Composing alarms for train stations

The considerations of the musical and the acoustical features in the auditory display design

Project Report

Sam Sernavski

Aalborg University Copenhagen
Sound and Music Computing

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Aalborg University Copenhagen
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Sam Sernavski

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Abstract:

The project focuses on the melodic auditory displays at train stations which inspired by the ones in Japan. The project will include the design of the melodic alarms with considerations of the musical and the acoustic features. The design prototypes will be tested in listening test that spot the light on the musical features influences on learnability and preferences. This project is an attempt to investigate the possible ways in improving the efficacy of the melodic alarms , which can be an interest for music composers , researchers , and industrial designers.

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Preface

Aalborg University, June 14, 2019

Sam Sernavski
<okalso09@student.aau.dk>

Chapter 1

Introduction

1.1 Background

Auditory display has a long history as a tool to provide people with events and the needed actions by means of sound. The use of audio as media has its advantage of being non-directional and the ability to cover a large area. The field of auditory display design had a continues improvement in the past years. [37] . As a major factor in developing a design is is to be easy to be recognized by the most of the listeners , as well as and simple in terms of understand the semantics and implications behind it [14] .

This area of study has been the interest of the industry and the scholars. Where all employed new and experimental methods that can be accepted as a social standard and an appropriate for the environment [37].

In the awareness of the salient of the phenomena of using music as a method in creating an auditory display , raised the questions about how the music can transmit the information as alarm, what are the music and sound elements that have major role on the effectiveness and sensitivity on the listeners, and what are the concerns that can effect learnability aspect [19].

The cultural respect of the music learnability and preferences can be an example of musical training and personality inn different countries such as the Japanese train station alarms or the Japanese ambulance sirens [43].

Considering these aspects this project will be an attempt to discuss the music in the auditory alarms design. As well as continuation to my previous project which spot the light on the contrast between icons and melodic alarms in regard of aspects of learnability and the sonic environment consideration [41] .

This project will include the process of designing melodic auditory display. As well as it will investigate the possible feature for improvement . It is a multidisciplinary progression that includes psychoacoustics, musicology and engineering. the project could be an interest for music composers , researchers , and industrial designers.

1.2 Problem formulation statement

The question of this project is designing a melodic alarm for train stations. The design will include the aspects learnability and preferences. The design considers the musical and timbre features. Questioning its effects on the listener in recognizing the meaning of the alarms, and which feature can affect the listening experience.

The inspiration of this project is the melodic alarms in the Japanese train stations which was espoused by the passengers for the past 40 years. These melodic alarms showed a perfect example of its effectiveness in the sonic environment of the train station, and the simplicity in conveying the information to the passengers [42].

This project will test the hypothesis of the relation of the musical and acoustical feature on the listener learnability, preferences. As well as the role of musical training and cultural difference in the likings of the listeners.

The process of the project starts with understanding the main elements of melodic alarms in semantics level. Followed by adapting a method for the design of the alarms. Later a study of the music features in the scope of composing the alarms. Then compose the main alarm which is the Train arrival in different form with attention all mentioned features. Next is constructing a tool by SuperCollider to generate the main three messages in the train station (Train departure, Information "halfway"). The hypothesis will be tested by setting up a formal listening test online that can run in different countries mainly from Europe, North America , and East Asia .

Chapter 2

Auditory Display

Auditory display is a field of study and a term that refers to the practice of using sound as a way to convey information to a listener. Some examples are, alarms,warnings, status indicators and data sonification. These examples can be divided into a few distinctive categories with different functions, purposes and technologies [20].

While the International Community for Auditory Display (ICAD) emphases on non-speech sounds *"...auditory display actually includes all uses of sound in the interface"* [20] as well as it considers speech as a method of audio information.

Auditory display is explained by borrowing the analogy from graphical user interface (GUI) , which generally implies to speech interfaces. The term of Auditory Display is obtained from Interface as two direction communication, while display is attended on the feedback of the message. Both together contrives both means of interaction with sound [16].

2.1 Classification of auditory display

The earliest and the most common form of auditory displays are alerts and notifications. **Alerts** refer to sounds that indicate that there's some task or event where the listener is required to attend to. The sounds used in alerts and notifications generally convey little information about the details of the event. An example of an alert is the telephone ring - it tells the listener someone is calling, the ring tone doesn't indicate who the caller is, or why the user/listener is being called [34].

With the advancements in technology and user interfaces, the need to provide more details about the events a sound is announcing emerges. **Icons** are brief sounds that represent actions, functions and objects of a computer interface. For example, the sound a user hears when a file is erased from the bin, could be the sound of squashing or ripping paper. Although the similarities between the sounds of objects in a operating system and the actual object can vary considerably. Any sound used to represent the sound of an action, object or function is generally considered an auditory icon [20].

While **Earcons** or abstract sound posses a hierarchical language of sounds which are often can be musical, while the relationship between the sound and the event is mostly metaphorical. An example could be some note pattern representing an elevator, as the elevator goes up the pitch increases and as it goes down the pitch decreases [29].

Another distinct form of auditory display is that of **sonification**, which is in short, the use of non-speech sounds to convey information for the interpretation of data [20]. Sonification is an interdisciplinary tool and it integrates concepts from acoustics, design, and art, engineering and human perception (just to name a few). A good example of the interdisciplinary nature of data sonification, can be found on the piece "A Song of Our Warming Planet". Daniel Crawford from the University of Minnesota interpreted the data shows measurements of the average global temperature since 1880. The temperature data were mapped over a range of three octaves, with the coldest year on record set to the lowest note on the cello . Each ascending halftone is equal to mapped to 0.03°C . Notes represented the years [10] here you can watch the performance .

The aforementioned examples of auditory displays provide an overview of types of auditory displays but these examples do not provide much detail about the distinctions within these categories, or what are the possible design choices and considerations that the designer may take into account. However, it's a necessary introduction if we want to examine each individual category more carefully. The examination of all the categories put forward by the study of auditory displays is beyond the scope of this thesis. However, the project proposed by this thesis examines more in detail the category of alarms in auditory displays.

As has been pointed out in previous article [2] that there are three main categories of alarm sounds:

- Speech: Speech uses signals that contains human vocal communication using language .
- Auditory-icons : Which are in the case of alarms the natural or artificial environmental non-speech sounds. These may include animal sounds, non-speech human verbalisation, mechanical sounds, etc.
- Abstract sounds: Which also referred to as earcons, are artificial sounds which may include melodies, single tones, etc.

Given the description of the categories above if we consider the sound of an alarm clock. It could be a message "Time to Wake Up!" (speech), the sound of a cock crow (auditory-icon) or a high rhythmic pitched tone (abstract sound) [40].

2.2 The relationship of auditory display with referent

The auditory display- referent relation is based on the semiotics as the study of signs and symbols and their use or interpretation. [2]. Nonetheless, semiotic relation is not clear as the deliberations in the previous studies of [2]. Where the it showed that consideration in the old literature of alarm design created misunderstanding in clarifying the sound-referent semiotics.

The main misunderstanding is in the relationship of the sound-referent and its aspect of learnability can be studied only in dyadic relation , in which the listener as interpreter is not considered. The dyadic connection is only between the single and the revetment . Instead the studied suggest the triadic where the listener learned the association of signal referent [2] . As shown in the figure 2.1

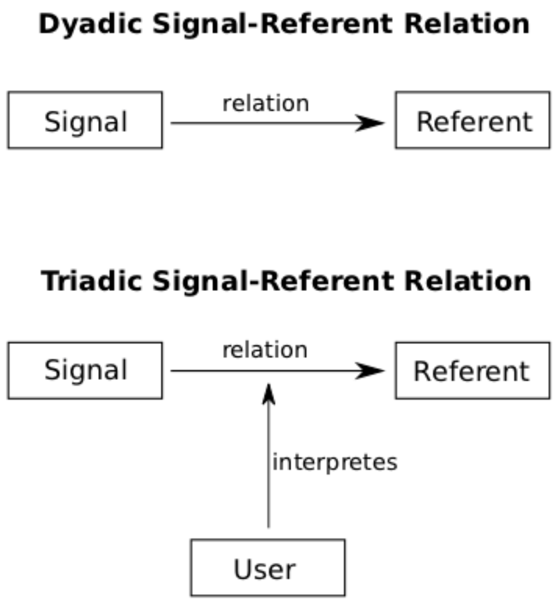

Figure 2.1: Dyadic and triadic signal-referent relation[2] .

Moreover, one of significant consideration is the articulatory of directness . Which is the degree to how the single represent to the event or meaning. Which be categorized into three classes . Nomic mapping as high level of directness where the sound represent almost a similar physical meaning . metaphoric mapping is less direct and less depended on physical interconnection such as using animal sounds . Lastly symbolic mapping which are least direct sounds which are not related to physical form . Mainly it rely on the social convention such as telephone rings and police sires [2]. The high level of directness will create an easier connection to be learned and recognized. on Other hand metaphoric and symbolic are harder to understand and remember [2].

Finally, one of the aspects that never considered on old traditional auditory display is the level of abstractness. Which are starting from concrete sound like the ones in everyday environment (winds, footsteps..). Semiabstract which are representative to changes in physical parameter such as pitch changes in icons. Lastly abstract sounds where the physical changes are not reflected , which are like musical motifs that can deliver a complex taxonomy of compound messages [2].

Chapter 3

Auditory Display Design

This chapter includes proposed guidelines, principles, considerations and methods that can be used to develop an auditory display design. Starting with the application and the context of the auditory display (for example melodic alarms at train stations), which will designate the phases of the design, as well as musical and environmental contemplation. Nonetheless, the design process is conducted by the perceptual and the physical and less based on previous design processes. As high level of the design cogitates the interaction of the listener to sound referents, which can support the final design implementation [46].

However, there are deficiencies in complete academic studies and industrial methods with the attentions to perceptual and to the effectiveness of auditory display in a certain environment. Therefore, there is an attempt to solve the problem of old auditory display design, as well as to understand the sound environment, musical features and acoustical features and other considerations such as sonic branding. The purpose of this study is to find an experimental method with novice design [46].

3.1 The Sonic Environment

Considering the train station as an environment, the sound classification will be divided into three sounds: the individual sounds as the voices of people, the auditory scene as the field sounds and the mechanical sound of the train machines and rails and possibly other alarms from different platforms, and alarm itself which is synthesized and effected by the acoustics of the scene. The environment of a specific location will dictate the physical attributes and the sensitivity of the listeners. The auditory display can be customized for certain environment [37]. As in my previous study [41] , the results showed that the majority participates were able to recognize the alarm and it’s meanings into train station environment more than the iconic short alarms.

3.2 listening modes

As the sonic environment included classification of sounds into specific location. These sounds with different sound sources will be perceived and processed in different ways and levels of implications [18]. The modes of listening can be categorized into four modes.

Perceiving a sound: Implies to listening to the sound without the doubt of the source and with a passive reaction toward it.

Hearing a sound: Implies to listening to the sound and selecting and perceive the sound of the interest out of other sounds.

Listening a sound: Implies to listening to the sound and finding the probable source of the sound and the nature of the experience.

Understanding a sound: Implies to listening to the sound and getting the meaning of it and the symbolic insinuation.

The melodic alarms as they have a musical and acoustic features can have more a focused source in which has a clearer semantics when dealing with sound and information [37].

3.3 Complexity of sound semantics

The experience of auditory display is combination of sensory and semantic familiarity. In previous studies showed a possible attribute of sound or alarm such as (attention, roughness/smoothness, temporal changes, familiarity/ unfamiliarity, preferences, urgency) [14].

The sensory features of alarm will conjure a certain sensation that will lead to a certain action or experience. In this contemplation the sound will be expressive and meaningful to the listener [14].

The semantics of auditory display were concerned the formal qualities of the alarm, but the perceptual features were never been fully studied [14].

The synthesized sounds have more complex semantics with associated to abstract meanings such as danger or urgency, as well as can indicate to elements of movement and speed [14].

There is a categorized construction in the expressive associations of auditory display semantics , in which first is the cognitive judgment, and later comes the psychoacoustic responses [14].

3.4 Sonification and auditory display

Since the term sonification used as a term that covers the aspects changing the perceptualisation of a data to auditory massage. Which is the use of non-speech as form of information. It can be understood as reparation of numeric data by mean of sound, but also study into the acoustic domain and the interpretations. The sonication concept can also broad to the non-numeric data information. The process of data can represent in no literal form of data to sound but somehow more detailed and constant [21].

3.5 Melodic auditory display features

Starting from the morphological description of sound by Pierre Schaeffer, where he implied that sound can be recognized by temporal evolution of its acoustical properties. This description is valuable to define melodic sound, however studies showed that is unmanageable to create a distinct outline to distinguish musical and non-musical sound [17].

The features that are suggested to convey a melodic perception divided into: acoustical features such as Perceptual Spectral Centroid and Harmonic/Noise Ratio, and musical features represented by tonal and rhythmic components.

3.5.1 Acoustic features

The previous studies in the field of environmental auditory display revealed the significance of the acoustic parameters in the design of alarms [34]. The physical space of the environment with certain acoustic features that can be validated in consideration of perceptual elements significance. (For example, industrial, car alarm) [37].

In order for a listener to correctly recognize a sound in loud environments, such as factory floors or train stations, the sound needs to display some characteristics separating it from the background noise: The sound level as well as spectral features. In the physical space these can be described by Perceptual Spectral Centroid (PSC) and Harmonic Noise Ratio (HNR) [37].

PSC (Perceptual Spectral Centroid) has a strong connection with the impression of brightness of a sound and it helps with the portrayal of the timber in music. Similar to the Spectral Centroid. This measure is obtained by assessing the "midpoint of gravity" using the Fourier transform's frequency and magnitude data [15]. The individual centroid of a spectral frame is defined as the average frequency weighted by amplitudes, divided by the sum of the amplitudes [38].

$$spectral\ centroid = \frac{\sum_{k=1}^{N} kF[k]}{\sum_{k=1}^{N} F[k]} \tag{3.1}$$

The Perceptual Spectral Centroid is with respect to mel-frequency of the signal spectrum [15]. The (PSC) can be computed in MATLAB with function perceptualCentroid(x,fs) by Christopher Hummersone [22].

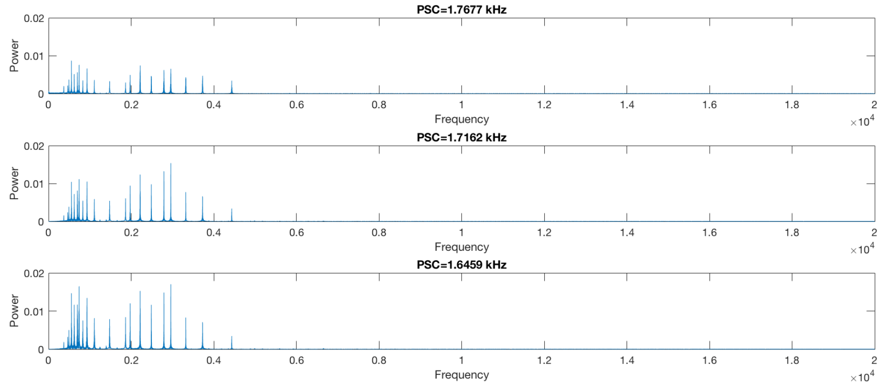

Figure 3.1: The DFT spectrum of same signal with different Perceptual Spectral Centroid and wider bin range progressively

In practice, centroid belongs for a frequency for a given frame, and then set in the closest bin for that frequency. The centroid is generally higher than expected, since there is more energy higher than the fundamental frequencies.as shown in the figure 3.1

HNR (Harmonic/Noise Energy Ratio) HNR (Harmonic/Noise Energy Ratio) can reveal the grade of hoarseness/roughness by giving the relative amounts of harmonic energy to noise energy contained in the signal. The value (in dB) shows the extent noise replaces the harmonic structure in the spectrogram of the signal [37].

Once these both parts (harmonic/noise) of the signal are extracted, the feature simply consists of the ratio of their respective loudness levels. represents the degree of acoustic periodicity, also called Harmonics-to-Noise Ratio (HNR), which is measured in dB[45].

$$HNR = 10 \times \log_{10}(\frac{Harmonic}{Noise}) \tag{3.2}$$

for example if 99% of the energy of the signal is in the periodic part, and 1% is noise. $HNR = 10 \times \log_{10}(\frac{99}{1}) = 20dB$, on other hand if the A HNR is 0 dB means that energy in the harmonics and in the noise are equal. In figure 3.2 the HNR is 30 dB.

HNR can be computed using MATLAB with the function harmonicRatio from Audio Toolbox.

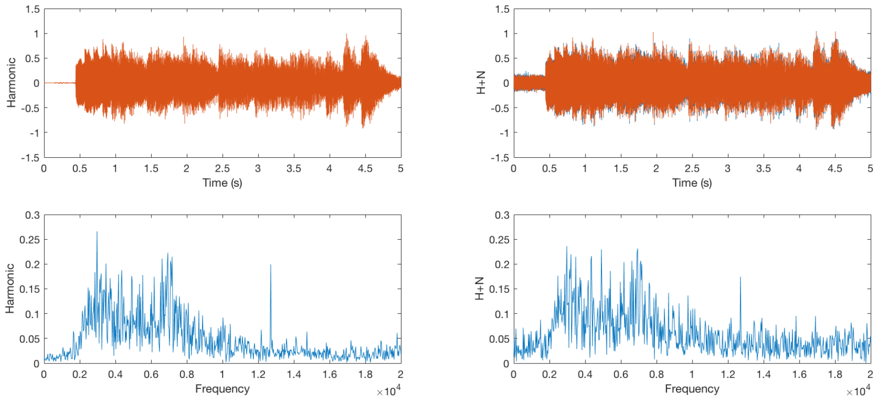

Figure 3.2: Example of a signal consisting of a harmonic part and a noise part.

3.5.2 Musical features

The musical features where extracted by the use of MIRToolbox for MATLAB. The process starts with the audio signal running into a chain of operation and modeling that include pitch, tonality and dynamics. Statistical moments and timbrel characteristics. can be computed with MIR toolbox from the audio waveform itself, the FFT-based spectrum, and the signal energy[32] . As shown in the features overview in the figure 3.3.

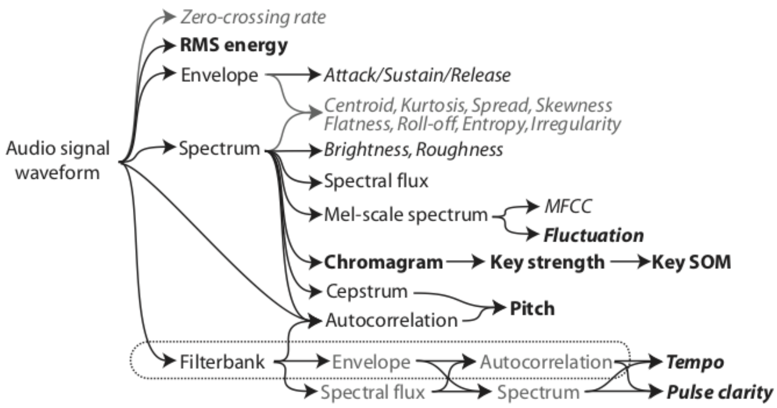

Figure 3.3: Overview of the extracted musical features be extracted with MIRToolbox [32] .

Tonality analysis

The spectrum is transformed from frequency domain into pitch in a logarithmic scale. The chromagram represents the distribution of the energy along with respect to the twelve possible pitch [32]. Th figure 3.4 shows the function that extract the musical features .

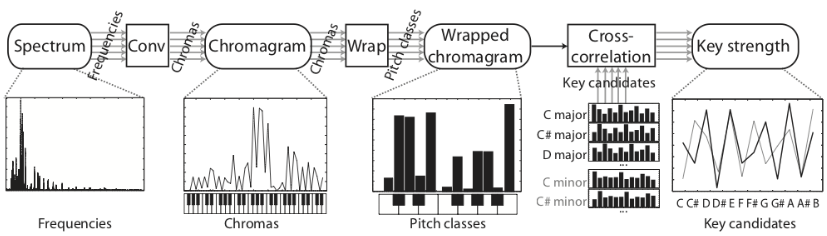

Figure 3.4: Overview of the extracted musical features be extracted with MIRToolbox [32] .

Also, with self-organizing map (SOM) which can show a deeper representation of the tonality. The configuration of the trained SOM reveals key relations that correspond to music theoretical notions [32].

Rhythm analysis

The auditory modelling can be used to approximate the rhythmic pulsation, where the audio signal is decomposed into channels via a bank of filters in which the envelope of each channel is extracted. The pulsation is related to the escalation of energy, the envelopes are distinguished and rectified, and later summed together. In this approach the description of the variation in energy can be produced in the different auditory channels.

In this onset detection is estimated through autocorrelation for a frame decomposition to show the changes of periodicity in small fragments [32].

This yields a periodogram that highlights the different periodicities, as shown in the figure 3.5

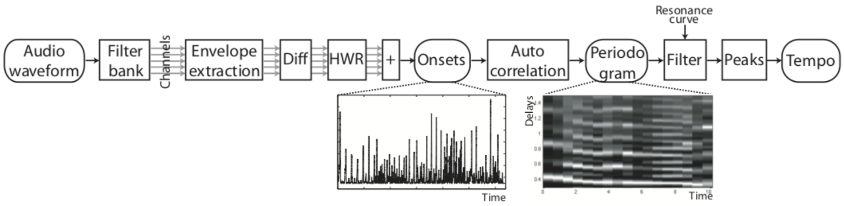

Figure 3.5: MIRToolbox steps for the estimation of tempo illustrated with the analysis of an audio excerpt [32] .

For a more defined representation in perceptible approach, the periodogram is categorized with resonance curves in which show the best tempi are estimated through peak picking, and the results are transformed into beat per minutes. Due to the difficulty of choosing among the possible multiples of the tempi, it will be shown in a histogram of all the nominated for all the frames which referred as called periodicity histogram [32].

Taken as an example to study of the musical features is the arrival melody of the train stations from JR in Osaka.

Figure 3.6: The arrival jingle in Osaka rain stations.

As can be seen from the score in the figure [3.6] ,the scale is F major . Generally has semiquaver notes and end up ascending two quaver that resolved into authentic cadence with Fmaj7 chord.

By using the MIRToolbox to have a deeper look at the features of tonality and rhythm.

Starting with tonal features ,the Chromagram which shows the degree of occurrence of the notes in a scientific pitch notaion. And as it shows in the figure[3.7] the most recurring note is A3.

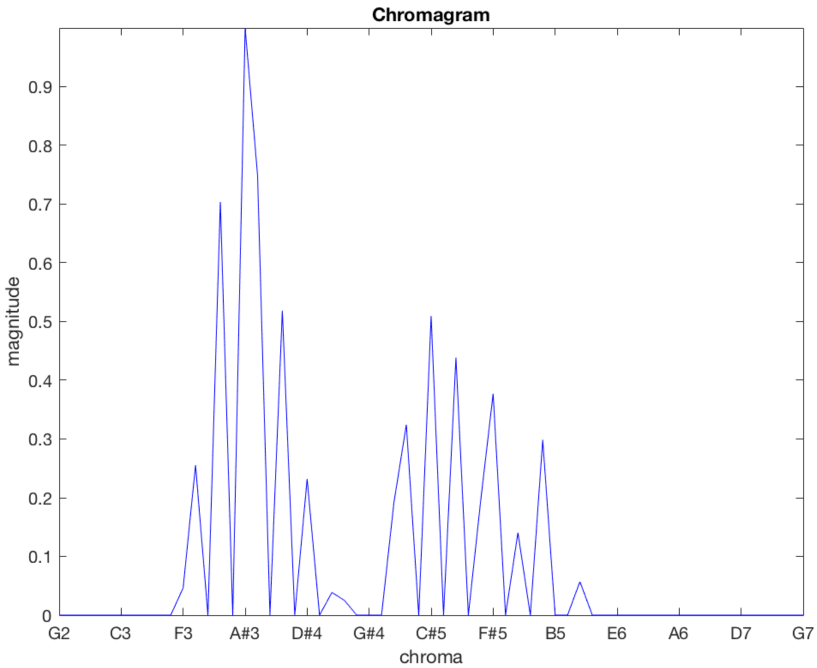

Figure 3.7: The Chromagram related to the arrival jingle in Osaka rain stations.

One other way to show the choroma of notes with elf-organizing map (SOM) which shows the hot colors as most recurring notes and cold colors as least recurring notes as shown the figure [3.8]

In the next figure [3.9] it the shows the key clarity and interval changes through time.

As for the key strength in time its hows the changes of key including for both modes major and minor and shows the predominant keys in the jingle as shown in the figure [3.10]

As for the key strength in time its hows the changes of key including both modes major and minor over the time of the jungle as shown in the figure [3.11]

As for the rhythmic features , starting with the tempo in the figure [3.12] shows the changes in tempo through time of the jingle as represented by BPM as a graph.

Additionally, the tempo also can be show as number occurrence of different tempi in the jingle as shown in the figure [3.13]

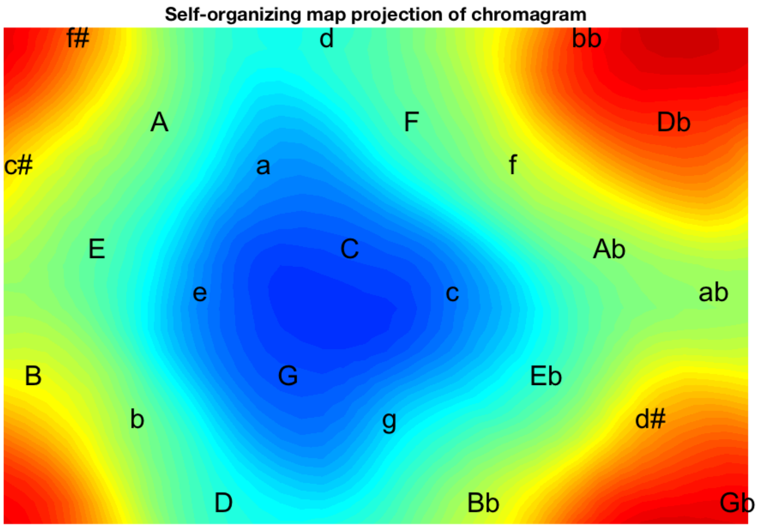

Figure 3.8: The SOM Chromagram related to the arrival jingle in Osaka rain stations. .

