cubes that provide the user with an interactive light display. The root note of the chords present in the jam track is displayed as a color that can be found on the piano keyboard.

This general design structure lends itself to a myriad of design options. Any system that can omnidirectionally display seven colors and a vertical arrangement of squares and dots can accomplish the main design parameters of Jam Tabs.

Included in these possible designs are projections, physical colored non-backlit cubes, light projection elements such as flashlights and laser pointers, LED strips, LED cubes, holographic displays, and other similar technology.

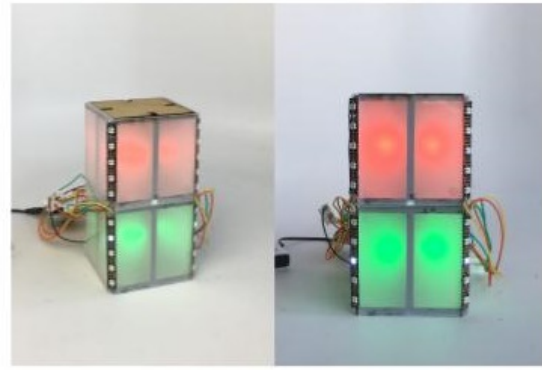
### 4.1 Supported Technology

#### 4.1.1 LED Cubes

Jam Tab lights reflect the color of the note present in the music at a given time. Jam Tabs allow for keeping track of what beat in the chord progression is currently occurring. LED Cubes reflect bars of music and accurately depict chord changes within key by color. LED Cubes can be seen from any angle (see Figure 10).

#### 4.1.2 Colored Keyboard

Colored bars were used for color application. These match colors present on LED cubes (see Figure 8 and 9).



**Figure 10.** Physical representation of the LED cube hardware prototype.

#### 4.1.3 Backing Tracks

Music in the form of “backing tracks” are provided to musicians at a recommended tempo of 75 beats per minute.

## 5. LIMITATIONS

### 5.1 Western Music

Jam Tabs can be used in improvisational settings for any genre of music. Currently however, the Jam Tabs system is designed to be played within tonal western music scales in order to improvise effectively. This is because the colors chosen are optimized for a twelve-note system.

### 5.2 Subdivision of the Bar

The current Jam Tabs system does not accommodate mid-bar chord changes. This is because each cube is treated as a single bar of music. It is possible to change the time signature to the number of beats present in the smallest subdivision of the bar and then apply the appropriate number of LED cubes to fill the rest of the notation, but this method could easily result in many LED cubes displaying what could be non-essential components of the progression. It is therefore preferred to assign subdivisions as full bars on a case by case basis.

## 6. DISCUSSION

Jam sessions using the LED cubes are possible in small or large group settings. The majority of users thus far have utilized the cubes in a private setting, in which they were practicing their improvisational skills. The usefulness and design implications of a commonly visible notation require further investigation, however; it is hypothesized that common visibility, like that of Jam Tabs, will enhance the interactive component of a jam session and will create a better sense of community than personal music notation.

Our initial observations lead us to believe that the system successfully accomplished the design parameters it set out to fulfill. It was observed that novice piano players can have fun, creative, and surprisingly successful improvisation sessions using the Jam Tabs system. The system has been utilized in groups of up to 25 people, a session which

had its own challenges and successes. It was nevertheless interesting to observe which design parameters work best for which group size. The effect of group size on the successful use of the Jam Tabs system is a topic for future investigation and may even shed light on the social dynamics present in group and collaborative musical play.

Overall accuracy of the notes being played by the participants when following a chord progression seems to be an accomplishable task for most, if not all, participants. Few errors with regards to pitch and duration occur throughout the improvisational activities indicating that players were not getting lost or confused.

Multiple players have responded in regards to the usefulness of the lights as a reference for the order of colors, such as in a progression. It is possible, however, that some participants have more auditory recognition skills than others for musical elements. This may suggest that there is a slightly different set of design parameters that may be uniquely applicable to players who are beginning to play a new instrument but have significant experience in music generally, or with another instrument. These players may be able to track the progression and time signature better than complete novices, but still have very little knowledge and capability of finding the correct notes on the piano keyboard instrument provided. Further investigation is needed to address this type of musician and a separate system may be designed if necessary.

Several usability problems arose in creating and observing the use of the prototype. The first is an issue with displaying subdivision of a bar of music. A single color currently represents a chord and a bar of music. If one wanted to represent two chords in a bar of music they would have to reduce the time signature or increase the number of cubes in the system. This issue is likely best solved on a case by case basis. The second issue that arose was the number of LED's present on the neopixel strip representing time signature. To solve this issue it may be helpful to use only common time signatures. It is also possible to use irregular spacing to solve this problem, although it may create other usability issues.

These two issues cannot be addressed without redesigning certain components of the system. Further iterations of Jam Tabs will address these concerns and relate them to current structures in music. It is likely to be the case that not all music can be completely represented on the Jam Tabs system, but it may be generalized or used in such a way that novices can still be successful with most music to warrant the current design.

## 7. CONCLUSIONS

Overall, the Jam Tabs system proved to be very useful for providing the essential information of a jam session to the novice musician. The practice of following the root note of a chord progression seemed to be improved and it was particularly helpful for identifying and playing sharps and flats. It was also observed that near all novice musicians were able to creatively and satisfactorily express themselves while improvising regardless of key. Most improvisers played as though playing with four sharps, such

as in the key of E major, was just as simple as playing in the key of C with all white notes.

In order to explore these concepts further, future studies aimed at evaluating the impact of the Jam Tabs system on improvisation learning and interaction will be conducted. In addition, future user studies that investigate the effectiveness of the several visual components as well as what degree of complexity can be achieved in the system will also be conducted. This would include a study investigating most effective choice of colors as well as a study addressing the effectiveness of the system on learning improvisation. Though improvements will be made in future iterations of this technology, the Jam Tabs system is apparently quite useful for novice musicians in group improvisational activities.

## Acknowledgments

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