Finally , with deep look at the onset in the beginning of every musical note, The envelope and onset can extracted and shown in the figure [3.14].

The other examples jingles from Osaka train station such as the Departure jingle and Halfway/Information jingle the music scores and musical features can be found in the appendix(B).

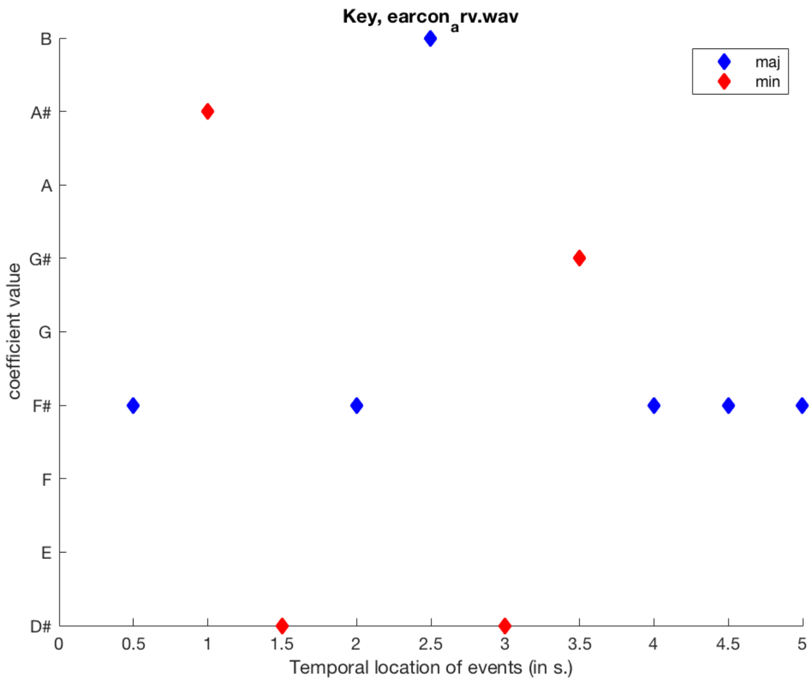

Figure 3.9: The Key clarity related to the arrival jingle in Osaka rain stations.

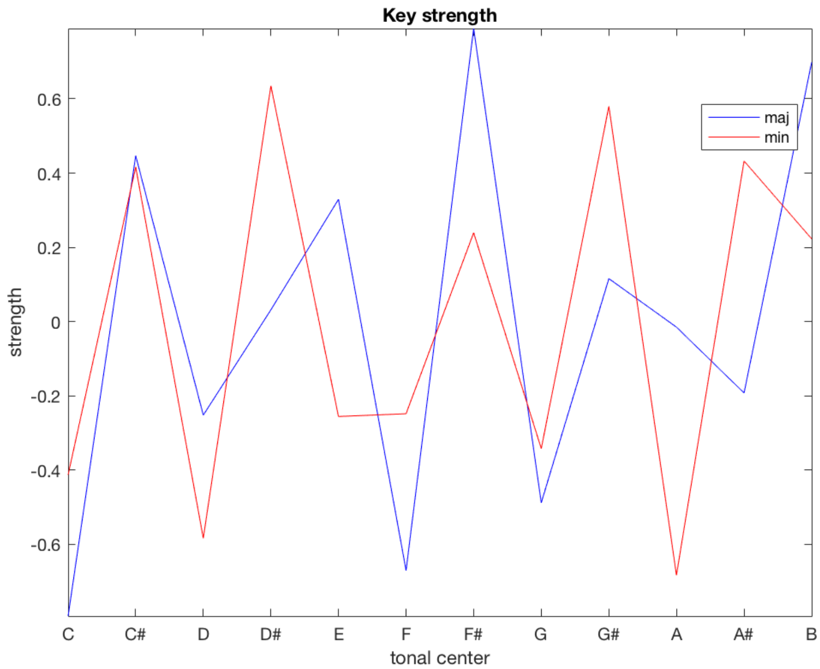

Figure 3.10: Key strength related to the arrival jingle in Osaka rain stations.

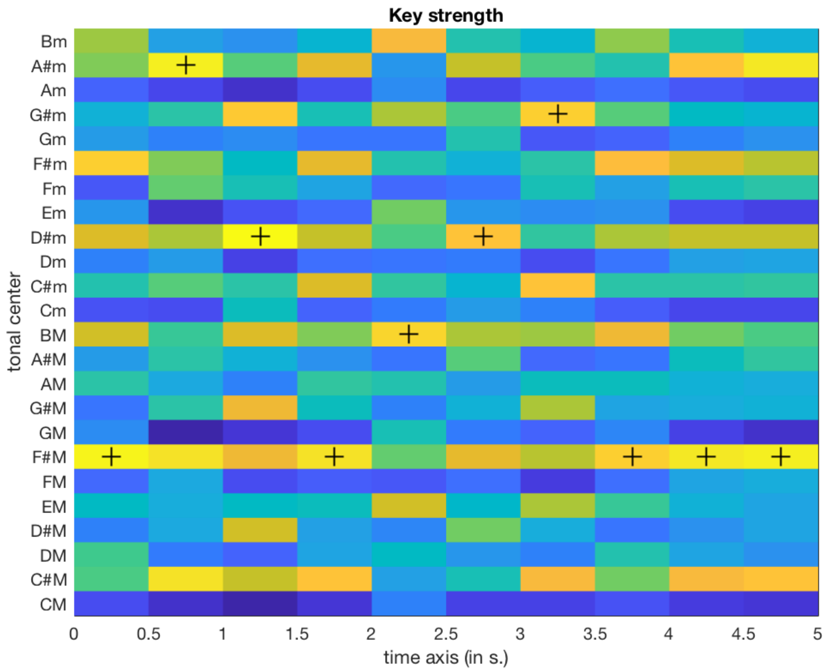

Figure 3.11: Key strength through time related to he arrival jingle in Osaka rain stations.

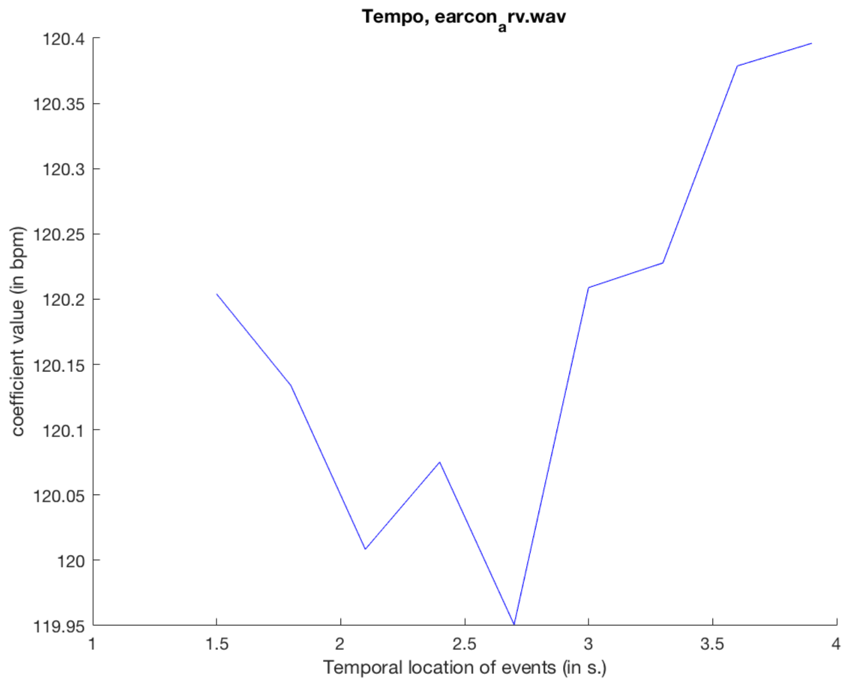

Figure 3.12: The Tempo related to he arrival jingle in Osaka rain stations.

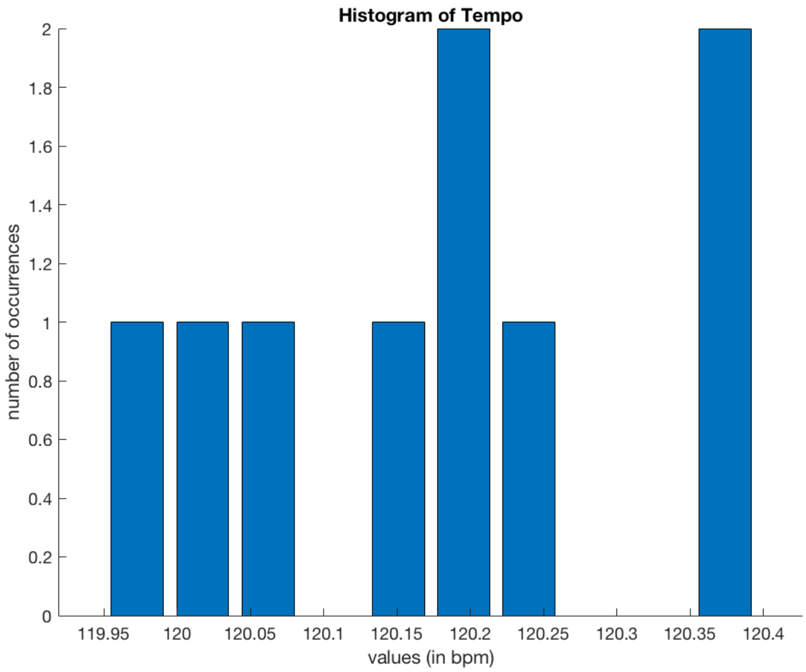

Figure 3.13: The Tempi histogram related to histogram the arrival jingle in Osaka rain stations.

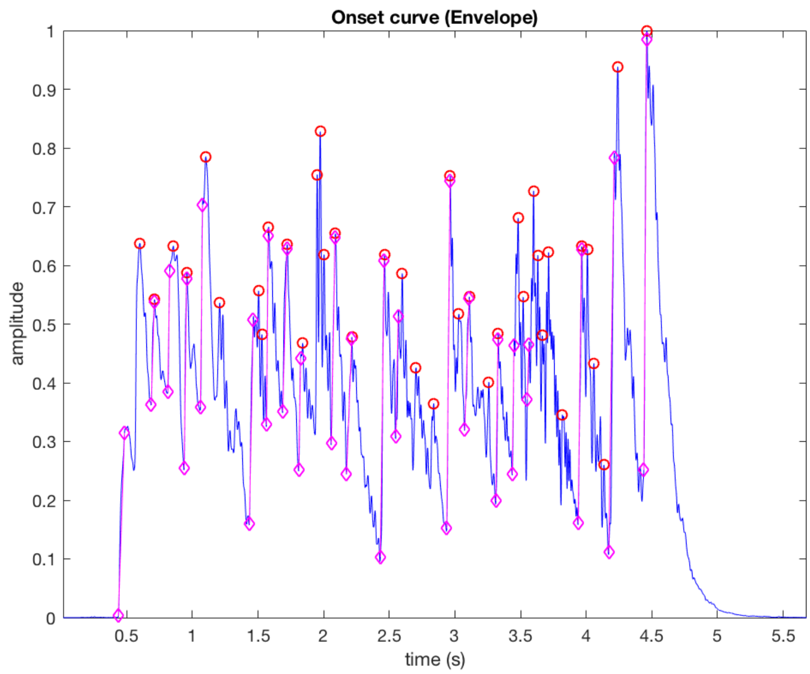

Figure 3.14: the Onset curve (Envelope) related the arrival jingle in Osaka rain stations.

3.6 Auditory display design tools

The design tools for auditory interfaces are a interesting developmental model which is concerned by both industry and academic research. Despite its widely adapted use, the industry did not revile a clear materials about how these methods are utilized in the sound design process. Nevertheless, a common way to critique the suitability of sound design in sound alarms is to use a sound quality assessment [24]. This assessment is a questionnaire designed to have subjective test about the sound features that are used in approaching the desired sound quality in question. The product designers then will have analysed psychological reactions on certain features that would lead to more improved and suited designs. [34].

Alternatively,one another way of monitoring the perceptual range of the sound in design is to include analysing the psycho-acoustical data such as loudness, harmonicity, and signal to noise ratio, and sound ecological considerations [35] .

As a common method to design an auditory can be divided into four phases : problem analysis, conceptual design, embodiment design, and detailing [34] . as shown in the figure 3.15

Problem analysis in this phase after studying the problem and analysis it . The designer will bring ideas as examples , possibly based on previous designs .

Conceptual design in this phase starts with a sketch a concept that can be suitable for a certain alarm . This draft design can be changed later in the final phase.

Embodiment design in this phase the alarm is functional model with variable features that can be alternated.

Detailing from the prototype designs the alarm will set up into a formal subjective listening test in and a qualitative listening test. The collected data will be analysis, and the resulted will be an evidences to the preferred features in the design, which will be utilized in the final alarm design. The experiment includes acoustic simulation of the desired environment. [34] As well as the semantic and conceptual coupling between the sound and referent will be included as the psychological dimension. [14] .

3.7 Disciplines of auditory display design

The auditory design consisted by multiple disciplinaries, which concerns the elements of **acoustics**, **engineering** and **psychology** [34].

The acoustics focus on the covers the physics of sound features such the sound pressure level , the wavelength and the frequency range. Additionally, the transmission medium's nature and the location, which effects the sound travel velocity and reflection and scatterings with surrounding surfaces. It is very important to include acoustics features in the design which can be simulated and after worth

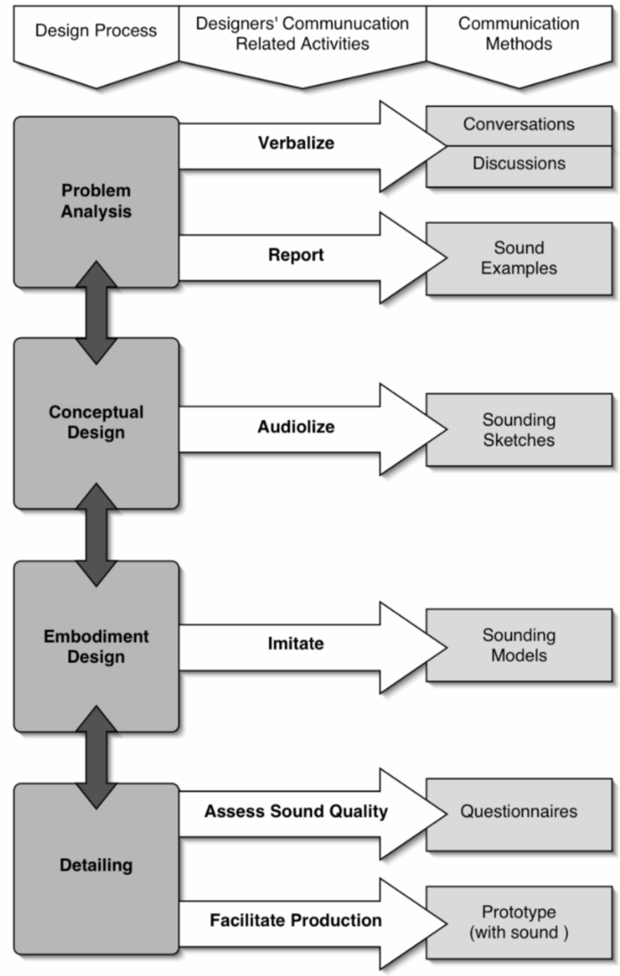

Figure 3.15: The Synopsis of 4 phases of auditory display design [34] .

measured by analysis the frequency response [34].

The engineering side of the auditory display design includes the materials and technology of design as a product. For example the loudspeakers design and how loud will have. As well as for the synthesized or recorded technology of the sound itself [34].

The psychological study in the auditory display design suggest the semantics of the alarms which can related of specific referent such as action or danger for example [14] .

These disciplines are conducting the progression of the design. However, there more field of studies that considered to the auditory display especially that ones with musical features which are **psychoacoustics** and **musicology** [34].

The psychoacoustics field concerns about the with sound features same as like the acoustics but with subjective observations which describe the perceptual quality of the sound . [34]

As for the musicology can be important in the auditory display design since it uses the musical melodies . The musicology study will be concerning the musical composition and music structures such as the the music scale mode , the harmonic structure, rhythmic patterns , and the timbre [34] .

3.8 Learnability of the auditory display

Speech as auditory display showed more capacity considering the learnability and recognition aspects compered to abstract auditory display [26]. No doubt, that verbal labels can perform better in comparison to abstract counterpoints. Which can be indicate the difficulty to associate abstract alarms with variety of possible meanings with actual verbal messages [13].

While, the learnability and recognition factors amongst icons and abstract sounds, preceding studies showed that both auditory display types has strong relation between the psychoacoustical features to the semantics of each sound[13].

Moreover, in a [7] experiment were abstract auditory test to iconic auditory. The abstract sounds were composed in short melodies that presumably fit semantically the most. The abstract sound should have the sense of movement and direction as for example with acceding or descending in pitch but inappropriately it represented inadequately comparing to iconic ones.

Therefor, the development of learnability element in the melodic abstract alarms are still ambiguous. Additionally the traditional iconic alarms still in use and showed approximately equal learnability quality to abstract as my previous study in [41]. Nonetheless, abstract auditory display has it potential in the term of learnability that worth to discover.

3.9 Psychology of music preference

The preference in music related to psychological aspects. Since music is heard in everyday life . and it affects people in the broader sense of music perception [51].

In previous studies showed that music training can increase the cerebral growth in the music vocabulary such as the liking to certain musical scales and intervals, the perception of music complexity, and the emotional implications of phrases. On other hand other studies showed the music preferences can be affected by personality traits [51].

One of the studies in Japan showed the association between sides of personality and music choices. For example, openness especially “aesthetic appreciation” showed that is related to preferences of “relative music”. Where on the other hand extroversion facet showed the connection toward common pop music [6].

One important factor to include is familiarity, where the sense of nostalgia in music can be perceived as positive experience that feels with serenity, a curiosity, and candidness. Familiar melodies can be easier to attract the attention of the listener than new ones [53].

3.10 Music and psychological equilibration

The relation between music and emotion has a complex exemplarity and considerably a vague field to study, which been negated and accepted the traditional believe. Even though music considered as a universal language but still no proofs of its meaning in respecting to modes, harmony and intervals. The conquest of music Equilibration (which is originally (Strebetendenz Theorie) was of the earliest example of psychological model which attempt to clarify the emotional effects of music by desiccating the basic elements of music among others modes and intervals. Nonetheless, that study considered more as personal and grounded on the cultural exposure [11].

In the book of Daniela and Bernd Willimek (Music and Emotions)[11] is a colossal experiment around the psychological effects of musical scale and harmony. As for the scope of this project the consideration will be limited only to major and minor scales. Major scale which includes the major third (for example E in the key of C major) The major scale can bring the feeling of happy or bright. Happiness in the sense of majestic or sentimental when is played slow. As for Harmonic major scale in which includes flat sixth, it creates Majestic, mysterious feel. Minor scale has a flat third (for example E-flat in the key of C), it gives a darker and more tragic feel to it. Looking at the natural minor scale, it has a sentimental, tragic feel somehow. On other hand the harmonic minor scale with sharp sixth, it creates a tragic and exotic feel someway with Middle Eastern touch. On the melodic minor scale, in which an ascending has sharp 6th and sharp 7th , and the descending is like nature minor scale . It creates a mysterious and very dark can be related to jazz music [11].

Moving on to the musical intervals which are the fundamental feature of musical tonality. In which can be explained as two notes in sequence or instantaneously. The distance is measured by the number of the semitones. In western music there are 12 intervals with added the unison and octaves so are 14. The function of consonance-dissonance is main expressive tool in the intervals. But in later studies in the experimental psychology the focus was into the semantics and embodied feeling of each interval. The studies concentrated the classic or popular music with a clear character of a distinguished and checking the general emotional sense of the phrase . Followed by alternating the intervals with other intervals for example m major intervals to minor intervals or from ascending to descending. The results of this study demonstrated that the changes in the intervals can evoke certain feelings

Interval	Sensorial	Affective	Intellective
Unisonous	fusion, smoothness	will, peace	insistence, serenity
Minor second	derangement, roughness	fear, anger	shyness, illness
Major second	movement, friction	wish, vulgarity	request, displeasure
Minor third	heaviness, shadow	sadness, pain	lament, discouragement
Major third	clearness, limpid	joy, happiness	hope, balance
Perfect fourth	hardness, cold	firmness, indifference	achievement, simplicity
Augmented fourth	fracture, heat	disdain, excitement	pretension, surprise
Diminished fifth	excitement, instability	restlessness, anxiety	doubt, uncertainty
Perfect fifth	balance, emptiness	love, calm	certainty, mastery
Minor sixth	upsetting, penumbra	suffer, melancholy	worry, pity
Major sixth	radiant, light	effusiveness, kindness	satisfaction, gratification
Minor seventh	dynamic, warmth	exaltation, love	lyricism, romantics
Major seventh	limitation, wound	wickedness, hate	pride, rebellion
Octave	solid, stable	courage, exaltation	heroism, liberation

Table 3.1: The expressive values of the intervals [27] .

in the same melody. As shown the figure [3.1] the verification of the semantical adjectives to characteristic musical intervals [27].

3.11 Limitations of traditional auditory display design

The main purpose of the old alarms is to draw attention of the listener as a highly important message. The efficiency of that purpose is when the alarm can be distinguished in the sound environment [54].

The old alarms had a high level of the sense of urgency , which also create a fast and unexpected onset. That will let the listener has an implosive and annoying reaction. As well as the old alarms are considerably louder which can effect the level of clarity of the sound and eventually its meaning[23].

The old hadn't the forms of synthesize that can provide variations in the sound. The technology were limited to a single sound. This issue created difficultly to recognize a range of alarms in a monophonic form [23].

Additionally, old alarms were designed with the consideration for the acoustical features of the environment [36]. Old train iconic alarms can be masked the noise of passengers and train machines noises [41].

The proposed solution for these problems with traditional auditory display design is to consider the acoustic and perceptual features to improve the design [25]. Design alarm with dynamic acoustics variable to match the environment. As well as create short abstract alarms that include a bigger space for silence which would less provoking to the listener [34]. Coloring the sound with pitch variation as a melodic jingle, so the listener would capable to understand and remember the semantics of the alarm referent [41].

3.12 Auditory display as a tool for sonic branding

One of the most important aspect of using jingles and music in any product sound design is the sonic branding which is an effective tool for marketing strategy. As for example; train jingles in a train station with multiple railways companies, the use of uniquely designed alarms would help to stand out in in aggressive marketplace. Brands can realistically, and efficiently assimilate music and sound into their overall communications strategy with the consumer [4].

The quality of the product or service is important to attract consumer , but the feature of engaging and stimulate the senses and provide an unique experience of the consumer is getting more interest recently [39].

As for the Japanese train, the passengers developed some sort of attachment towards the certain train station jingles. Which also helped to identify the rails operator [49]. Since there multiple companies that might share the same platform , the unique jingle created unblemished brand among the others [52].

Chapter 4

Stimuli Composition

As the short tunes are related to referents in jingles and TV themes, also can be incorporated in auditory displays. The melody as auditory display has the potential to be effective and easy to learn in numerous of scenarios in contrary of iconic alarms which can be mystifying [19] [41].

The previous melodic methodologies signposted that stimuli must consider the aspects of music cognition and human' hearing limitations. Recent researches revealed that the music contour is one the elements that can best lead to the referent. Where in similar alarms that same contour were the less complicating to learn which can hold the same music features with slight alternation [19].

The musical features in composing of the melodic alarms structure (repeated phrases, clear contours, and recognizable intervals) can increase the possibility of correct semantic meaning of the alarm [19].

In regards of choices of modes and type of intervals will have the global effect of the perception and understanding the semantics of the melody [27] [11].

The consideration of cultural and musical training is also very important factor on the listeners when it comes to melodic auditory display [51].

As for the temporal features can affect the perception of movement. Moreover, the variations in tempo can get the listener attention to if the message has a high significance. For example this can achieved by use of fast melody with upward sweep [12]. On other hand, slow-tempo music will give a more relaxed feel to it. As well slow tempo can be understood as a waiting sign , where usually the alarm is shorter[31].

The timbre as attribute in auditory deign is very important as perceptual parameter. In which two sounds or two melodies with same pitch, temporal pattern and loudness can be told apart [48].

Understanding the perception of timbre in music can be described by multi-functional sensory, such as the changes in brightness and roughness. The brightness can implicate in categorizing the music source. The brightness as a perceptual element is translated by Perceptual spectral centroid of the source .The spectral centroid can shoe the degree irregularity in the frequency spectrum (for example is high in vibraphone and low for trumpet) [47]. As for roughness or hoarseness which acoustically explained by harmoncity ratio (HNR) as explained in the section 3.5.1. High ratio of harmonicity can be sensed by fluctuations between high and low frequencies which add a jittery feel to the sound [3].

Finally, a factor of considering of the melodic alarm as trade mark, it will showcase the necessity to create an adaptive system that can include multiple version of the melodies with different events and occasions and yet still they can keep that overall sense of relation with meanings [52] [39] .

The consideration of all these features , the stimuli were composed to show the contrast between the features . The stimuli will tested later in a learnability test that might affect the listener recognise the referent, as well as a preference test in pairwise that might show what are preferred features among others.

4.1 Melodies composition

As mentioned above regrading to the musical considerations for composing melodies for the arrival of the train. Starting from the original arrival melody in Osaka train station in the figure [3.6] ,as well as the extracted musical feature by mean of MIR-toolbox , a new arrival melody was composed. The new melody as shared from the Osaka's the features ; such as the contour , the alteration of intervals around the dominate (D) and the tunic (G) , the descending in the before to the last bar, the resolution into authentic cadence in G major chord. The rhythmic pattern differs by using quaver instead of semiquaver but still follows the contour . as it shows in the figure [B.13].

It was in consideration also the elements of key strength shape ,key clarity , the onsets curve , and tempo changes . As shown in the appendix B.5

New Arrival Melody

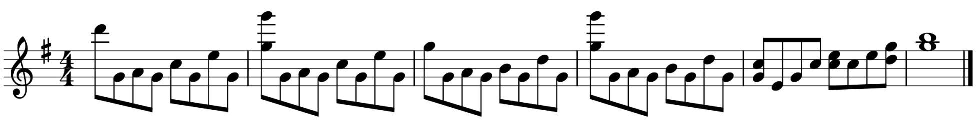

Figure 4.1: The score of the new arrival melody in G major .

The new arrival melody used as foundation to create variations in which the musical elements can be test in the experiment.

From the score in the figure[4.2] , we can see what types of changes that have been done to the main theme.

1 - Is the new arrival melody without any alteration just as a reference in comparison with other versions.

2- In this version, the intervals are decreased a semitone , so for example the major second becomes minor second , or major sixth becomes minor sixth , in which the feeling movement changes into derangement.

3- In this version, the rhythm changes from quaver notes to dotted quaver note with semiquaver note , in which creates a swing feel , and unseriousness .

4- In this version, the intervals are increased by a semitone , in which for example major second moved up to minor third , which changes the feel of movement into heaviness and sadness .

5- In this version, the intervals are increased by three semitones , so for example major second become perfect fourth , which brings the feeling of cold and indifference , which makes the message of movement less important .

6- In this version , notes double up with added minor second to every note, which creates a dissonance or a nonchord tone . It has a whimsical effect in which contrasts with the theme's meaning .

7- In this version, the the rhythm changes from quaver notes to semiquavers which creates faster pace, which add a feel of urgency.

8- In this version, the intervals are increased by two semitones , so in this case the major second becomes major third which adds the movement sense of clearance and happiness.

9- In this version, the key changes from G major to the relative E minor , this change creates a sentimental or tragic feel , which changes the meaning even though the sense of movement

10- In this version, the key changes from G major to the supertonic key A major , in which will add the feeling of cheerfulness yet still includes the movement sense .

The variations are shown in the figure 4.2 .

Figure 4.2: The variations on new arrival melody .

As for there other train messages Departures and Halfway were composed in respect to the extracted musical feature in MIRtoolbox . The new melodies resemble the Osaka's the features which are shown in the appendix B.

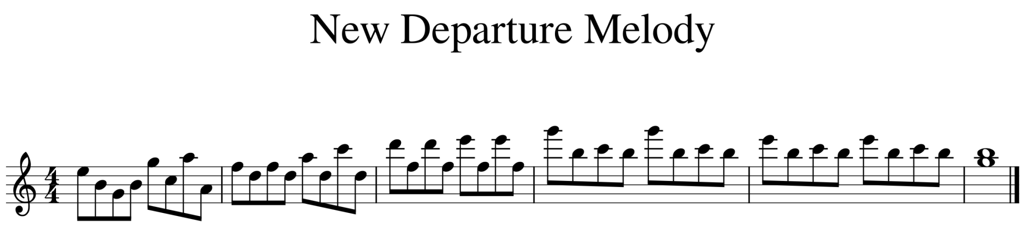

Figure 4.3: The score of the new departure melody in C major .

Figure 4.4: The score of the new halfway melody in C major .

The versions of Departures and Halfway that related to the other nine arrival variations will be extracted by a SuperCollider program , which will be explained in the next section 4.2 .

4.2 Melodies generating and processing

In this section the process for generating the various melodies that will be used is the experiment is described in the next chapter. Keeping in mind that this is a general explanation of the process, the full in depth explanation of all the functions that are used in this code are beyond the scope of this paper.

The new arrival , departure , and halfway melodies were composed , but as well as the variations of the arrival theme , there will be a need to have a tool to extract the other message best on one melody or another . Find the relation between the three melodies which in which considers the number of measures , the the tempo , the key and its mode, and the type of intervals. The music will be handled and processed as **MIDI** [5] information and later processed.

In regards of the timbre effects it was chosen to be synthesized as a vibraphone since it has comfortable bright sound. The next step to create the different kind of timbre with the chosen changes the (PSC) , and control the hoarseness can be achieved by changes in the (HNR) ratio.

The implementation for this was done in **SuperCollider** [28] environment which is a free and open-source software. A dynamic programming language for real-time audio synthesis and algorithmic composition. It is used by both artists and scientists who are working with sound. As for the timbre effects were archived in **Ableton Live** [1].

4.2.1 Implementation with SuperCollider

The overall the code can be explained by dividing it into three sections.

1st section

The first step is to load the midi file for the composed melodies which are based on the melodies used to indicate the arrival of the train.

The class ImportMidiFile is used, where the path to the directory where the midi file is located is specified. This returns a list of midi notes pitch (a), notes duration (d) and tempo (t).

```
# a, d, t = ImportMidiFile("~path—to—midi—file/arv1.mid",1);
```

Which can be represented as MIDI piano roll in the SuperColider window, in the figure [4.5].

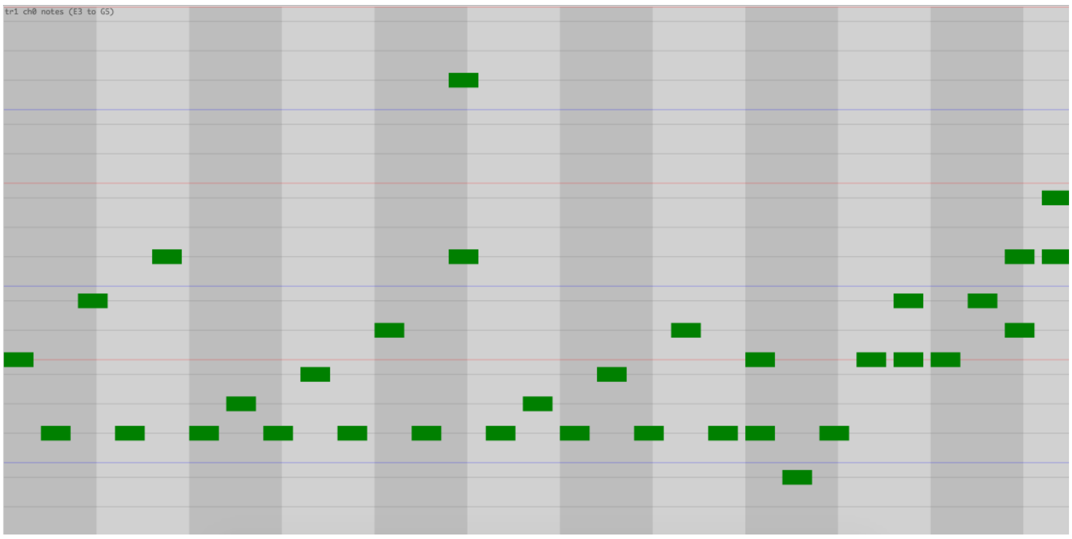

Figure 4.5: The midi representation of the composed arrival melody in the SuperColider .

The same is done for the previously composed melodies used to indicate half-way/information and departure. We then store the list of midi notes inside a variable.

```
~arv = a; //arrival
~hw = b; //half-way
~dpt = c; //departure
```

As well as can be represented as MIDI piano roll in the SuperColider window, in the figures [4.6] [4.7].

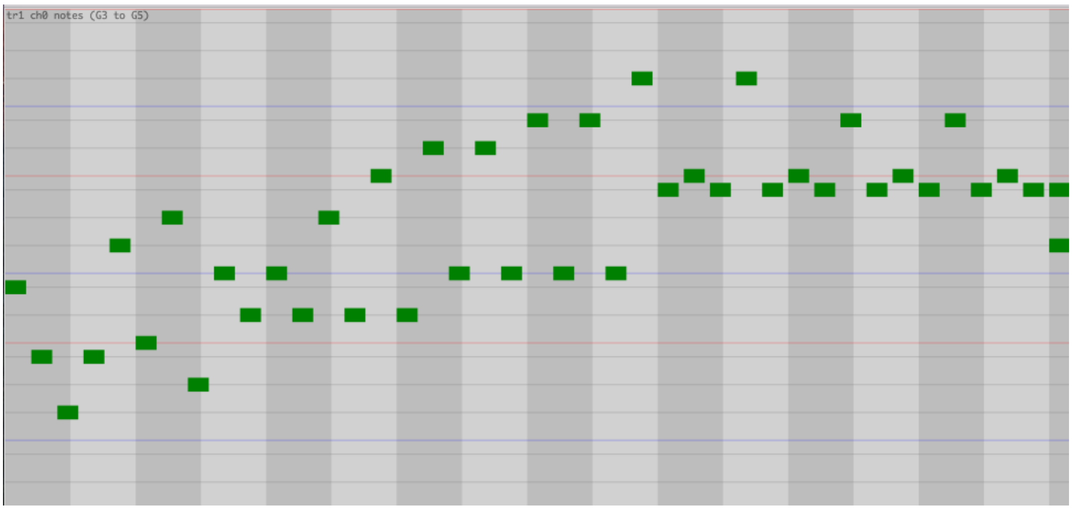

Figure 4.6: The midi representation of the composed departure melody in the SuperColider .

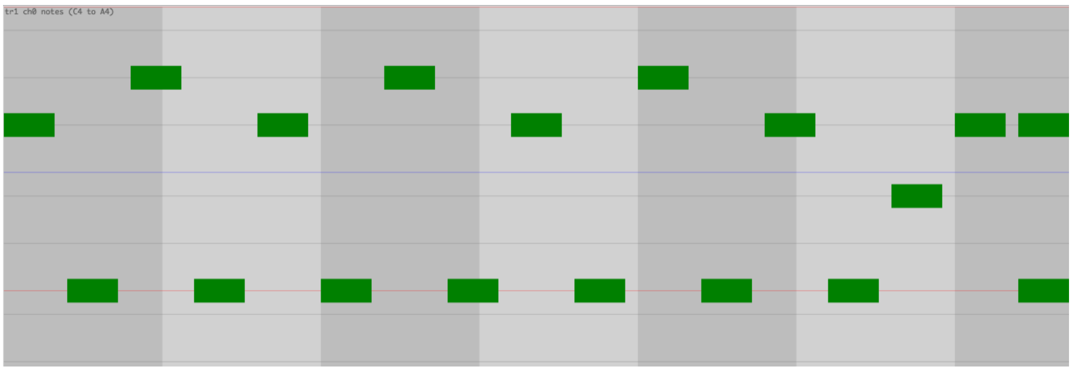

Figure 4.7: The midi representation of the composed halfway melody in the SuperColider .

From the arrival melody every notes that comes after the 13th note in the sequence were removed from the arrival melody in order to make it the same size as the half-way/information melody, and assign it a new variable. This is done for the sake of the next step.

```
~h2 = ~arv.removeAllSuchThat({ arg item, i; i <12 });
```

In this step the difference between the notes for the given melodies are then calculated. This difference is stored as a variable in order to later generate new half-way and departure melodies for each different composed arrival melodies from the variation .

```
~tlt = ~h2 - ~hw; // difference between arrival and half
   way.
~tlt2 = ~arv - ~dpt; // difference between arrival and
   departure.
```

2nd section

Here we create the synth engine that will be used to play the melodies. We chose a synthesized vibraphone sound. As it is the same used in the train station in Japan which. The vibraphone sound is generated using **FM**(Frequency Modulation) Synthesis.

In SuperCollider this is done using a class called 'SynthDef'. First we define the name of this synth. Then we provide the function, specifying the arguments and variables that will be used.

```
SynthDef.new(\vibraphone, {
        arg freq=440, modindex=0.5, amp=0.3;
        var sig, sig2, env, noise, modfreq;
```

This is our modulating frequency, here we make it have an inharmonic relationship with the original carrier signal(freq). This is what allows for a more percussive and bell-like spectra to be created.

```
        modfreq=freq*2.015;
```

Then we generate our first signal. The signal here is a Triangle wave, modulated by a Sine wave. Notice how the modulating frequency is affected by the frequency modulation index.

```
        sig=LFTri.ar(SinOsc.ar(modfreq)), // the frequency
           of the oscillator.
                SinOsc.kr(5), // the phase, here we also
                   add a slight phase modulation.
                modfreq*modindex, // the output is
                   multiplied by this.
                freq // the carrier frequency is then added
                    to the output.
```

The second signal is used to give more sound to the low end of the spectra. Notice how the frequency is half the size of the carrier signal.

```
sig2 = BPF.ar(SinOsc.ar(freq/2,3,0.55),freq/2);
```

Then an envelope generator is created in order to define the shape of the signal.

```
env=EnvGen.kr(Env([0,1,0,0],[0.01,0.65,0.15,1.3],
   \sin),levelScale:amp,doneAction:2);
```

We also create a noise signal that is bandpassed at the modulating frequency, to add noise for the percussive aspect of the spectra.

```
noise = BPF.ar(PinkNoise.ar,modfreq,0.5)*(env*0.7);

//      we add the first signal with the noise signal,
        sig = sig + noise;

//      we filter the result,
        sig = BPF.ar(sig,modfreq/1.5,1);

//      combine it with the second signal,
        sig = sig + sig2;

//      assign the envelope,
        sig = sig*env;

//      And output the signal.
        Out.ar(0,sig!2);
```

3rd section

In this section the new melodies will be generated and saved as midi files which can then will synthesized and exported as WAV file. For this procedure we use 'Pbind'. In short this generates a single stream of events based on multiple streams. In this case the events will be the notes and the duration of these notes, which will then generate our melody.

```
p = Pbind(


//We define the instrument we use, in this case the synth
   we created.
        \instrument, \vibraphone,

// We specify the duration of the events.
        \dur, 0.2,
```

Then we define the sequence of notes using 'Pseq' and assign to it the formula to generate the melody. In this case the variable which contains the list of notes for the "arrival melody" plus variable which contains the list with the the difference previously calculated.

to generate the halfway/information melody

```
\midinote,Pseq(~h2 + ~tlt ,1),
```

to generate the departure melody

```
\midinote,Pseq(~arv + ~tlt2 ,1),
```

Then we create an empty midi file,

```
m = SimpleMIDIFile( ~ /GeneratedMelodies/HW4.mid" );
```

take the values from the stream generated

```
m.fromPattern(p)
```

and write it to the empty file we just created.

```
m.write;
```

Finally, we can listen to the result and create an audio recording and store the generated melody into a .wav file:

```
p.play; s.record(duration:10);
```

All the generated melodies in all the 10 variations are shown in MIDI form in the SuperCollider window at the appendix D .

4.2.2 Processing with Ableton Live

The melodies that were generated and synthesized with SuperCollider , have been imported to the Ableton Live environment.

The goal of this step to create multiple versions of all the melodies composed and generated with variable (PSC) and (HNR) , using the advantage of processing all the melodies on one track.

As for emulating changes in (PSC) , a Band-Pass Filter used , the choice was 1 kHz [30] as central frequency since it has most energy of the instrument sound around its range . As a variable tool the choice Q factor (Quality Factor)will affect of band pass width. The choices to have first Q = 0.25 which will create a wide range of 3 octaves , also Q = 0.75 which a narrower range of 2 octaves .

For example here is the Arrival 3 processed with two Q values, in the figure[4.8].

Regarding the (HNR) in Abelton the tool Noisy was used . This tool will enter noise in the harmonic structure of the signal, and experimental the (HNR) measured . The choices where 20 dB so the signal has 100 times the power of the

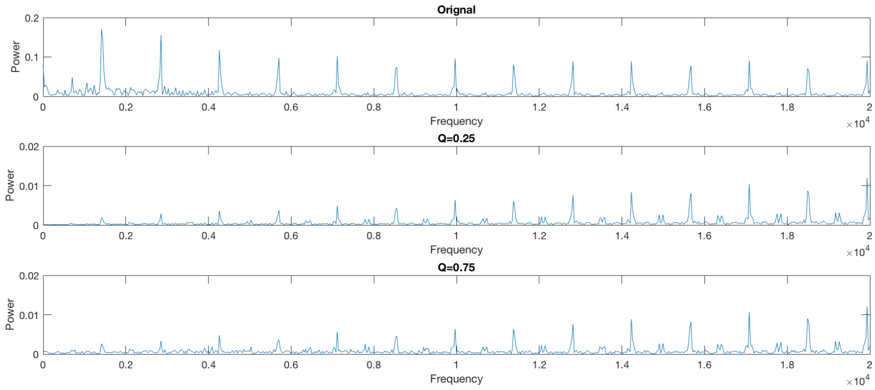

Figure 4.8: Arrival 3 band-pass filtered

noise, also 30 dB the main signal has 1000 times the power of the noise which it is barely noticeable. As can be seen in figure [4.9]

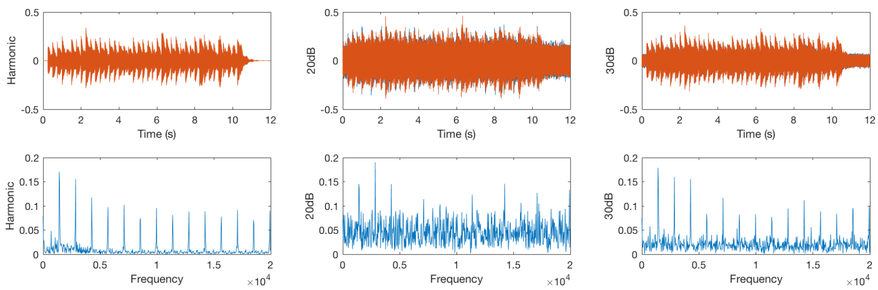

Figure 4.9: Arrival 3 harmonic noise original , 20 dB , 30 dB

Chapter 5

Experiment

5.1 The case of the study

The train station in Japan use abstract alarms as musical jingles. This method got a global attention in past years as it is something not commonly used in Western Couturiers. The melodies that are used as alarm in Japanese train station have the ability to convoy multiple information such as the train arrival and departure. The variations of musical features in the alarms can imply number of messages. The alarm melodies can alert without startling the passengers. As well as these alarms designed acoustically to be distinguished in the train station environment in which it may contain the noises made the trains and the passengers [44].

The alarms in Japanese train stations have many versions, where different regions or train lines use different melodies. As well occasional alarms based on a ceremonial season or a advertising to a certain event as a sort of sound marketing and branding [49].

The phenomena of train station melodies is a interesting case to study and to dissect. Where these jingles have unique musical and acoustical features as explicated by the jingles composer Minoru Mukaiya [49]. The choice of melody itself, the timbre, the musical mode, the musical intervals , the rhythmic patterns, and overall the morphology of jingle are elements can affect the perception of the jingle message [8].

5.2 Method

An experiment were set up , in which included a questionnaire and listening test. The experiment focused on the learnability and preferences aspects and the role of the music features , the musical training and cultural background.

The questionnaire was made possible online by **SoSci Survey** [50] , which allows to use audio files and different types of questions such as multiple choices, pairwise selection and demographic questions. The advantages of using an online questionnaire are it is easy to design , reliable to store the data , as well as the possibility to use it globally in different parts of the world (mainly East Asia, Europe , and United States).

The experiment is employed to provide an evidence to the hypothesis that the abstract melodic alarms can have an efficient ability of learning and recognition . As well as that the musical and acoustical features in composition of these alarms can affect the meanings and preferences . The stimuli were composed to test the learnability regarding the meanings and pairwise sets to measure preferences between the musical and acoustic features. The tests take in considerations the musical training and the prior experience of the melodic type of alarms.

5.2.1 Procedure

The questionnaire started with welcome page, in which it explains the sections and tasks of the experiment. As well as assure that the collected date will be treated anonymously according to SoSci Survey policy [50]. later the participants will asked to check if latest version Flesh installed into the web browser on their computer, and adjust the volume on the headphones to the provided audio test sample.

The participants randomly assigned to two groups. One group included a training section and the other were tasted without a prior training. The groups had different questionnaires which is a feature in SoSci Survey that can be randomly alternating . Both of questionnaires included the Learnability section , the Preferences section and the Demographic section. The questionnaire that includes training section is shown in the Appendix A .

Training section

In this section the participants get familiarized with the original alarms from Osaka train stations and the labels (meanings) to each melody as arrival , departure and halfway (or information). The participants had the chance to listen to the audio samples as much is needed .

Followed by by a test to check the participants ability to recognize the labels of each alarm . The set of stimuli were divided into two pages ; the original Osaka melodies and the composed melodies. The participants had to choose what is the label for the sound they hear. As a feedback the score of the correct answers was summed and shown in the last page of the training section to show the participants how many labels/melody they could identify.

Learnability section

This section was designed to test the participants ability to identify the label for each sound.

The number of stimuli are 24 , where are they divided into 3 pages. The stimuli are generated of the original alarm composition into 10 variation of the arrival melody to cover all the alternative versions that cover the musical and acoustical features. The rest of melodies that represent the departure and halfway were extracted by the SuperCollider and proceed by Abelton as shown in chapter [4.2].

The participants asked to choose between the three labels (Arrival Departure, Halfway) after listening to randomly distributed stimuli - with recording the latency of their answers-, followed by question about their degree of confidence about their answers and to show it on a 5 point slider from (unsure to sure). Later the participants were asked few question about the experience with melodic alarms in general and especially in train stations and if they had a prior experience with such alarms. Finally a question concerning about if participates can figure the differences and similarities between the stimuli.

Preferences section

This section was set up to measure the participants feedback on pairwise test , where they have to choose between two stimuli of the same label based only on their their preferences which can represent the label best among two. The pairs were 24 pairs divided into 4 pages.

The pair of randomly distributed stimuli are set up to test musical and acoustical features with recording the latency of the participants answers. As the previous section the melodies were the variations on the arrival melodies , where the departure and halfway that were extracted by the SuperCollider program. The pair were chosen in two sets to test one feature in which one of the pair includes a case of minimum alteration in the feature , where the second pair has an extreme example of feature differences between the stimuli pair. For example according to the musical intervals; in first pair the intervals were transposed to have a major second (2 semitones) between each other, as for the second pair transposed to a perfect 4th (5 semitones). Moreover for the acoustical features such as Harmonic Noise Ratio (HNR) , the first pair is comparison between the original sound and same sound with (HNR) ratio equals to 30 dB, on other hand the the (HNR) ratio of 20 dB, where it is easier to notice the harmonic noise content.

Later on the participants were asked a question about their was their experience in this section of tasks and what are that the reasons that might influenced their choices.

Demographic information and music experience section

This section is intended to collect the information about the participants age , gender , nationality , the past countries of residence and the current country of residence . These information will be considered as factor to study , since the participants from Japan or lived in Japan they have a prior experience with melodic alarm in the train stations.

The question about musical experience and background. The questions start with if they are musicians, how many years they practiced , and their knowledge in music theory.

Finally as optional question to assess the musical sophistication of the participants. Considering the Ollen Musical Sophistication Index (OMSI) . As it was recommend in the question with the affiliated link [33]. The music practice is very important factor in the experiment . Since the trained musicians with sufficient music theory experience could figure the differences between the stimuli and it can affect in the learnability and preferences tests.

As a last question in the questionnaire the participants were ask to write their suggestions for a better design for alarms in train station and an overall comment on their experience responding to the experiment.

5.2.2 Stimuli

All of the composed and acoustically processed arrival melody and its variations , and their affiliated the generated and processed departure halfway melodies ,were used in the experiment . The total of 33 stimuli .

Here a description of the stimuli used in the three sections.

Training section

First set of stimuli were the 3 original Osaka melodies where they can listen as much it is needed.

Later set for training test 1 used the 3 original Osaka melodies in 5 rows the stimuli and the selections were randomized . In training test 2 used the composed 3 melodies (arrival 1, departure 1 , halfway 1) also as well as the test 1 were randomized .

Learnability section

The melodies in use were only the ones that were the arrival variations (excluding the original composed) and the acoustically processed , and generated and processed departure halfway melodies. In total were 30 stimuli that cover the features of musical intervals, rhythm , harmony , musical mode and key , harmonic noise ratio , and spectral centroid.

Since the test here about selection of right label. The stimuli of the same feature were in one question , yet randomly distributed .

Preferences section

The stimuli in use in the section were ss in the previous test the same 30 stimuli but added the 3 composed melodies .

This test is about the preferences, so the stimuli were set up in a pair . The musical and acoustical features were tested in comparison with the composed melodies . The pairs were set up in two levels of feature. It included test one feature with original composed which is somehow less noticeable , and the other pair of the same feature was more extreme modification which can be more noticeable . For example in the intervals first pair had as change of 1 semitone , and other pair has a change of 5 semitones . So on in the way fashion with the other features.

5.2.3 Participants

As mentioned in Procedure section 5.2.1 , the participants were asked to take part in the online questionnaire via SosSciSurvey. The questionnaire was open through 7 days.

The number of the participants 44 , divided in 17 male and 27 female , with nationality from (United Kingdom, Denmark, Iceland, Finland, Estonia, Germany, France, Switzerland, Romania, Slovakia, United States, Japan, Australia, Brazil , Argentina) only 10 of them was (Born/Lived/Currently living) in Japan.

15 participants showed high level of music training and music sophistication's (OMSI) [33] index of 500+ (OMSI).

As for the type of questionnaire 29 participants the test with training section , and 15 did the questionnaire without training.

5.3 Analysis & interpretation of the results

In the section will include a walk through the collected Quantitative data from the experiment , the handling and processing of the data , the use the statistical indexes , and descriptive graphs. As well as form the participants qualitative data. The most poignant and most representative quotes will be selected and will be issued. The full version of the data will added as an excel file in attachment.

5.3.1 Quantitative Data

Training Test

Before the training test the precipitant had the chance to be familiarized of the melodies and the labels , later a training test set up to see if the participants has to choose between 3 selections labels that represented the melody they hear as feedback to the result of correct answers where provide.

The selection data variable in the way the first choice as value 1 and second choice as 2 , and third choice as 3.

29 precipitants took this test, only 14 of them get all the answers right. 5 are related to Japan , 12 were highly musical trained , and 4 were related to Japan and musically trained. as shown in the figure [5.1] The average latency for each question is 28174 msec.

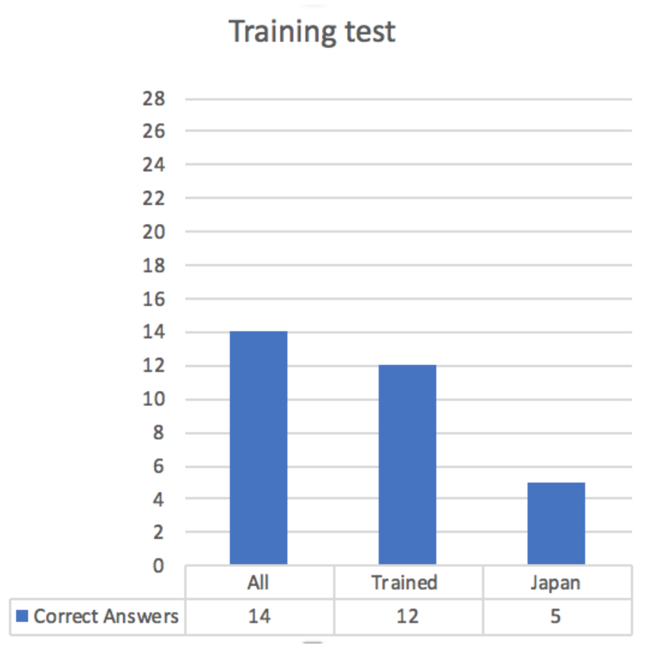

Figure 5.1: Training test results.

A Chi-square test used in this test by assuming that results are normally distributed . So with 2 degree of freedom for all groups , the chi-square statistic is 2.717. The P-value is 0.25701504. where the cutoff the significance level a is 0.05.

Hence, the p-value was greater than the error level, this concludes that participants had no statistically significant different choices.

It can be interpreted from the results of correct answers numbers that the musically trained and japan subjects were more accurate in their answers among their group, since the the alarms prior experience and ear training helped in distinguishing the labels, yet this not significant difference

Learnability Test

In the this test the participants spited into two groups of questionnaires (Which training section, with out training section) . 29 in the training questionnaire and 15 in no-training questionnaire.

The questions where to choose between the labels that represent the melody. In this test musical and acoustical features were tested . The result shown in the figure [5.2]

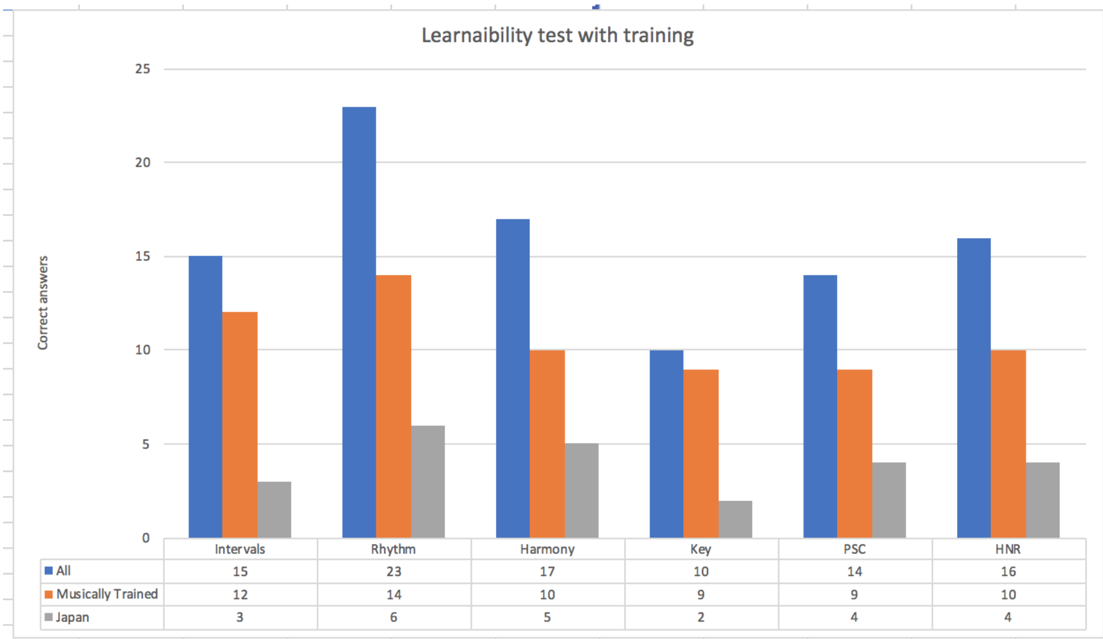

Figure 5.2: Learnability test with training results.

To test the significance of the results, a Chi-square test used The alpha (level of error) is 0.05 and H0 (the null hypothesis) was that there were no differences between samples. with 5 as degree of freedom. The test for the three groups . chi-square statistic is 5.6578. The P-value is 0.6588278. In considerations that the cutoff the level is 0.05 .

The p-value was more than the error level, so there is no statistically significant difference on the choices in regards of features.

By observing the figure [5.2] , it shows the rhythmic feature is most helpful in recognizing the label , on other hand the Key was the less to figure.

Moving to the second group of questionnaires without training , the results are shown in the figure [5.3]

By adapting a Chi-square test to see if the data has a normally distribution . So with 5 degree of freedom for the groups of musically trained and Japan, and overall, the chi-square statistic is 3.542. The P-value is 0.43837468. In considerations that the cutoff the level is 0.05 .

The p-value is larger than the a , implies that it is not statistically significant difference on the choices in regards of features.

	Intervals	Rhythm	Harmony	Key	PSC	HNR
All	6	10	8	6	8	9
Musically Trained	5	6	6	5	5	5
Japan	2	3	1	1	1	2

Figure 5.3: Learnability test without training results.

As well as in the [5.3] , it seems that rhythmic feature is more effective in recognizing the label , and the key changes was confusing to differentiate between labels.

Considering the Training section as factor , the observation of the mean number of right answer in both questionnaires types. The mean of correct answers per participants in questionnaire with training 3.2759 on other hand the mean of correct answers per participants in questionnaire without training 3.133 . The compression is not showing a substantial effect of the training .

As for recorded average latency for each question is 32245 msec.

Preferences Test

In this test the data set up in pair wise where choice A has the value 1 and B and the value 2.

The choices of A and B were set up to test two melody of the dame label (which is given), The melodies are the original composed or melodies with the versions of it that melodies that had one of the feature alternated .

Data collected as the number of the choices one over the other , and later a Binomial Test [9] used to check the if there is a significant preference between the two or they have partial preference. considering the 95 percent degree of confidence.

The Binomial Test tool [9] showed that the overall participants result indicates to a significant difference in preference . By observing the the table [5.4] it is clearly that the majority preferred the original over the modified.

All	Intervals	Rhythm	Harmony	Key	PSC	HNR
Original	33	29	38	39	34	36
modified	11	15	6	5	10	8
M trained	**Intervals**	**Rhythm**	**Harmony**	**Key**	**PSC**	**HNR**
Original	8	7	10	10	9	11
modified	7	8	5	5	6	4
Japan	**Intervals**	**Rhythm**	**Harmony**	**Key**	**PSC**	**HNR**
Original	9	5	8	8	7	8
modified	1	5	2	2	3	2

Figure 5.4: The number of choice between the melodies in groups : overall, musically trained , japan related .

On other hand the participants with high music training and the ones (born/lived/living) in Japan, the Binomial Test hat there is not a significant difference in preference and that they achieve parity. The implication for it that musically trained participates enjoined the an adventurous design , and Japan participates looked for maybe new sounds since they have long experience with it.

5.3.2 Qualitative Data

The qualitative data collected during the experiment which had positive and negative comments, as well as in depth feedback.

Confidence, confusion, experience

Majority of participants did not find the experiment confusing but slightly tedious. Some participants said that experience was interesting to use multiple strategies especially in the learnability test. Even though the majority chose uncertainty on the confidence scale in the end of the learnability test. As for the prior experience of those types of alarms only mentioned that had been experienced in Japan , as well as in Paris, France.

The elements in the experiment

In this question the participants asked to explain the elements that make the different from each other. Only few participants could figure every aspect in the musical composition and acoustical modifications , it showed that they had a long experience with music theory and music production.

Future recommendations

The suggestions were around the nature of the sound and the composition.

For example some asked to use animal and nature sounds, or a realistic piano, or even different instrument with different timbre for different messages .

Musically the recommendations for a shorter and soft rising tone for departure melody, and a more strident, even alarming descending tone, to advise people of arriving trains. A constant melody to mark the halfway point of a jump between stations that can catch people attention. Additionally, to find more distinction between qualities of chords/cadences for arrival/departure for example to resolve on major 7th chord in the end of arrival

5.3.3 Experiment evaluation

The study and experiment included many aspects which are relevant for the design yet it considered as overkill and not in main scope of the research.

The experiment lacked in the variety of the demographics and number of subjects.

The experiment considerably long and tedious , since the long exposures to repetitive melody can create hearing fatigue, which can influence the results. A pause between the section of the test could enhance the experience.

The questionnaire had few the technical difficulties with server of SoSciSurvey such as the page can get stocked will pressing next . Some participants used mobile devices to run the experiment even thou it was recommended to use only computers which had issues when they had to open the page of music sophistication and go back they lose the link of the survey.

As for handling of such amount of data was overwhelming , so the analysis were simplified.

Chapter 6

Conclusion

This project was a continuation on my previous project [41] that suggested the melodic alarm as mean of alarm in contrast with iconic alarms.

Thus , this project is a more in depth attempt to design a melodic alarm for train stations. The design focused on the aspects of learnability and preferences. As well as the design considered the musical and acoustical features in the alarm. Additionally, a implementation of a tool to create melodies out a certain theme.

An experiment was set up to analysis the elements and the features of the composed alarms , to monitor the affects on learnability and preference.

The results did not justify to demonstrate any signified effect on the learnability test with changes in the features, but suggested that the rhythmic pattern can be a clear indication. As for preference aspect of the experiment as well did not come with statistically significant preferred feature . Yet it showed that experience with type alarms and musical training can open the way for more experimentation with melodies and modifications.

6.1 Prospective and future work

One of the goals is to refine the SuperCollider music generating tool , in sense to have less data distortion by change the music data formats . Also to have more control on other acoustical feature of the sound .

One aspect for future goal is to include the interactivity in the project, in which the responses can be handled in real time. This characteristic will need the use of a physical implementation which be can tasted in the train's stations.

AS well as include physiological and psychological monitoring of the participants response in the experiment , which will include wearable sensors, were the results can be more honest and less biased .

Acknowledgement

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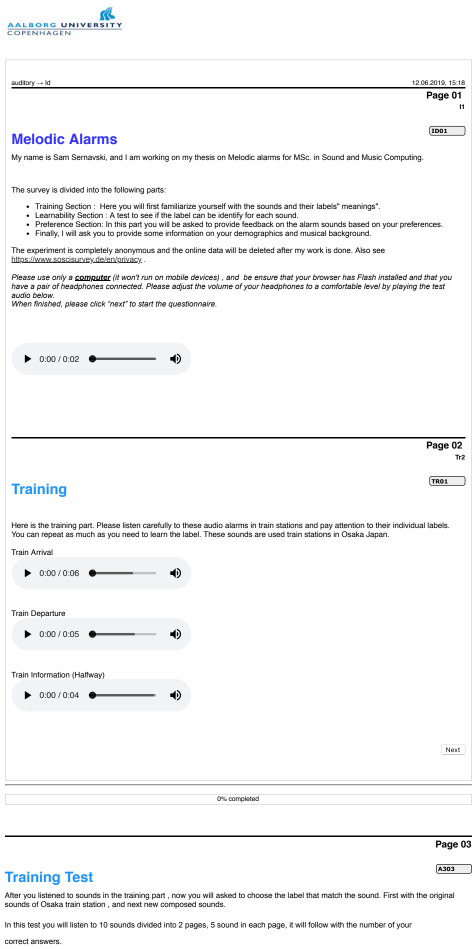
Appendix A

Questionnaire


AALBORG UNIVERSITY COPENHAGEN

auditory → Id 12.06.2019, 15:18

Page 01
I1

ID01

Melodic Alarms

My name is Sam Sernavski, and I am working on my thesis on Melodic alarms for MSc. in Sound and Music Computing.

The survey is divided into the following parts:

- Training Section : Here you will first familiarize yourself with the sounds and their labels" meanings".
- Learnability Section : A test to see if the label can be identify for each sound.
- Preference Section: In this part you will be asked to provide feedback on the alarm sounds based on your preferences.
- Finally, I will ask you to provide some information on your demographics and musical background.

The experiment is completely anonymous and the online data will be deleted after my work is done. Also see https://www.soscisurvey.de/en/privacy .

*Please use only a **computer** (it won't run on mobile devices) , and be ensure that your browser has Flash installed and that you have a pair of headphones connected. Please adjust the volume of your headphones to a comfortable level by playing the test audio below.*
When finished, please click "next" to start the questionnaire.

0:00 / 0:02

Page 02
Tr2

TR01

Training

Here is the training part. Please listen carefully to these audio alarms in train stations and pay attention to their individual labels. You can repeat as much as you need to learn the label. These sounds are used train stations in Osaka Japan.

Train Arrival
0:00 / 0:06

Train Departure
0:00 / 0:05

Train Information (Halfway)
0:00 / 0:04

Next

0% completed

Page 03

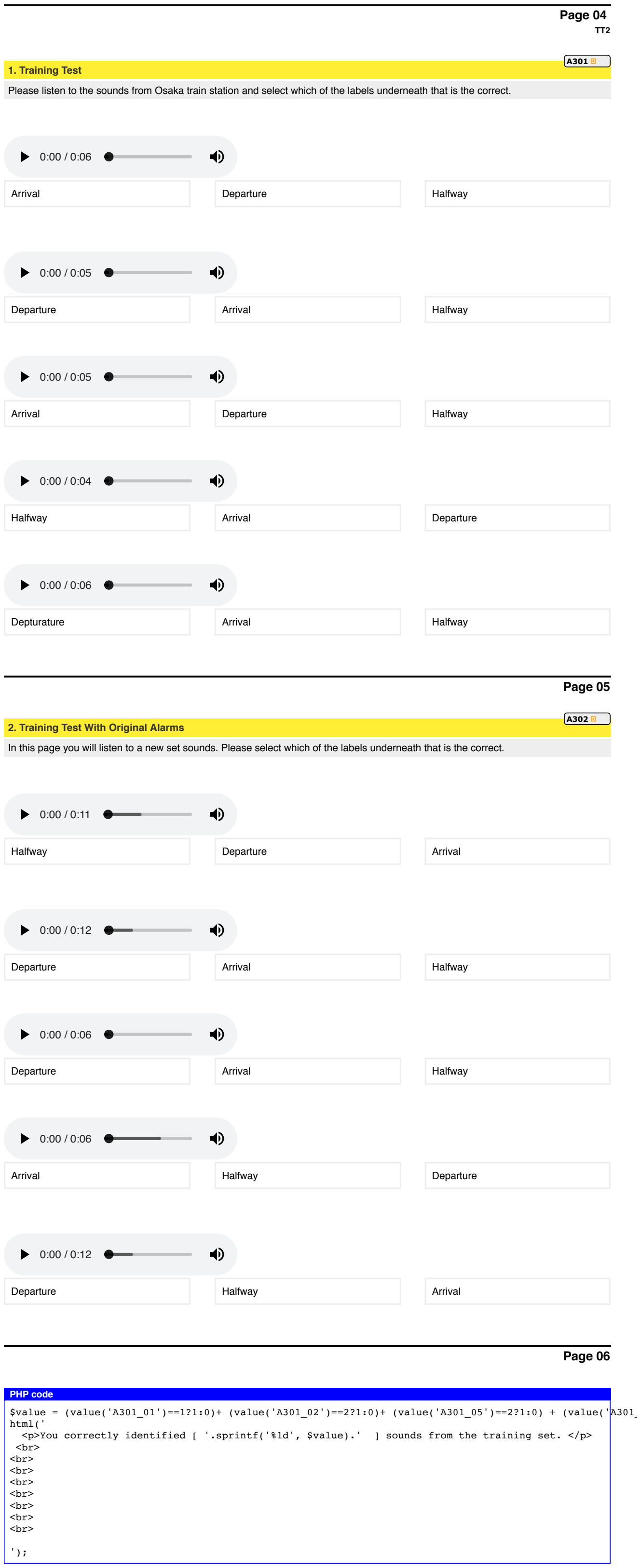
A303

Training Test

After you listened to sounds in the training part , now you will asked to choose the label that match the sound. First with the original sounds of Osaka train station , and next new composed sounds.

In this test you will listen to 10 sounds divided into 2 pages, 5 sound in each page, it will follow with the number of your correct answers.

Figure A.1: Page 1 from the questionnaire



Page 04
TT2

A301

1. Training Test

Please listen to the sounds from Osaka train station and select which of the labels underneath that is the correct.

0:00 / 0:06

Arrival	Departure	Halfway

0:00 / 0:05

Departure	Arrival	Halfway

0:00 / 0:05

Arrival	Departure	Halfway

0:00 / 0:04

Halfway	Arrival	Departure

0:00 / 0:06

Depturature	Arrival	Halfway

Page 05

A302

2. Training Test With Original Alarms

In this page you will listen to a new set sounds. Please select which of the labels underneath that is the correct.

0:00 / 0:11

Halfway	Departure	Arrival

0:00 / 0:12

Departure	Arrival	Halfway

0:00 / 0:06

Departure	Arrival	Halfway

0:00 / 0:06

Arrival	Halfway	Departure

0:00 / 0:12

Departure	Halfway	Arrival

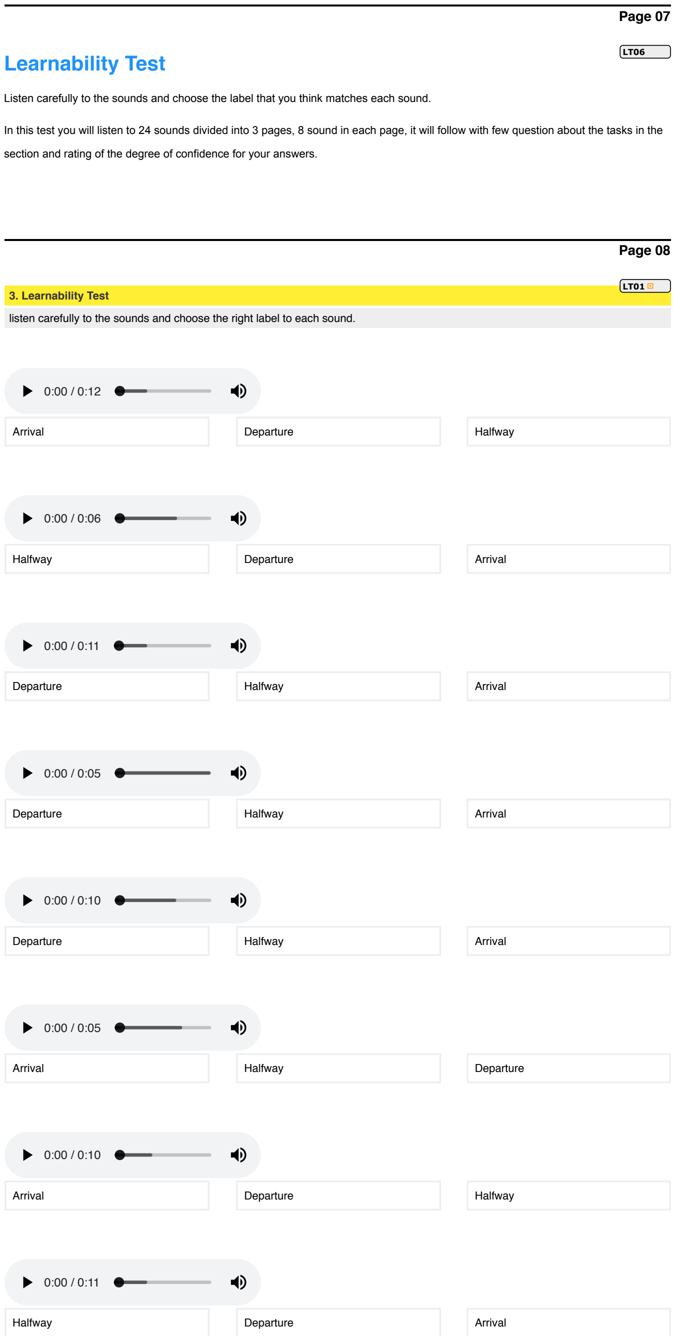
Page 06

PHP code

```
$value = (value('A301_01')==1?1:0)+ (value('A301_02')==2?1:0)+ (value('A301_05')==2?1:0) + (value('A301_
html('
  <p>You correctly identified [ '.sprintf('%1d', $value).'  ] sounds from the training set. </p>
 <br>
<br>
<br>
<br>
<br>
<br>
<br>
<br>

');
```

Figure A.2: Page 2 from the questionnaire



Page 07

LT06

Learnability Test

Listen carefully to the sounds and choose the label that you think matches each sound.

In this test you will listen to 24 sounds divided into 3 pages, 8 sound in each page, it will follow with few question about the tasks in the section and rating of the degree of confidence for your answers.

Page 08

LT01

3. Learnability Test

listen carefully to the sounds and choose the right label to each sound.

0:00 / 0:12

Arrival	Departure	Halfway

0:00 / 0:06

Halfway	Departure	Arrival

0:00 / 0:11

Departure	Halfway	Arrival

0:00 / 0:05

Departure	Halfway	Arrival

0:00 / 0:10

Departure	Halfway	Arrival

0:00 / 0:05

Arrival	Halfway	Departure

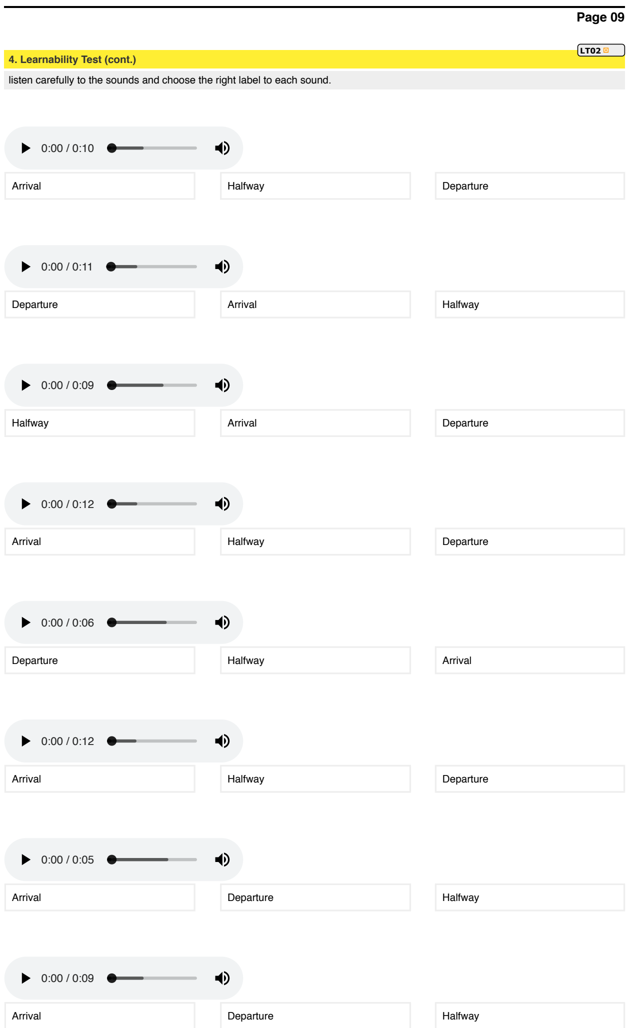
0:00 / 0:10

Arrival	Departure	Halfway

0:00 / 0:11

Halfway	Departure	Arrival

Figure A.3: Page 3 from the questionnaire



Page 09

LT02

4. Learnability Test (cont.)

listen carefully to the sounds and choose the right label to each sound.

0:00 / 0:10

Arrival | Halfway | Departure

0:00 / 0:11

Departure | Arrival | Halfway

0:00 / 0:09

Halfway | Arrival | Departure

0:00 / 0:12

Arrival | Halfway | Departure

0:00 / 0:06

Departure | Halfway | Arrival

0:00 / 0:12

Arrival | Halfway | Departure

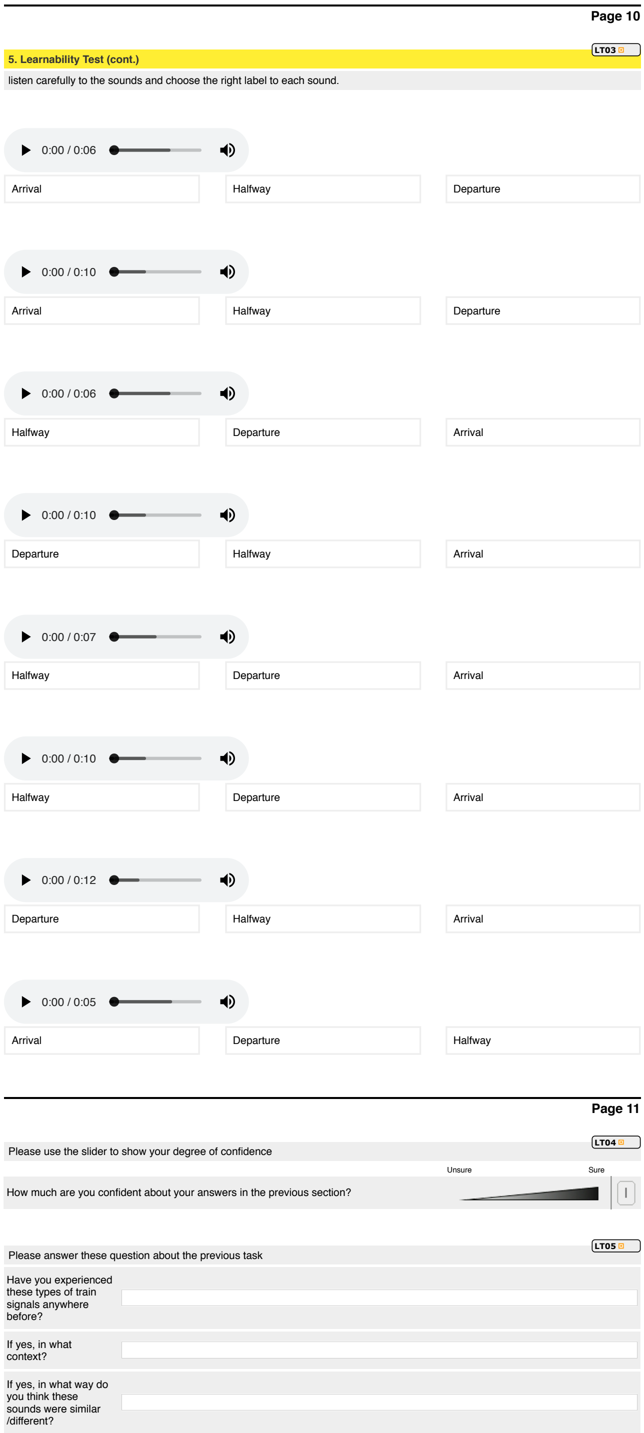
0:00 / 0:05

Arrival | Departure | Halfway

0:00 / 0:09

Arrival | Departure | Halfway

Figure A.4: Page 4 from the questionnaire



Page 10

LT03

5. Learnability Test (cont.)

listen carefully to the sounds and choose the right label to each sound.

0:00 / 0:06

Arrival	Halfway	Departure

0:00 / 0:10

Arrival	Halfway	Departure

0:00 / 0:06

Halfway	Departure	Arrival

0:00 / 0:10

Departure	Halfway	Arrival

0:00 / 0:07

Halfway	Departure	Arrival

0:00 / 0:10

Halfway	Departure	Arrival

0:00 / 0:12

Departure	Halfway	Arrival

0:00 / 0:05

Arrival	Departure	Halfway

Page 11

LT04

Please use the slider to show your degree of confidence

Unsure Sure

How much are you confident about your answers in the previous section?

LT05

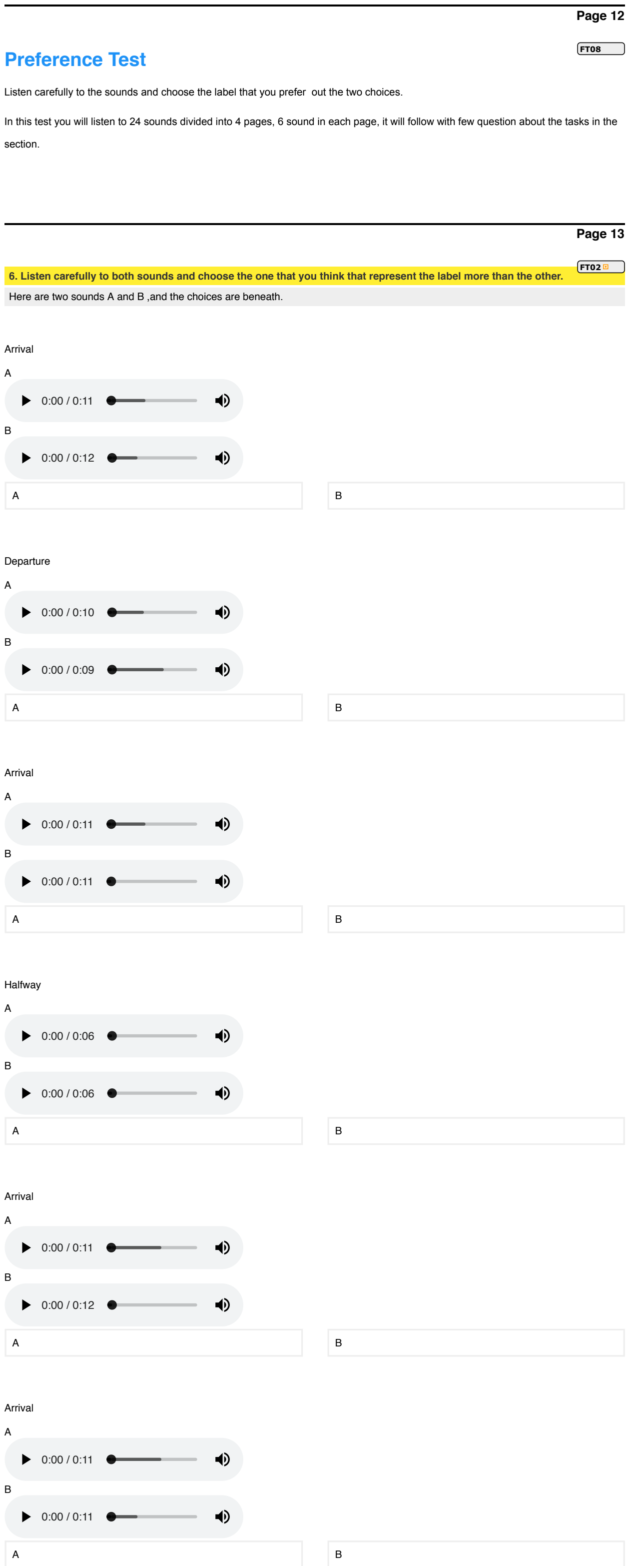
Please answer these question about the previous task

Have you experienced these types of train signals anywhere before?

If yes, in what context?

If yes, in what way do you think these sounds were similar /different?

Figure A.5: Page 5 from the questionnaire



Page 12

FT08

Preference Test

Listen carefully to the sounds and choose the label that you prefer out the two choices.

In this test you will listen to 24 sounds divided into 4 pages, 6 sound in each page, it will follow with few question about the tasks in the section.

Page 13

FT02

6. Listen carefully to both sounds and choose the one that you think that represent the label more than the other.

Here are two sounds A and B ,and the choices are beneath.

Arrival

A

0:00 / 0:11

B

0:00 / 0:12

A B

Departure

A

0:00 / 0:10

B

0:00 / 0:09

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:11

A B

Halfway

A

0:00 / 0:06

B

0:00 / 0:06

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:12

A B

Arrival

A

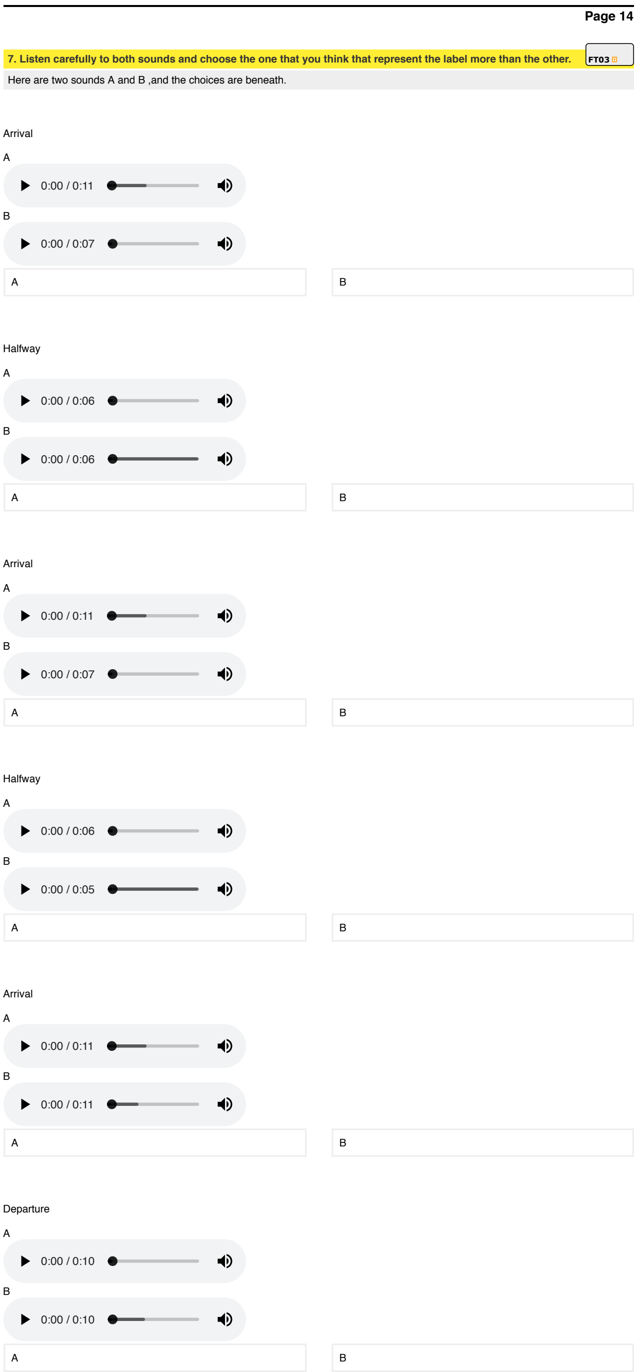
0:00 / 0:11

B

0:00 / 0:11

A B

Figure A.6: Page 6 from the questionnaire


Page 14

7. Listen carefully to both sounds and choose the one that you think that represent the label more than the other. FT03

Here are two sounds A and B ,and the choices are beneath.

Arrival

A

0:00 / 0:11

B

0:00 / 0:07

A B

Halfway

A

0:00 / 0:06

B

0:00 / 0:06

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:07

A B

Halfway

A

0:00 / 0:06

B

0:00 / 0:05

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:11

A B

Departure

A

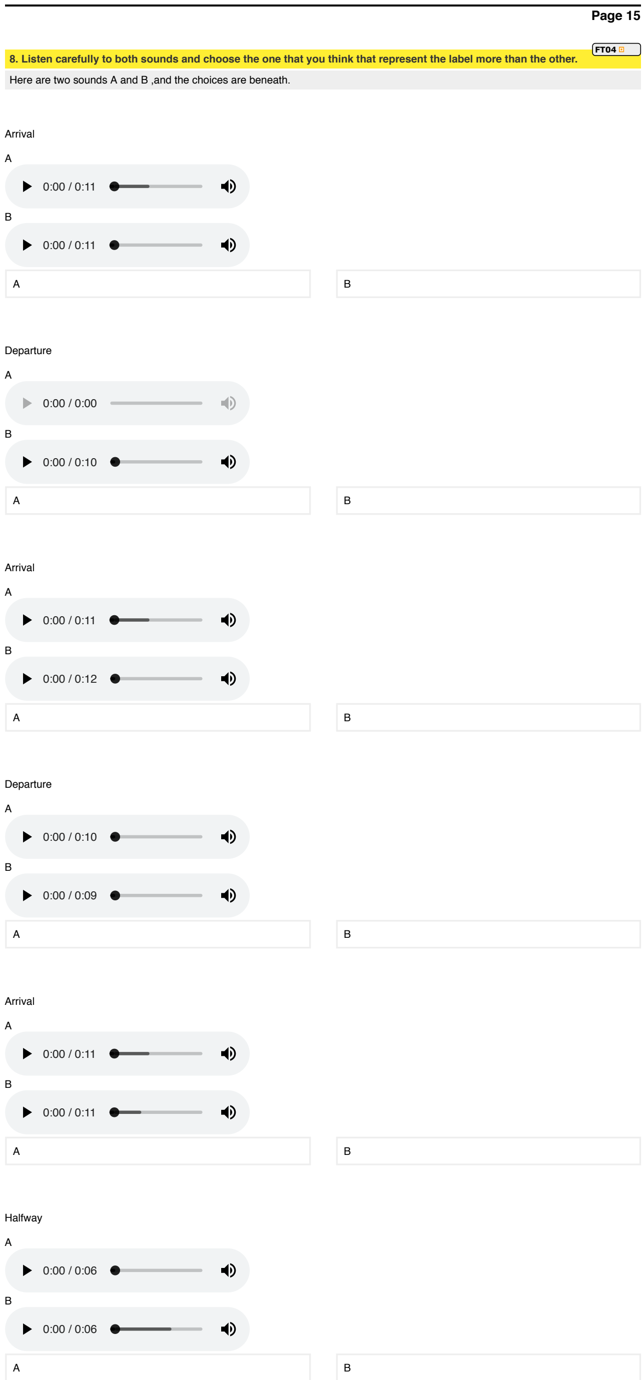
0:00 / 0:10

B

0:00 / 0:10

A B

Figure A.7: Page 7 from the questionnaire



Page 15

FT04

8. Listen carefully to both sounds and choose the one that you think that represent the label more than the other.

Here are two sounds A and B ,and the choices are beneath.

Arrival

A

0:00 / 0:11

B

0:00 / 0:11

A B

Departure

A

0:00 / 0:00

B

0:00 / 0:10

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:12

A B

Departure

A

0:00 / 0:10

B

0:00 / 0:09

A B

Arrival

A

0:00 / 0:11

B

0:00 / 0:11

A B

Halfway

A

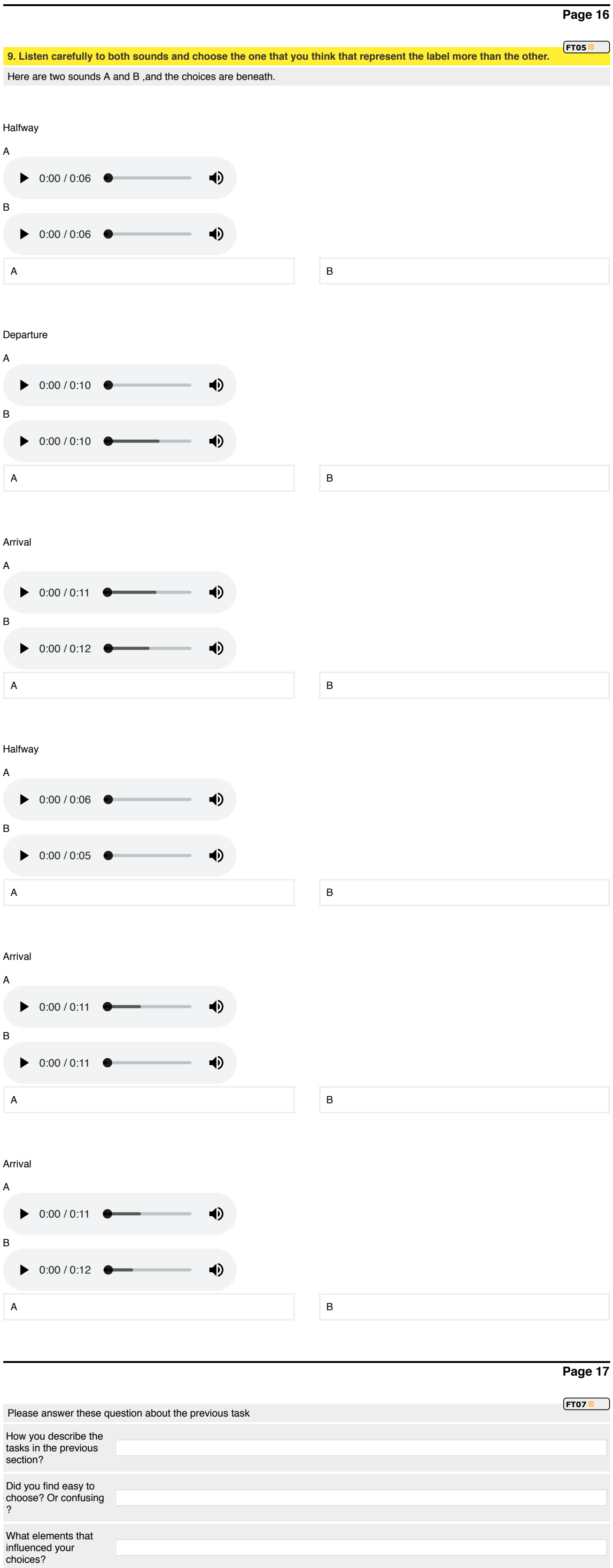
0:00 / 0:06

B

0:00 / 0:06

A B

Figure A.8: Page 8 from the questionnaire



Page 16

FT05

9. Listen carefully to both sounds and choose the one that you think that represent the label more than the other.

Here are two sounds A and B ,and the choices are beneath.

Halfway

A

0:00 / 0:06

B

0:00 / 0:06

A | B

Departure

A

0:00 / 0:10

B

0:00 / 0:10

A | B

Arrival

A

0:00 / 0:11

B

0:00 / 0:12

A | B

Halfway

A

0:00 / 0:06

B

0:00 / 0:05

A | B

Arrival

A

0:00 / 0:11

B

0:00 / 0:11

A | B

Arrival

A

0:00 / 0:11

B

0:00 / 0:12

A | B

Page 17

FT07

Please answer these question about the previous task

How you describe the tasks in the previous section?

Did you find easy to choose? Or confusing ?

What elements that influenced your choices?

Figure A.9: Page 9 from the questionnaire

Page 18

DM04

Demographic and musical experience information

Here are few question about your age , gender , nationality and current residency . Followed question about music experience and music sophistication.

Page 19

DM01

Demographic information and music experience

Please answer these question about the previous task

How old are you, and what is your gender?	
What is your nationality?	
Which country that you spent the formative years of your childhood and youth?	
Where is current country residency	

DM02

Are you a musician? Please specify.	
How many years of music practice do you have?	
How do you describe your knowledge in music theory?	
Please log to the following link , and write your score of Ollen Musical Sophistication Index , Click here .	

Page 20

DM03

10. Future Development

Please , write inside the balloon, what you would like to have in train alarm sounds ?

Last Page

Thank you for completing this questionnaire!

We would like to thank you very much for helping us.

Your answers were transmitted, you may close the browser window or tab now.

Figure A.10: Page 10 from the questionnaire

Appendix B

Score and musical features of Osaka train station jingles

B.1 Departure of Osaka Train station

Figure B.1: Score of the departure of Osaka Train station in D major.

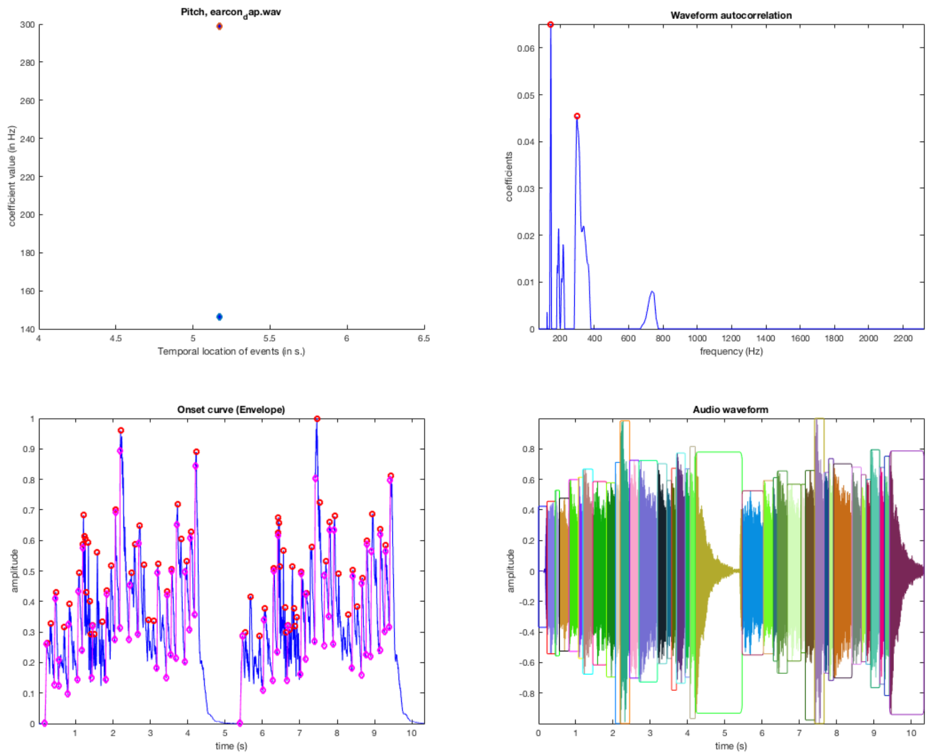


Figure B.2: Musical features of the departure of Osaka Train station (1).

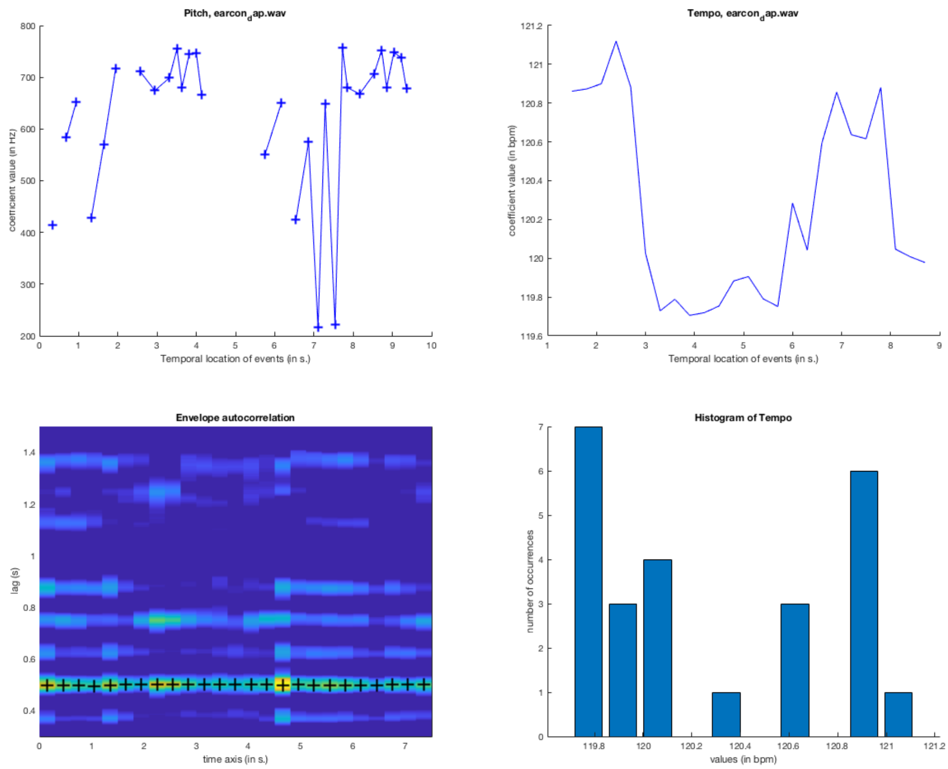


Figure B.3: Musical features of the departure of Osaka Train station (2).

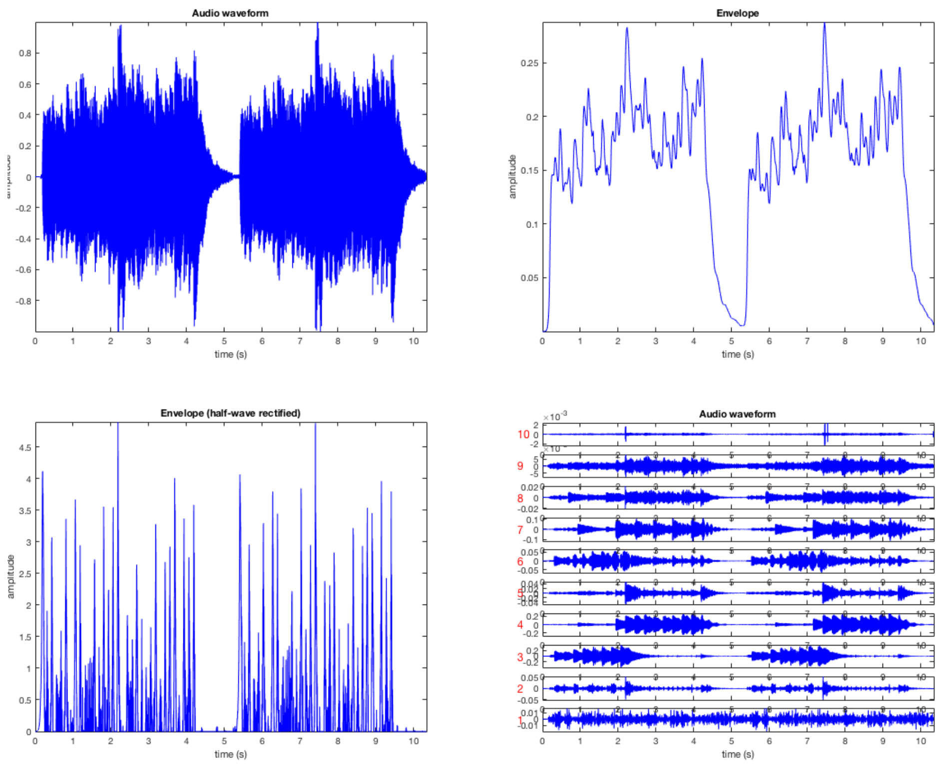


Figure B.4: Musical features of the departure of Osaka Train station (3).

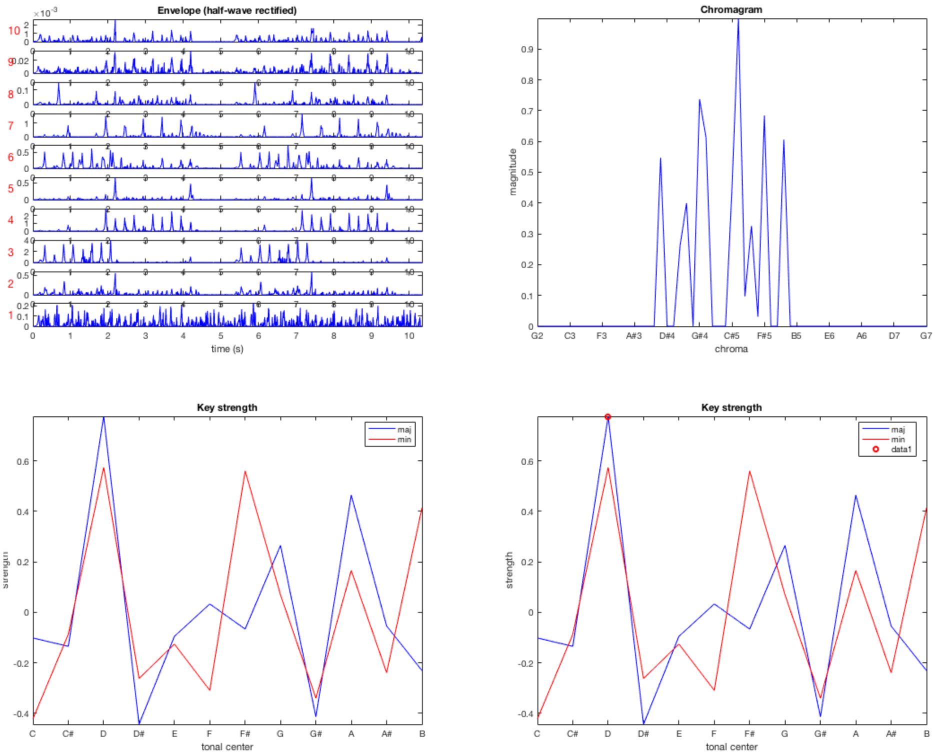


Figure B.5: Musical features of the departure of Osaka Train station (4).

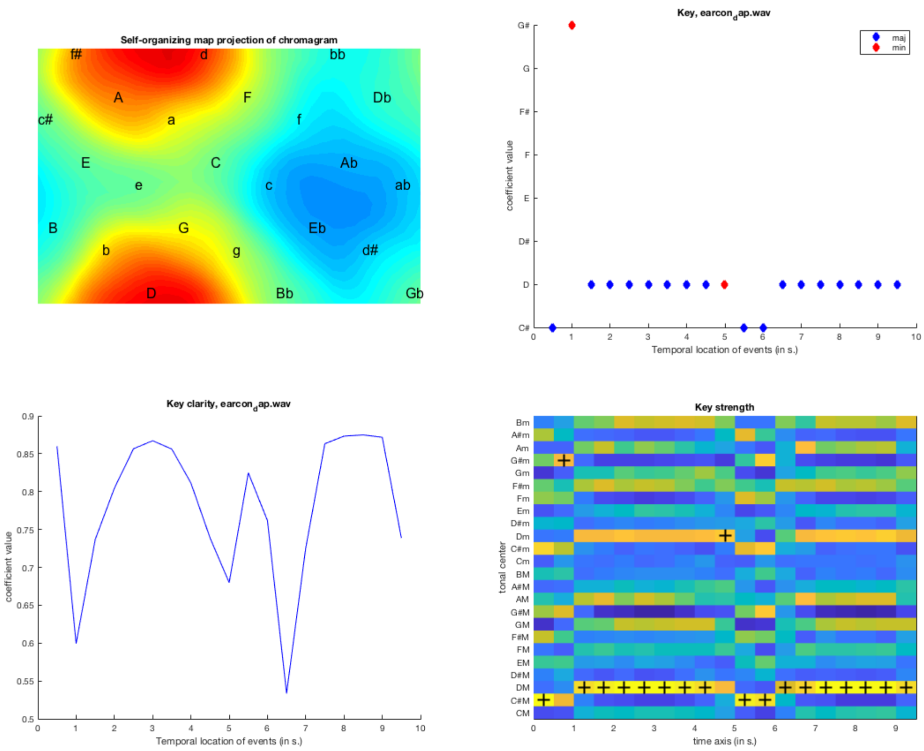


Figure B.6: Musical features of the departure of Osaka Train station (5).

B.2 Halfway of Osaka Train station

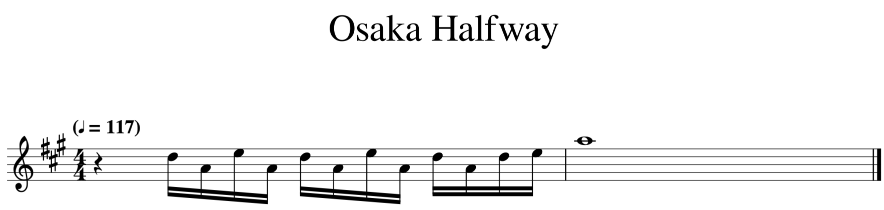


Figure B.7: Score of the Halfway of Osaka Train station in D minor.

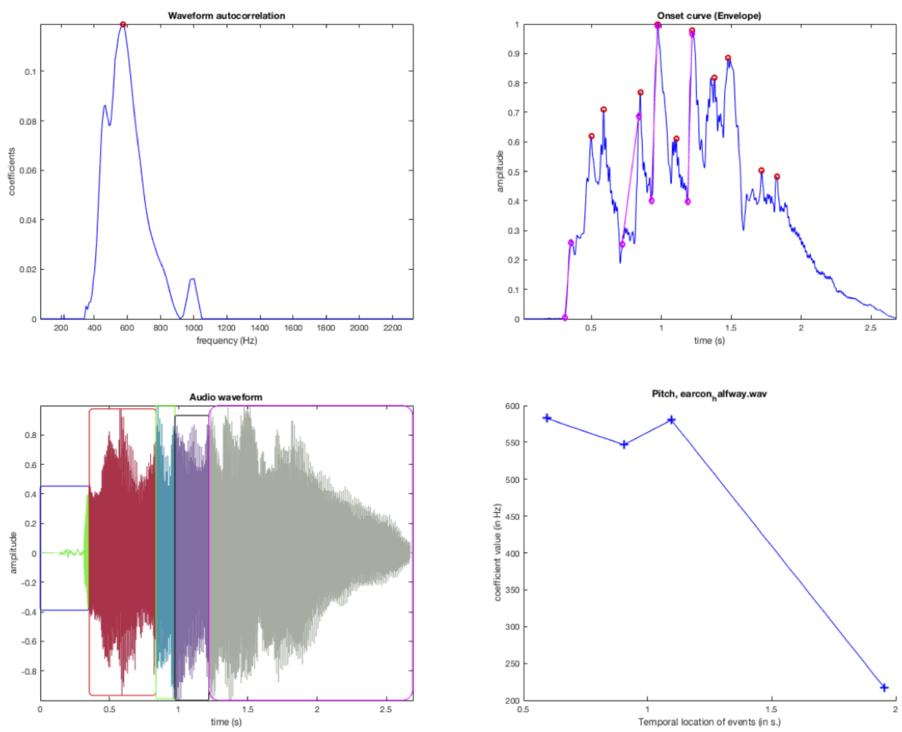


Figure B.8: Musical features of the halfway of Osaka Train station (1).

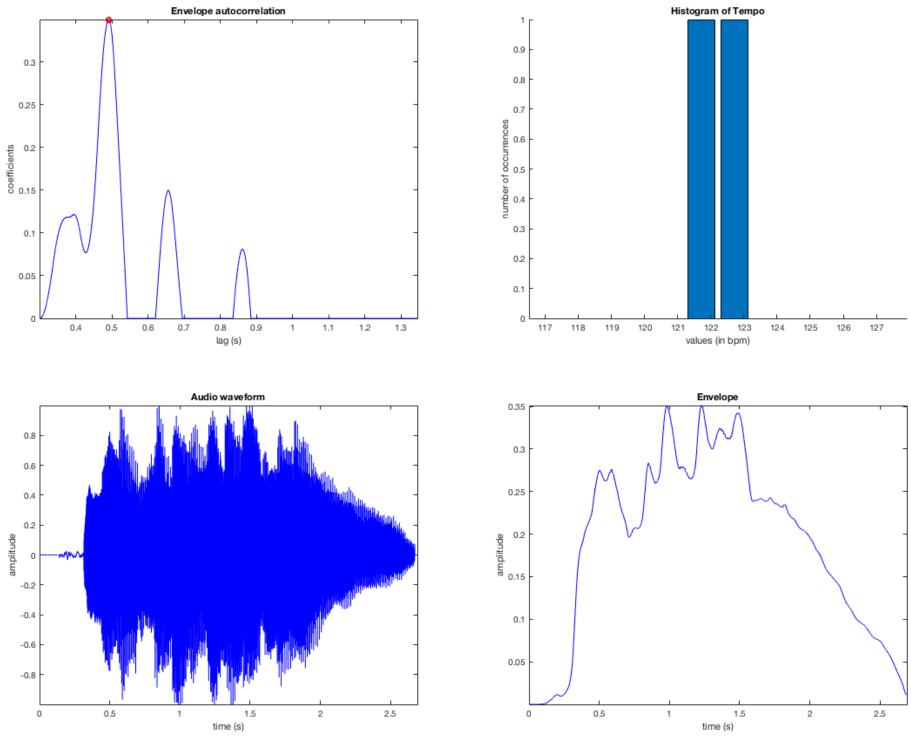


Figure B.9: Musical features of the halfway of Osaka Train station (2).

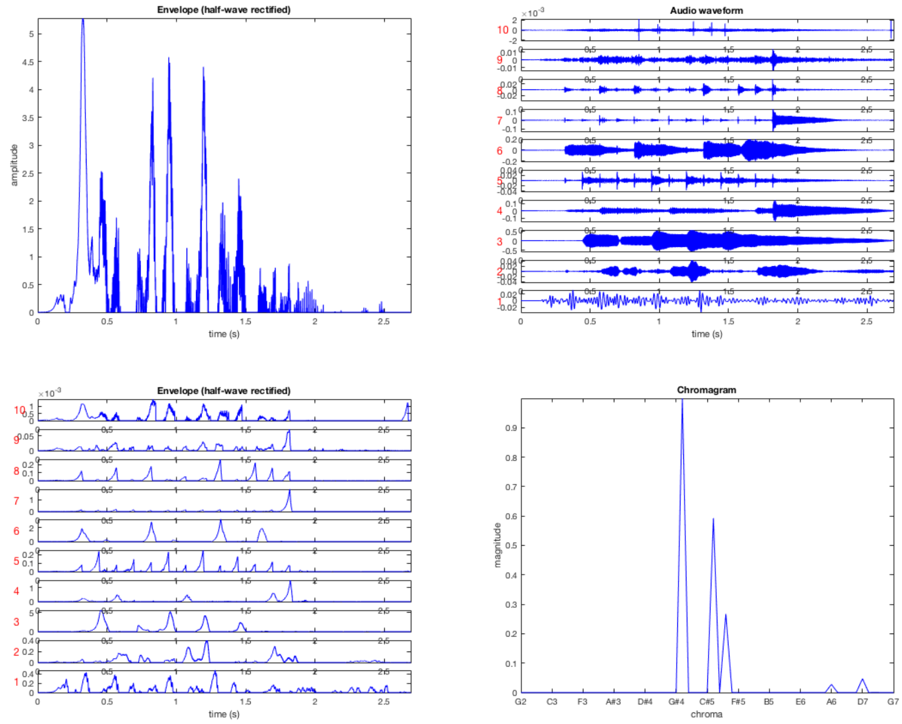


Figure B.10: Musical features of the halfway of Osaka Train station (3).

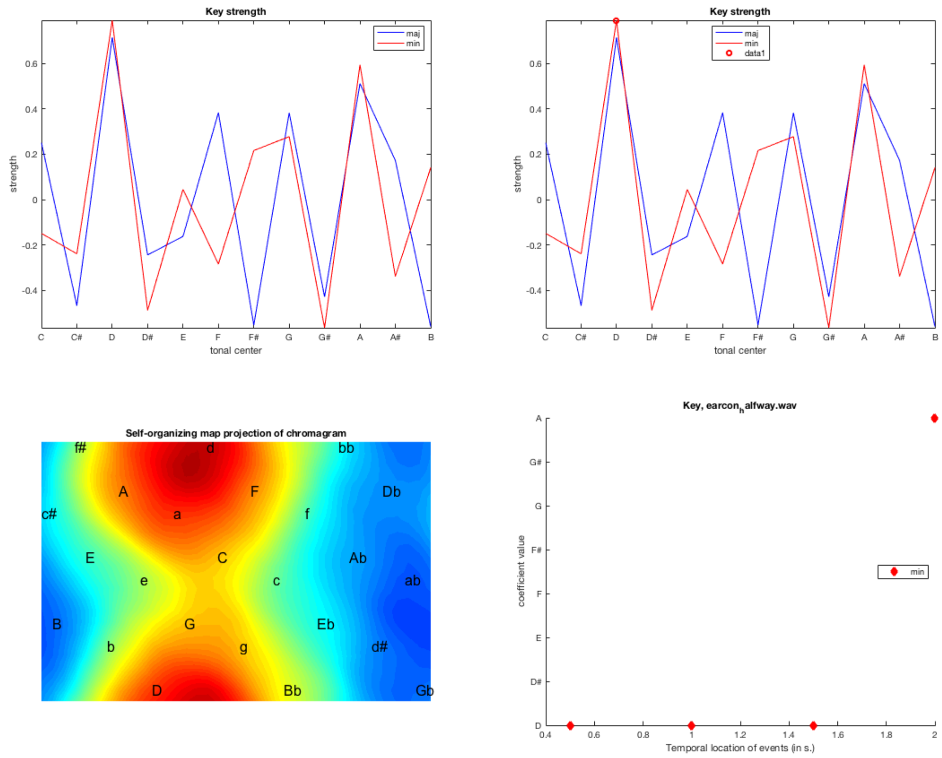


Figure B.11: Musical features of the halfway of Osaka Train station (4).

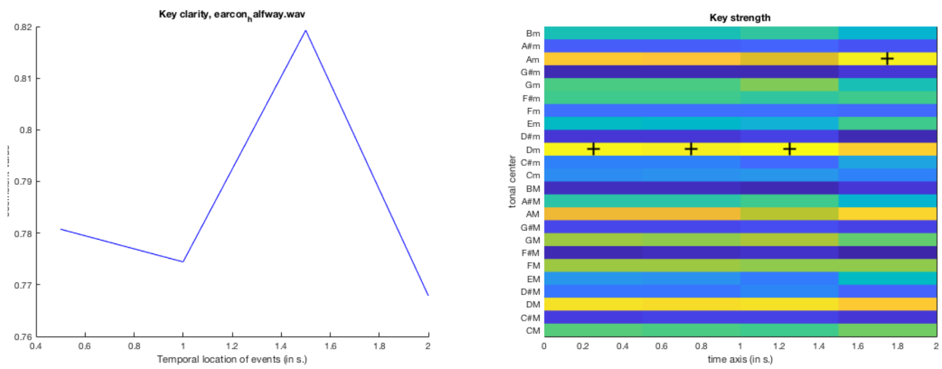


Figure B.12: Musical features of the halfway of Osaka Train station (5).

B.3 The new composed arrival melody

New Arrival Melody

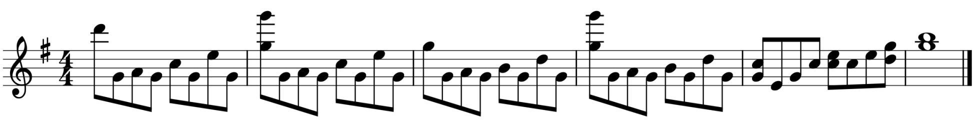


Figure B.13: The score of the new arrival melody in G major .

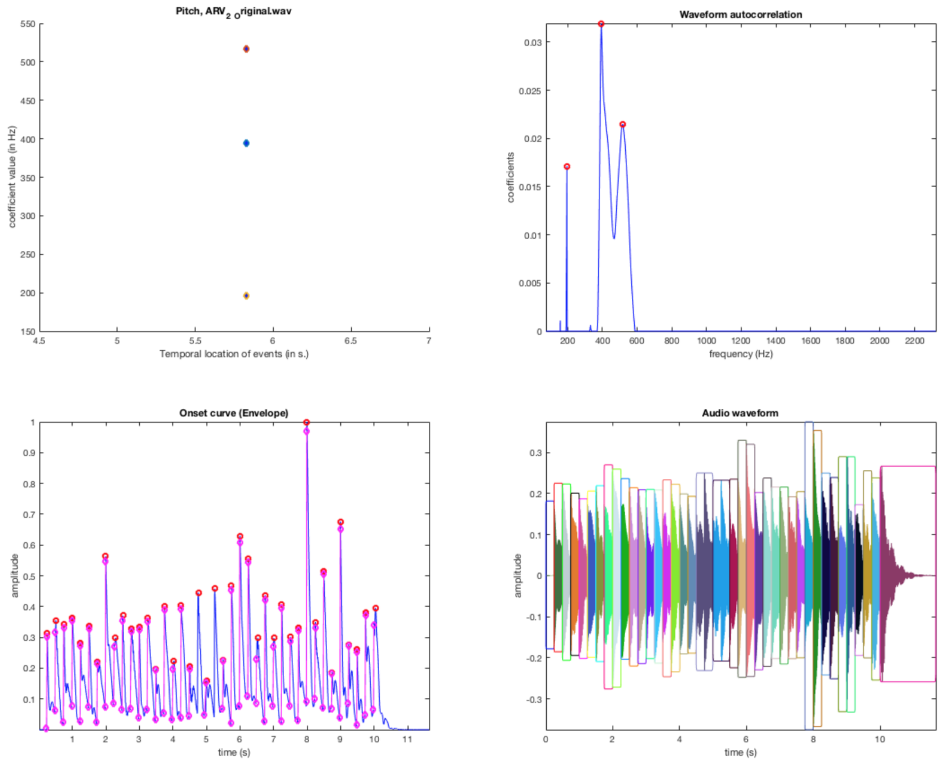


Figure B.14: Musical features of the composed arrival (1).

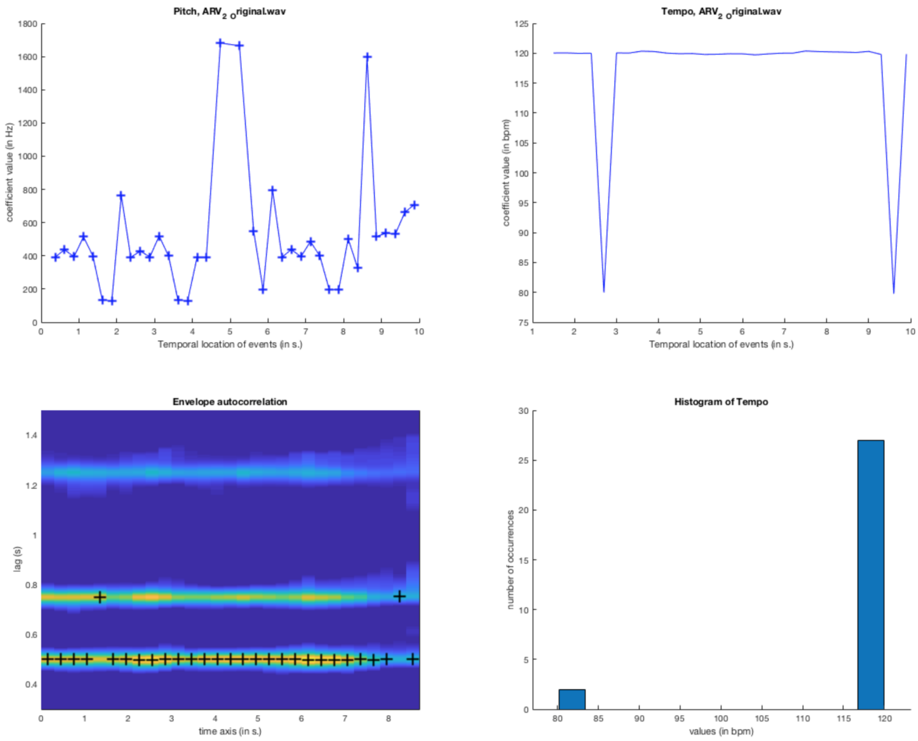


Figure B.15: Musical features of the the composed arrival (2).

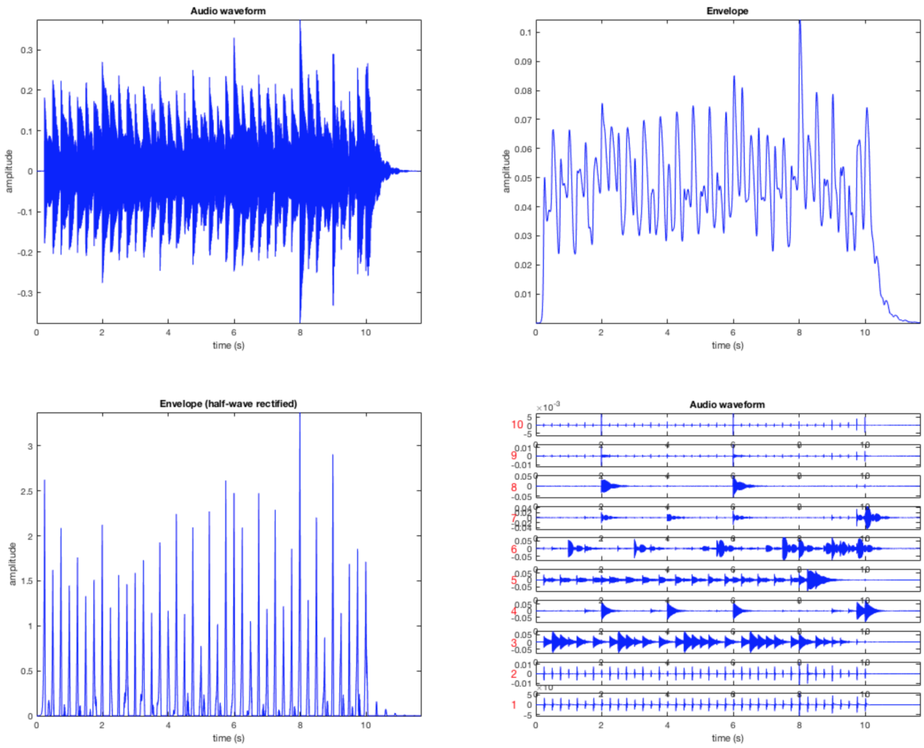


Figure B.16: Musical features of the the composed arrival (3).

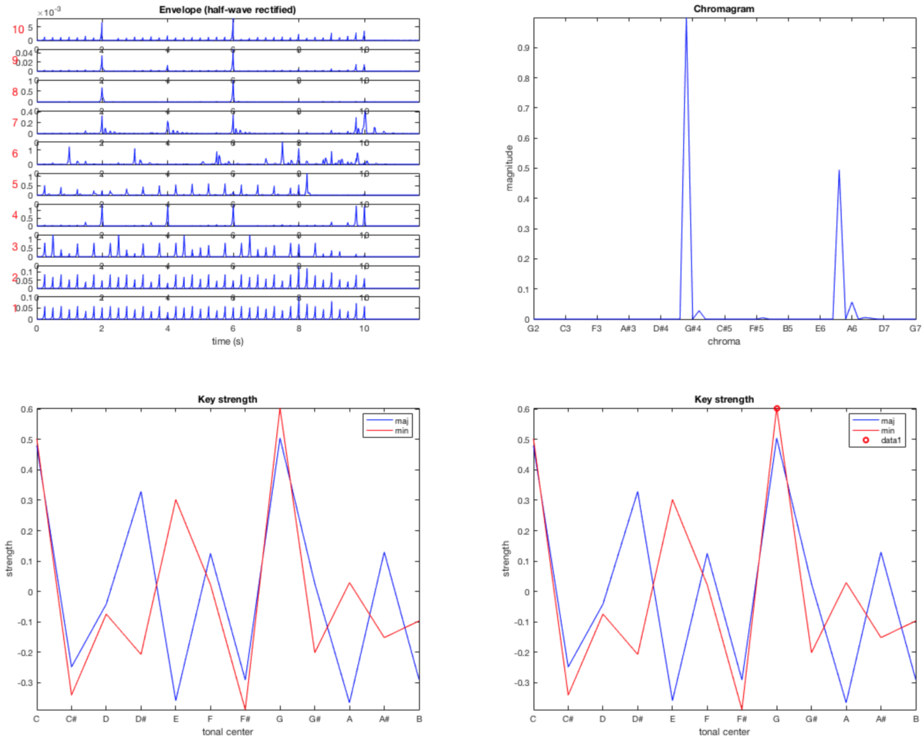


Figure B.17: Musical features of the the composed arrival (4).

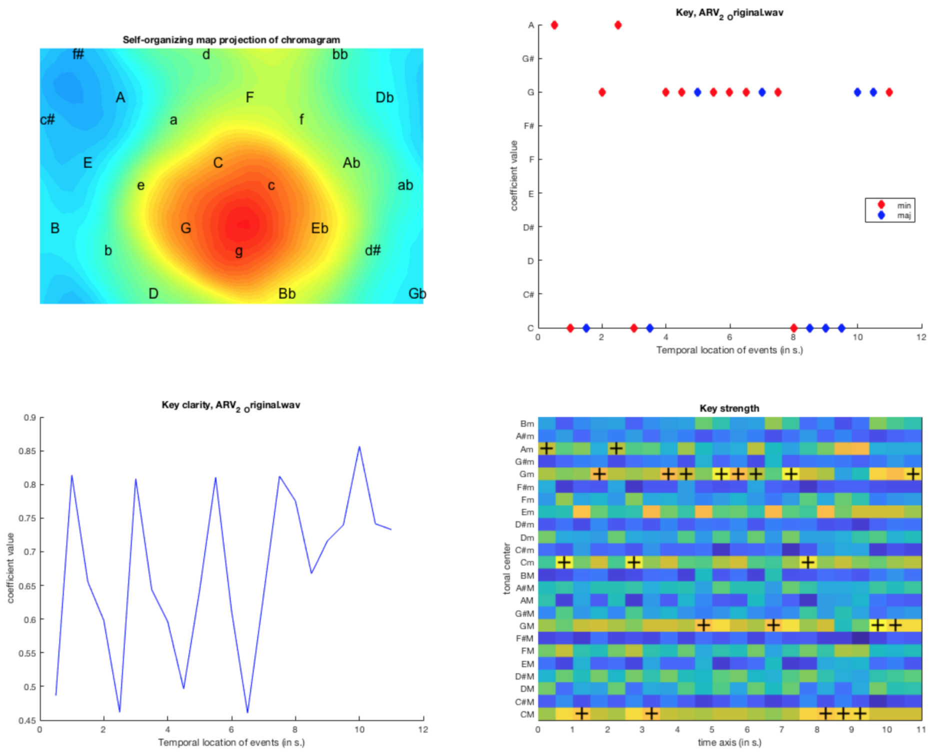


Figure B.18: Musical features of the the composed arrival (5).

B.4 The new composed departure melody

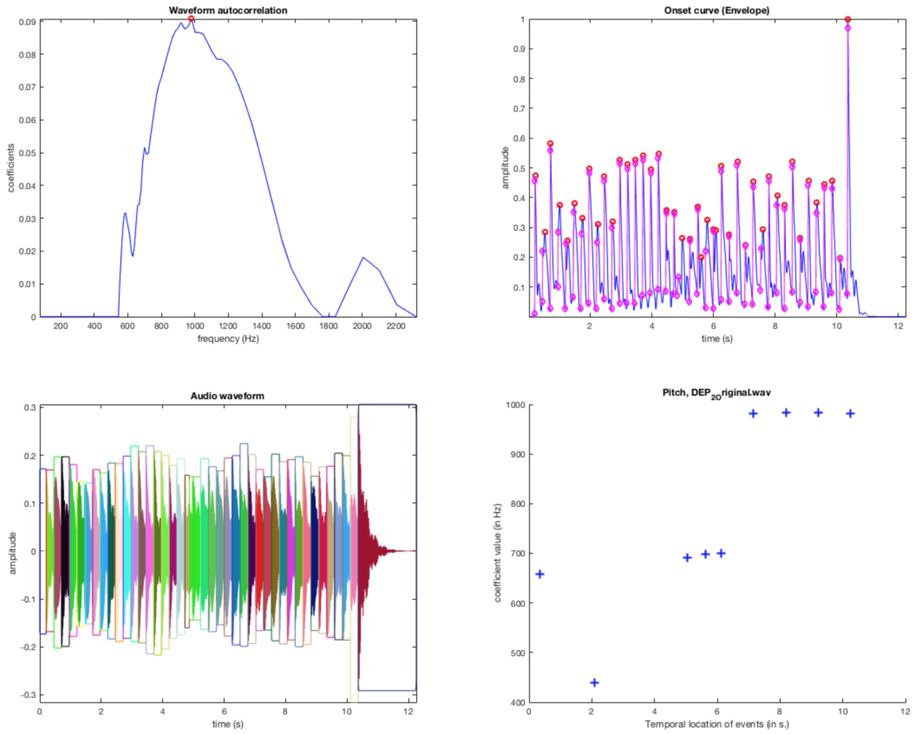


Figure B.19: Musical features of the composed departure (1).

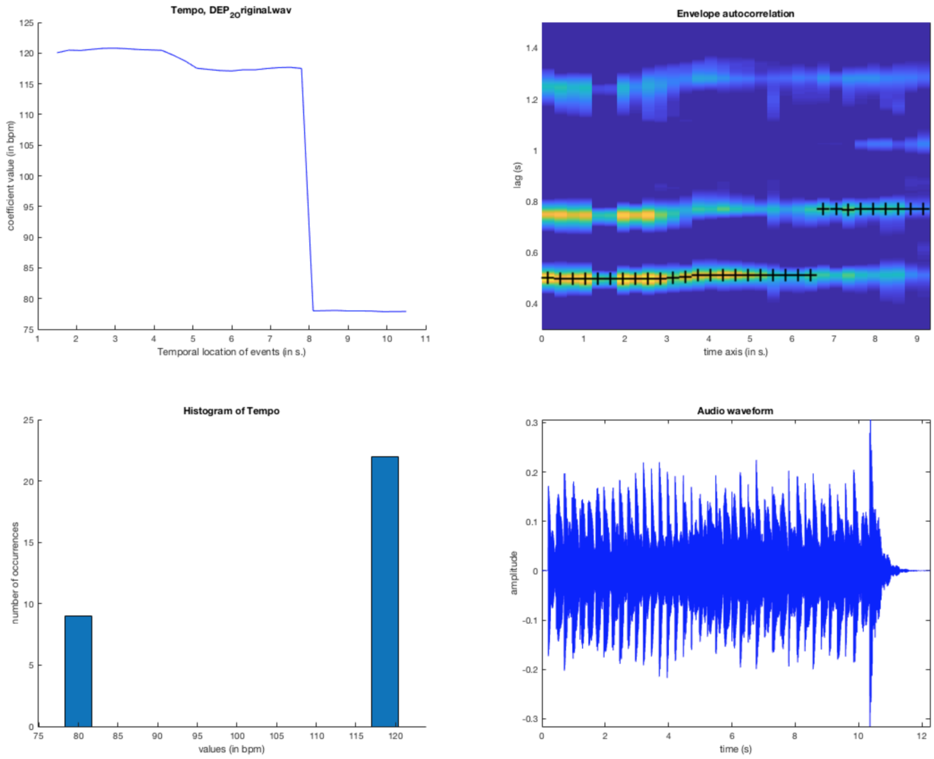


Figure B.20: Musical features of the the composed departure (2).

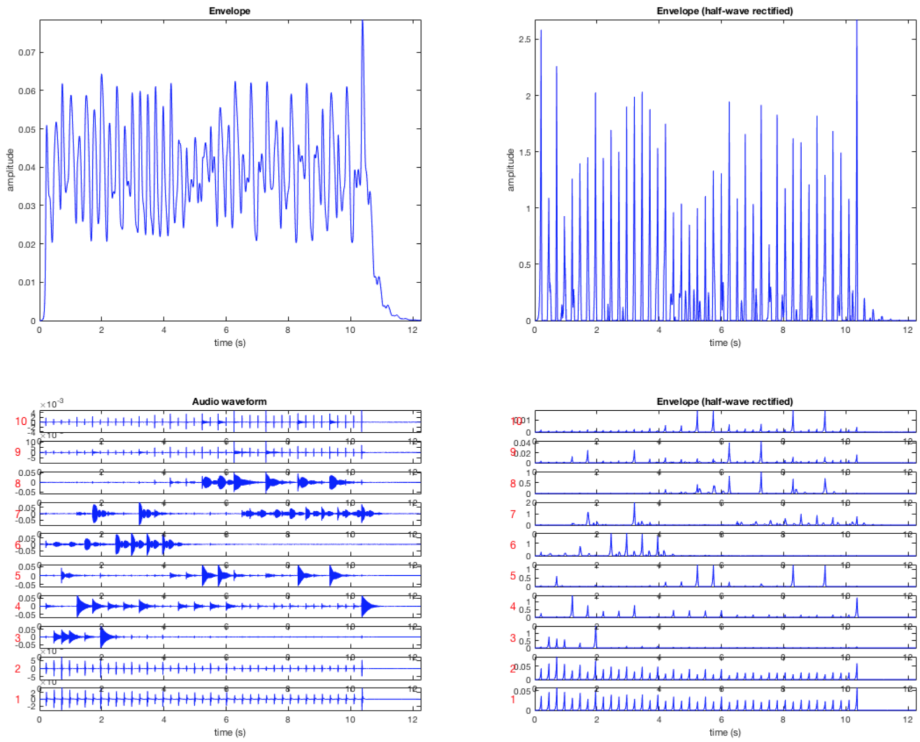


Figure B.21: Musical features of the the composed departure (3).

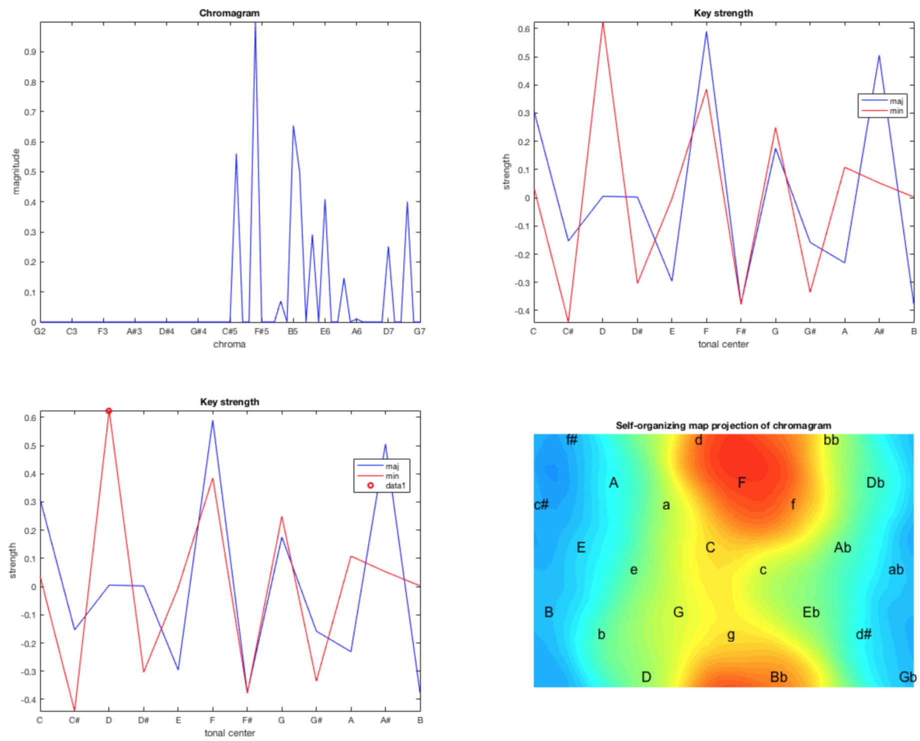


Figure B.22: Musical features of the the composed departure (4).

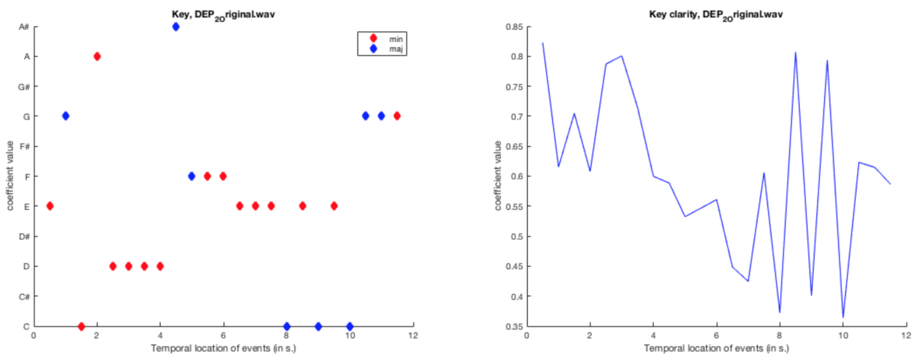


Figure B.23: Musical features of the the composed departure (5).

B.5 The new composed halfway melody

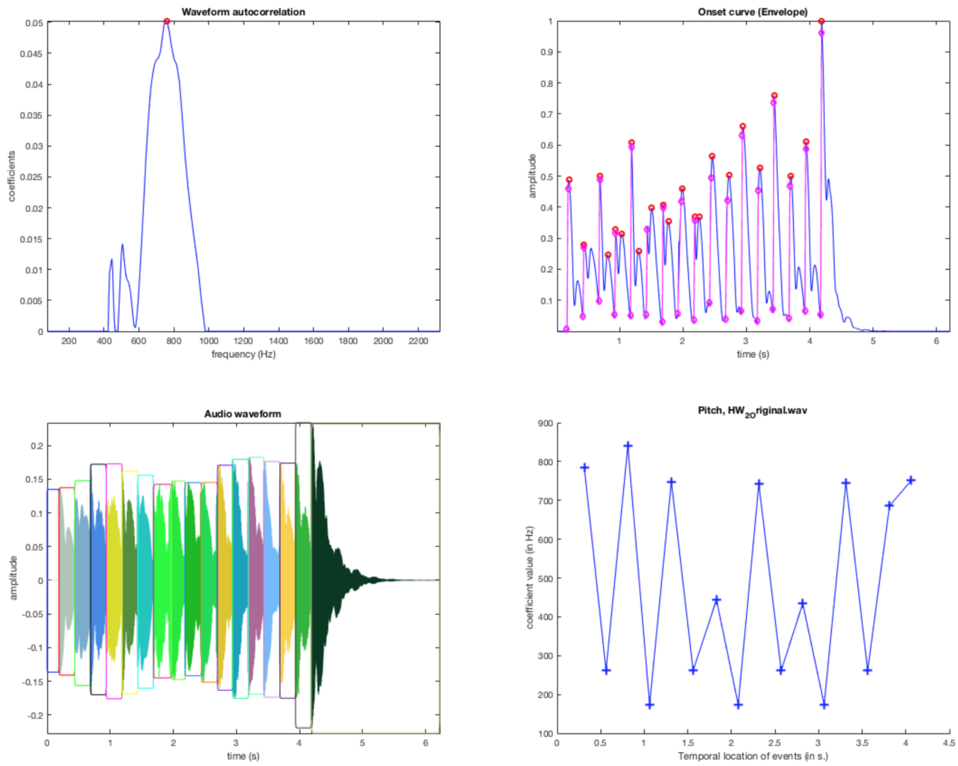


Figure B.24: Musical features of the composed halfway (1).

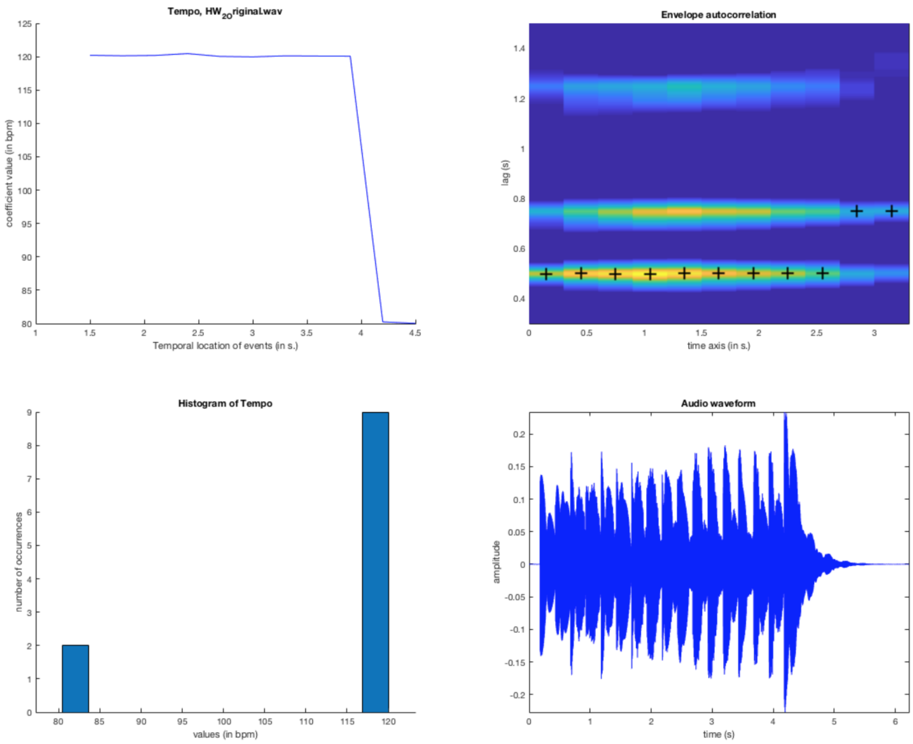


Figure B.25: Musical features of the the composed halfway (2).

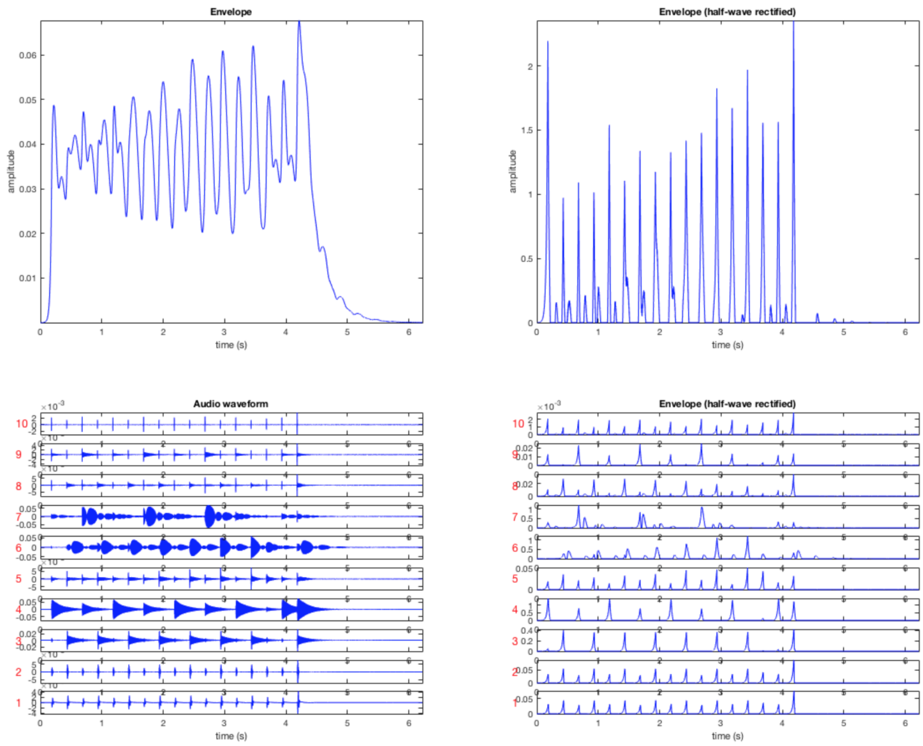


Figure B.26: Musical features of the the composed halfway (3).

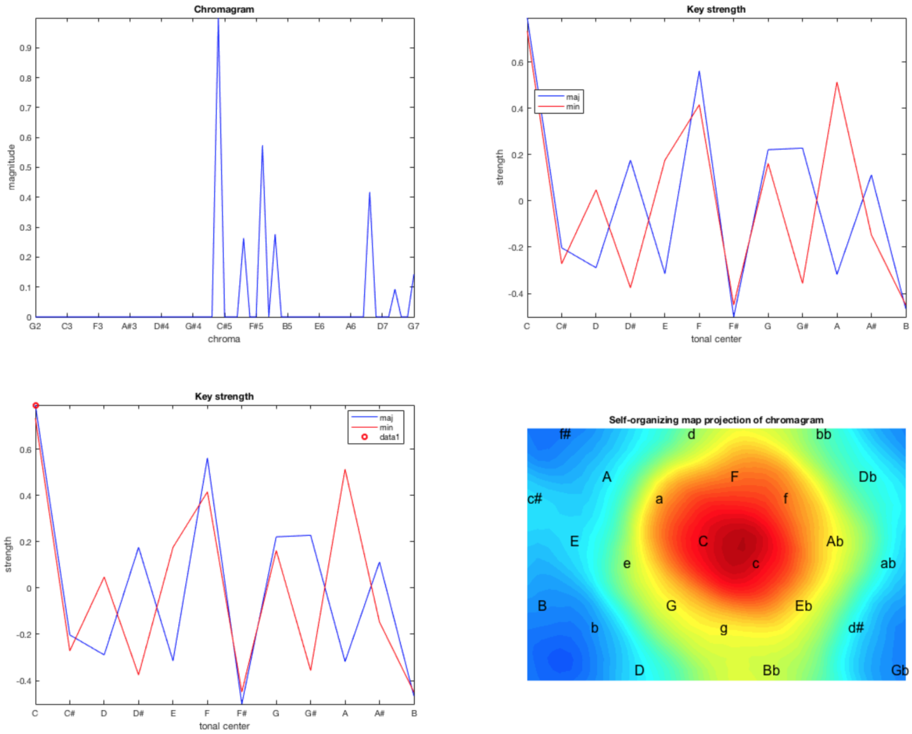


Figure B.27: Musical features of the the composed halfway (4).

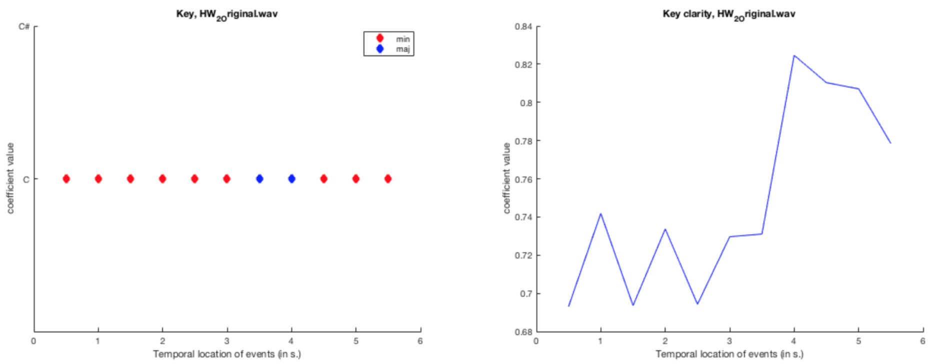


Figure B.28: Musical features of the the composed halfway (5).

Appendix C

Implementation

C.1 SuperCollider Code

```
s.boot; // boot SuperCollider server

(
//here we load our midi files for the arrival melodies
# a, d, t = ImportMidiFile("/path-to-midi-file/arv3.mid",1)
   ;

//here we load our reference midi files for half way and
   departure.
# b, d, t = ImportMidiFile("/path-to-midi-file/hw2.mid",1);
# c, d, t = ImportMidiFile("/path-to-midi-file/dep2.mid",1)
   ;


~arv = a;
~hw = b;
~dpt = c;

~h2 = ~arv.removeAllSuchThat({ arg item, i; i < 12 });

~tlt = ~h2 - ~hw;
~tlt2 = ~arv - ~dpt;

)

(
```

```
SynthDef.new(\vibraphone, {
        arg freq=440, modindex=0.5, amp=0.3;
        var sig, sig2, env, noise, modfreq;
        modfreq=freq*2.015;
        sig=LFTri.ar(SinOsc.ar(modfreq,SinOsc.kr(5),modfreq
           *modindex,freq),1.5,0.35);
        sig2 = BPF.ar(SinOsc.ar(freq/2,3,0.55),freq/2);
        env=EnvGen.kr(Env([0,1,0,0],[0.01,0.65,0.15,1.3],
           \sin),levelScale:amp,doneAction:2);
        noise = BPF.ar(PinkNoise.ar,modfreq,0.5)*(env*0.7);
        sig = sig + noise;
        sig = BPF.ar(sig,modfreq/1.5,1);
        sig = sig + sig2;
        sig = sig*env;
        Out.ar(0,sig!2);

}).add;


p = Pbind(

        \instrument, \vibraphone,
        \dur, 0.2,

        //\midinote, Pseq(~arv, 1),

        //\midinote,Pseq(~h2 + ~tlt ,1) + 12,

        \midinote,Pseq(~arv + ~tlt2 ,1) + 12,

);

)

(
m = SimpleMIDIFile( "/path-to-midi-file/dep2.mid" );

m.fromPattern( p );

m.plot;
```

```
m.write;

p.play;s.record(duration: 10);
)
```

Appendix D

The MIDI representation of the generated melodies

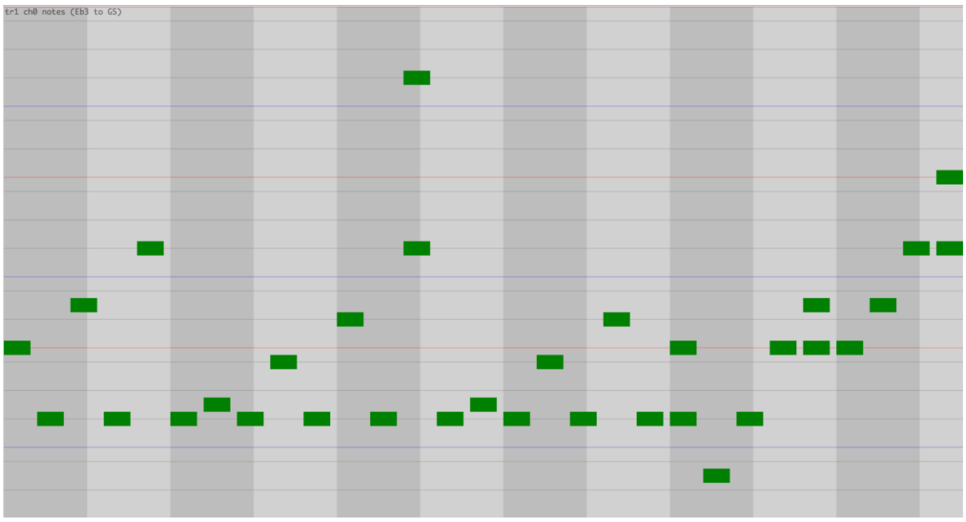


Figure D.1: The MIDI representation of 2 version of arrival melody .

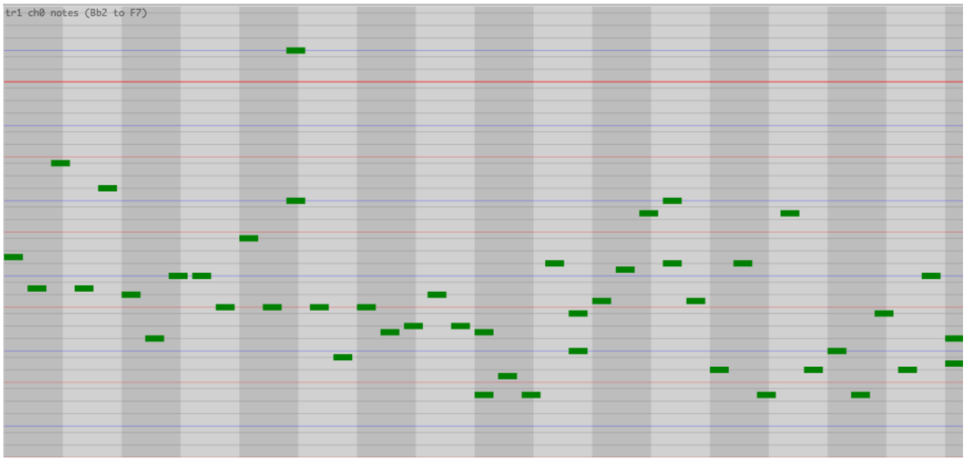


Figure D.2: The MIDI representation of 2 version of departure melody .

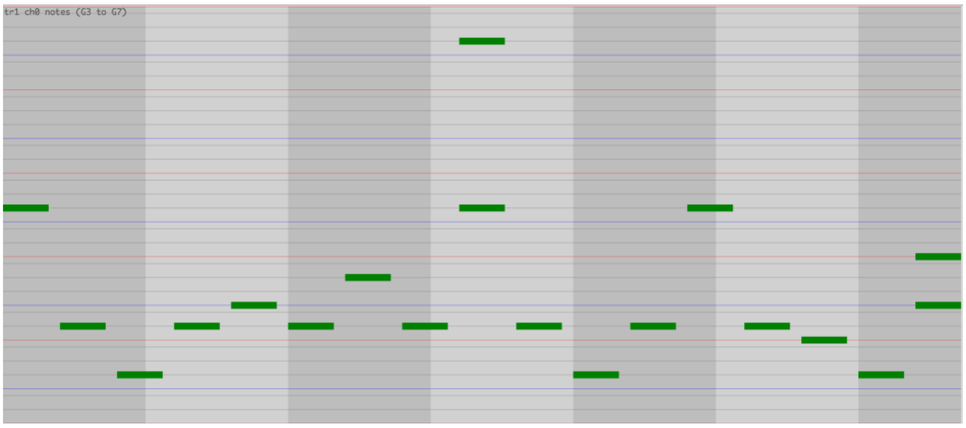


Figure D.3: The MIDI representation of 2 version of halfway melody .

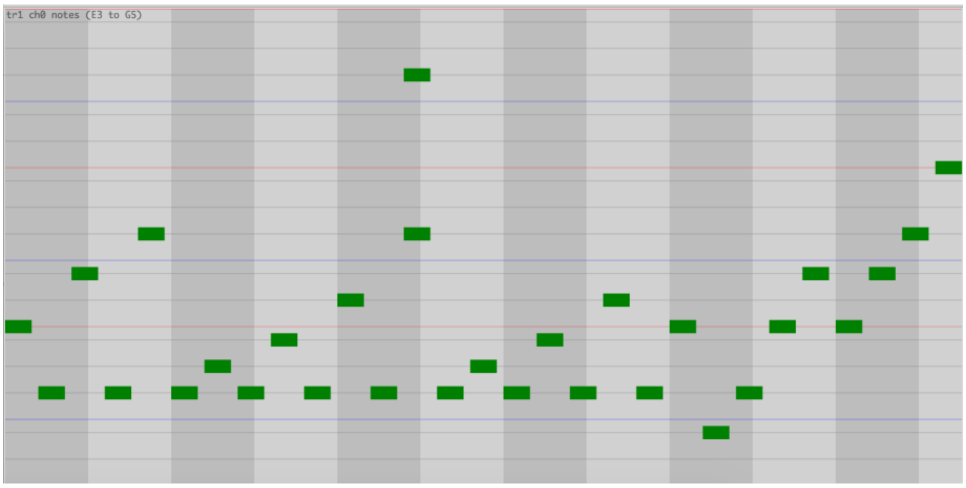


Figure D.4: The MIDI representation of 3 version of arrival melody .

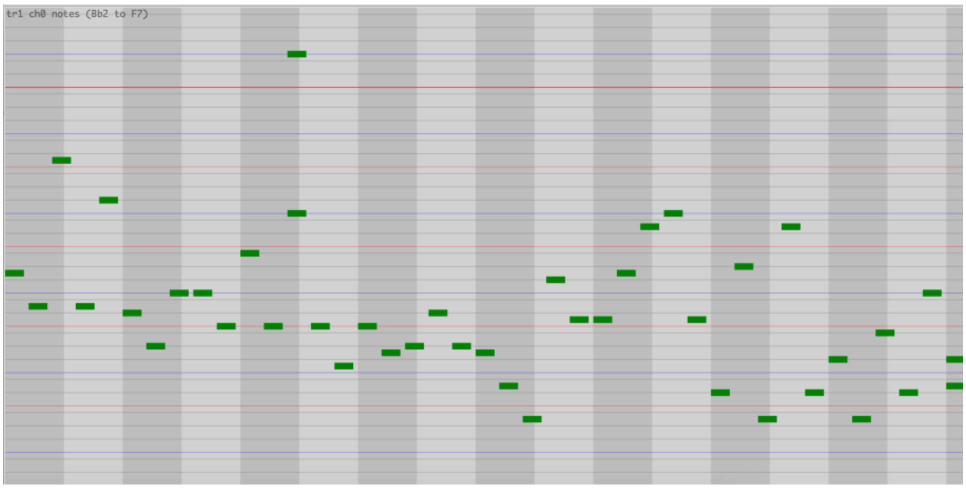


Figure D.5: The MIDI representation of 3 version of departure melody .

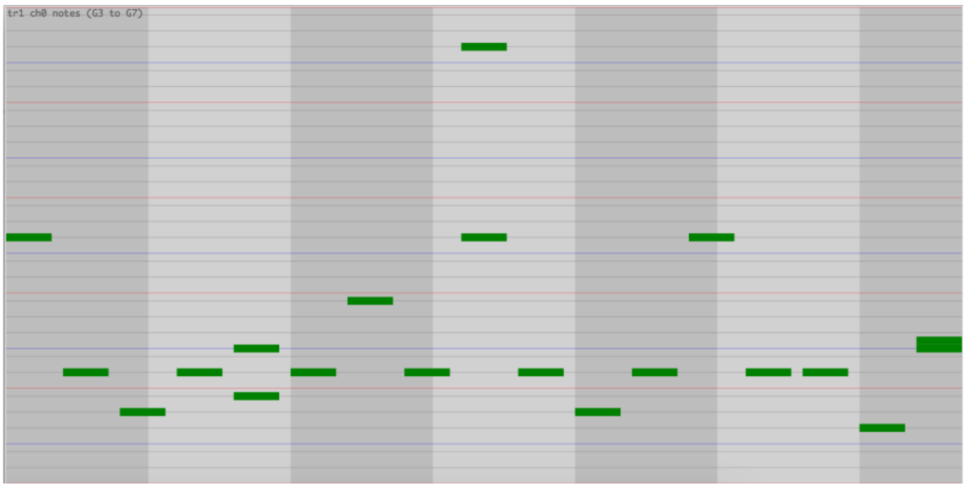


Figure D.6: The MIDI representation of 3 version of halfway melody .

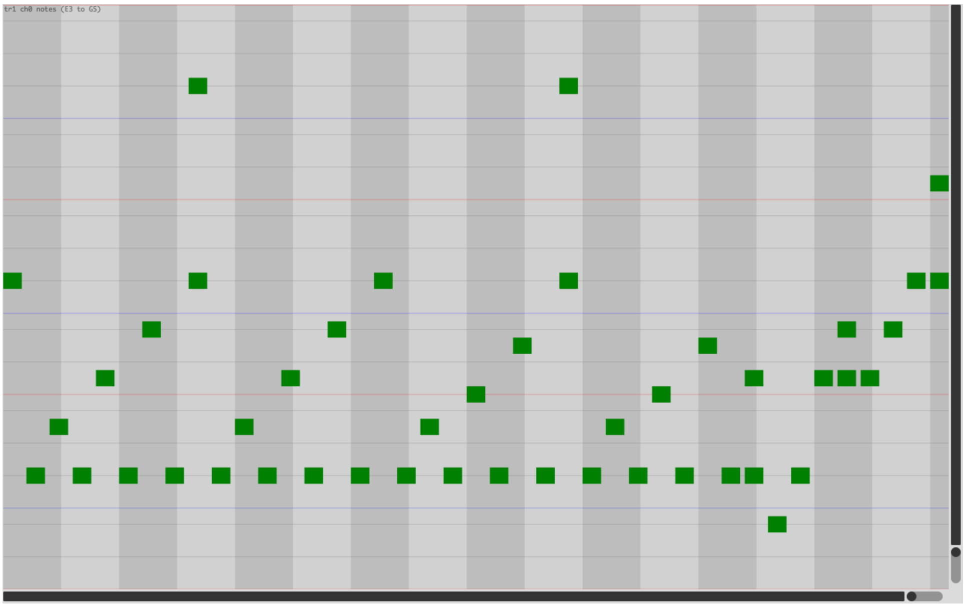


Figure D.7: The MIDI representation of 4 version of arrival melody .

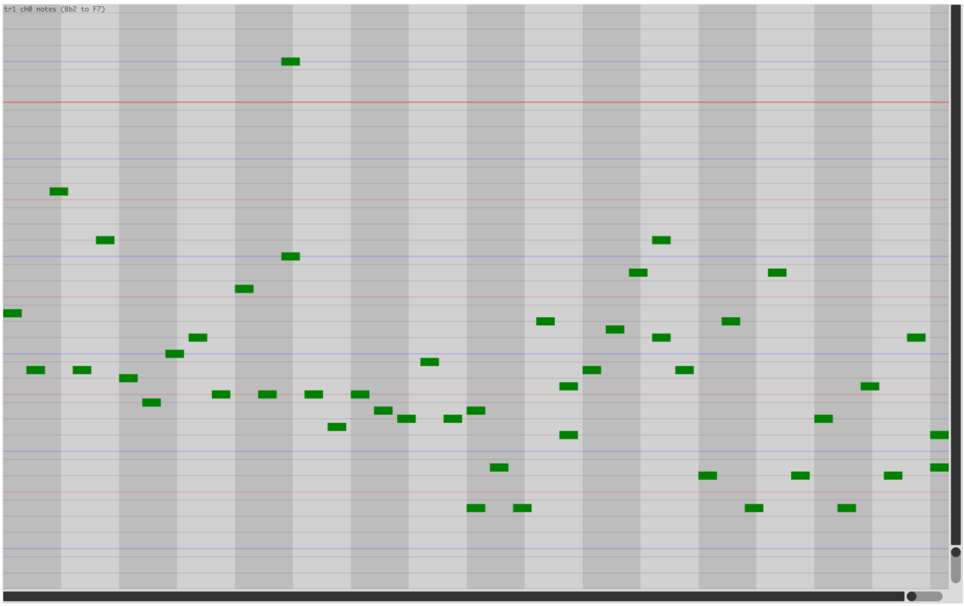


Figure D.8: The MIDI representation of 4 version of departure melody .

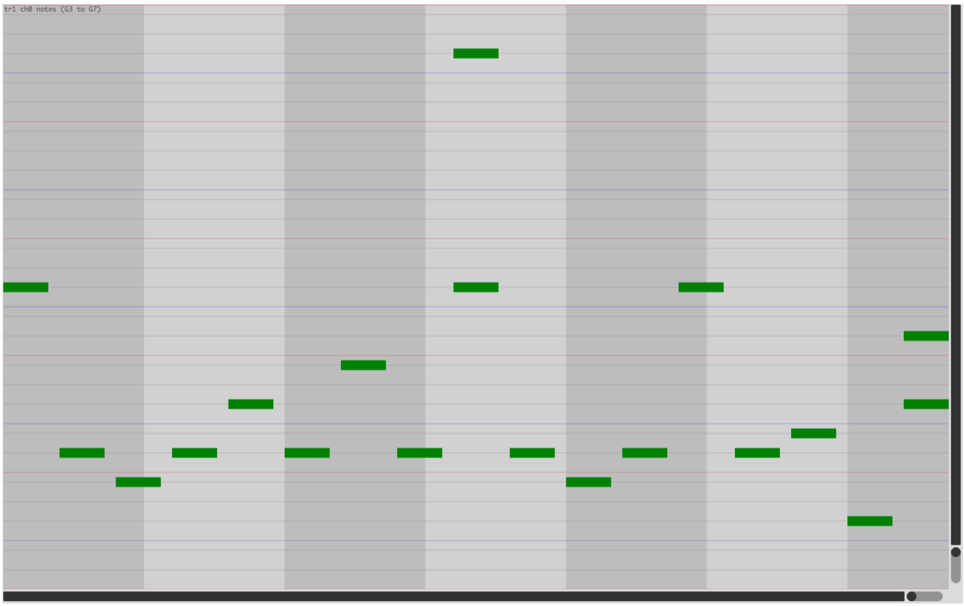


Figure D.9: The MIDI representation of 4 version of halfway melody .

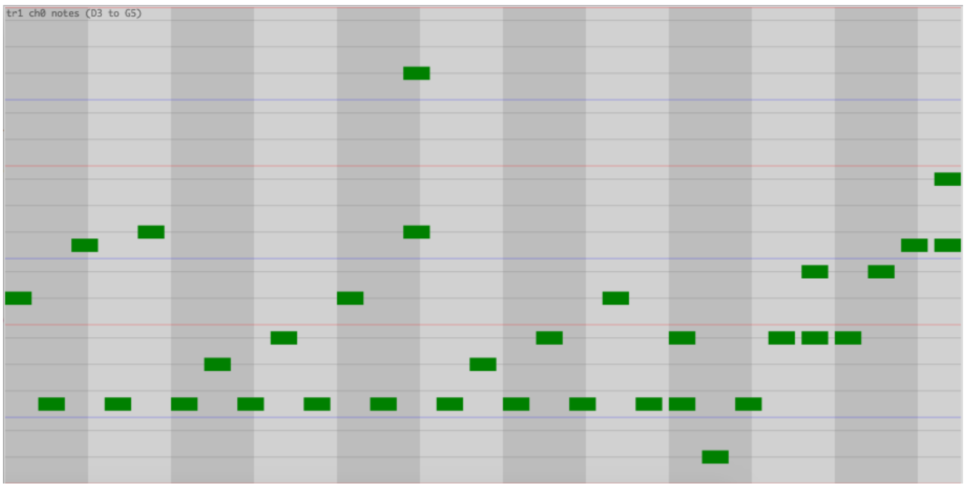


Figure D.10: The MIDI representation of 5 version of arrival melody .

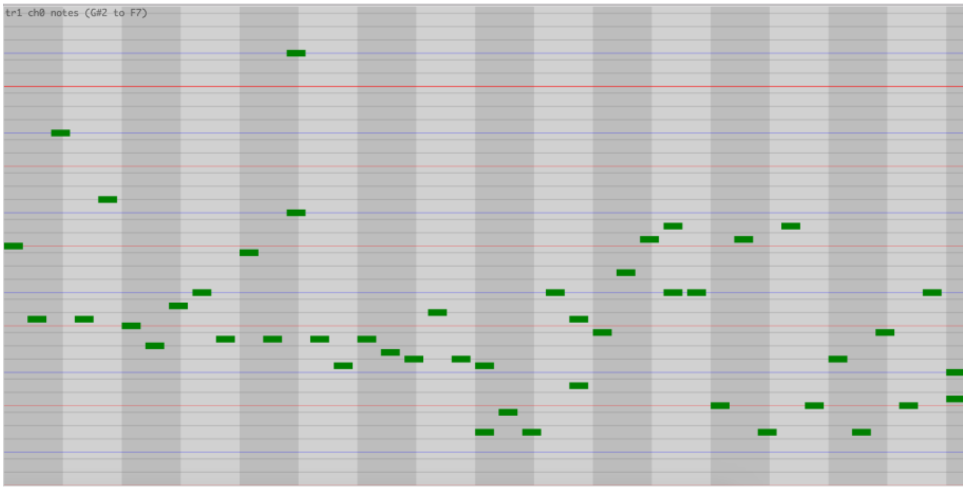


Figure D.11: The MIDI representation of 5 version of departure melody .

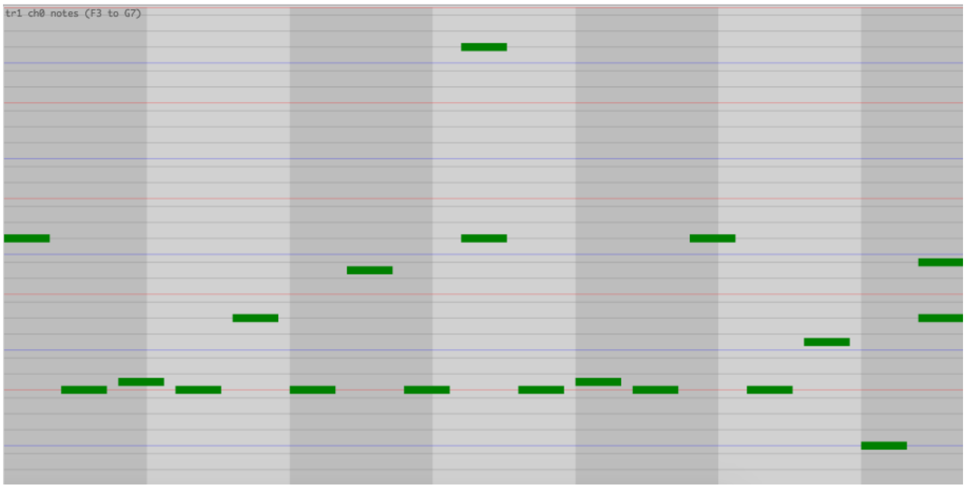


Figure D.12: The MIDI representation of 5 version of halfway melody .

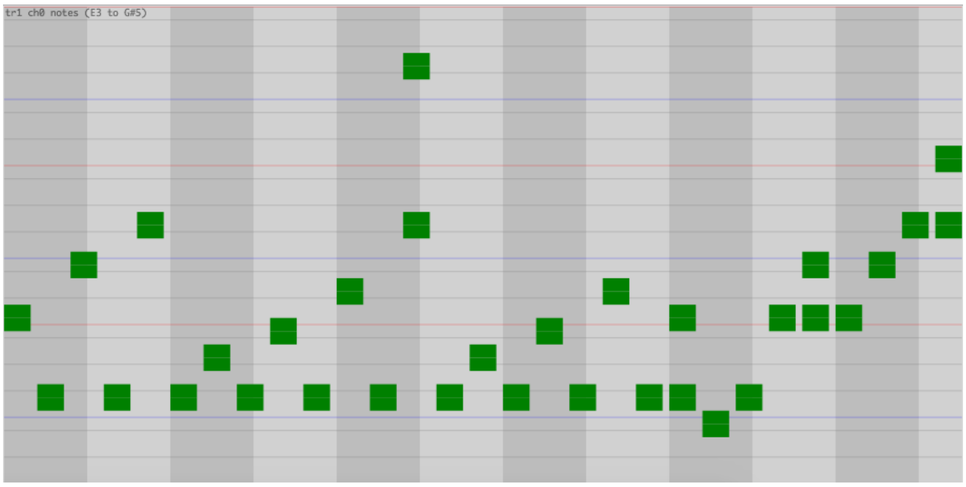


Figure D.13: The MIDI representation of 6 version of arrival melody .

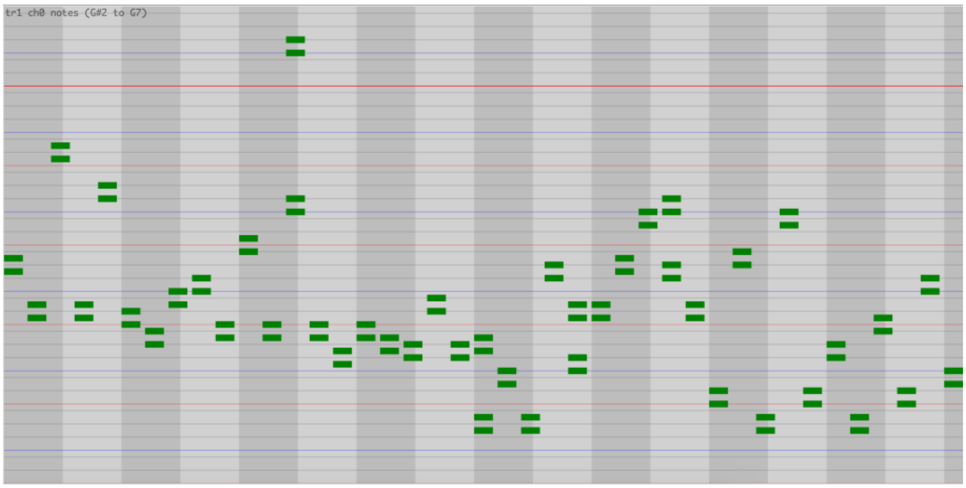


Figure D.14: The MIDI representation of 6 version of departure melody .

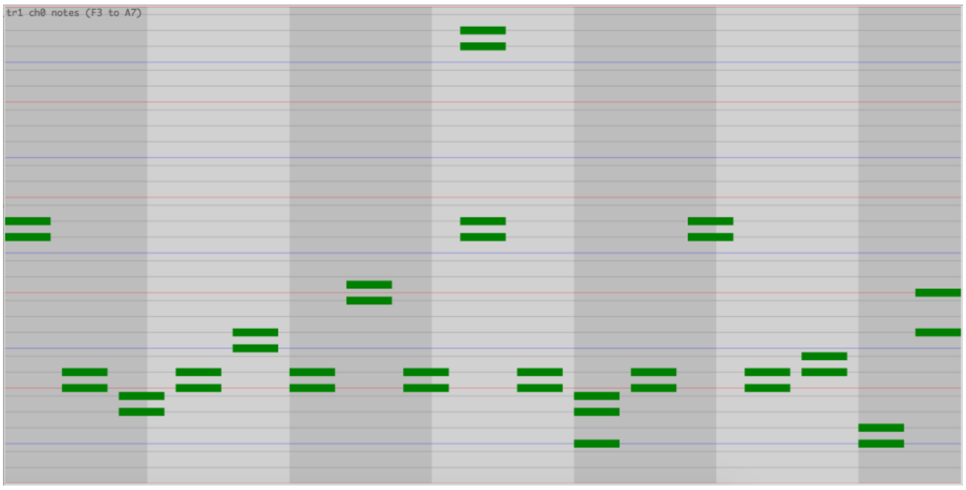


Figure D.15: The MIDI representation of 6 version of halfway melody .

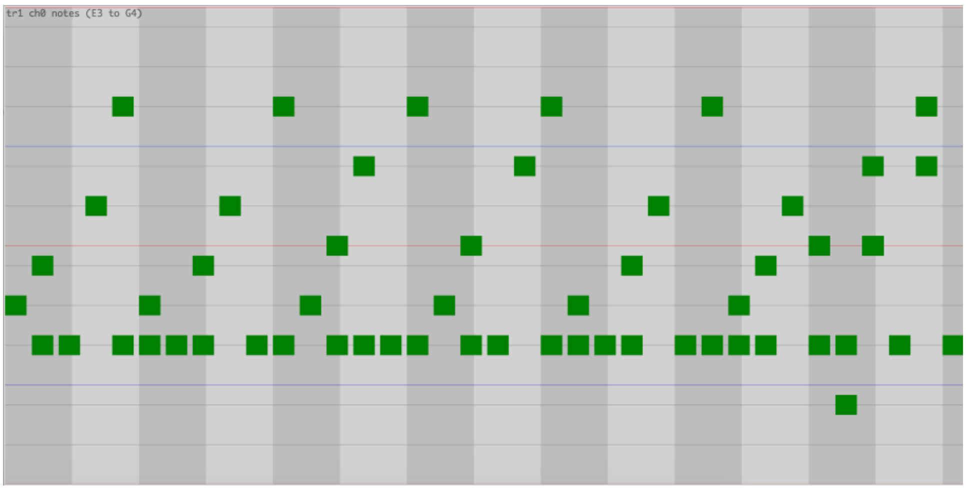


Figure D.16: The MIDI representation of 7 version of arrival melody .

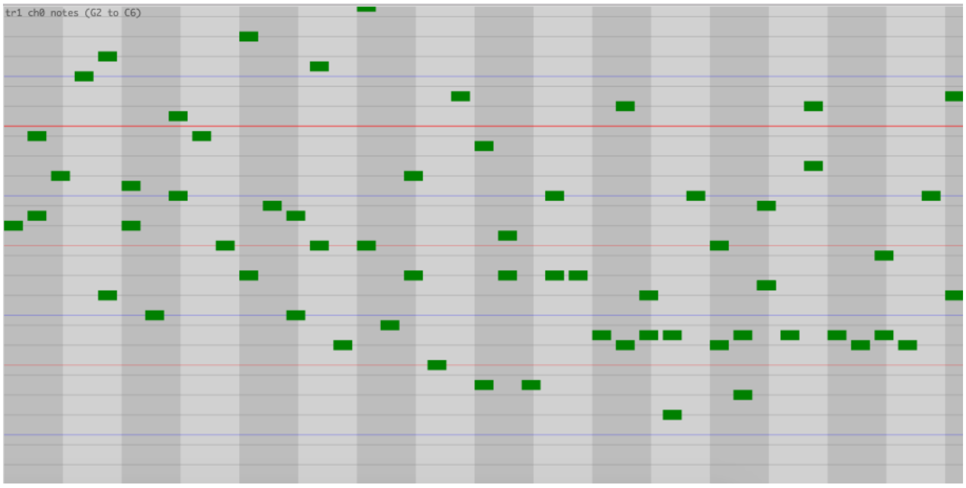


Figure D.17: The MIDI representation of 7 version of departure melody .

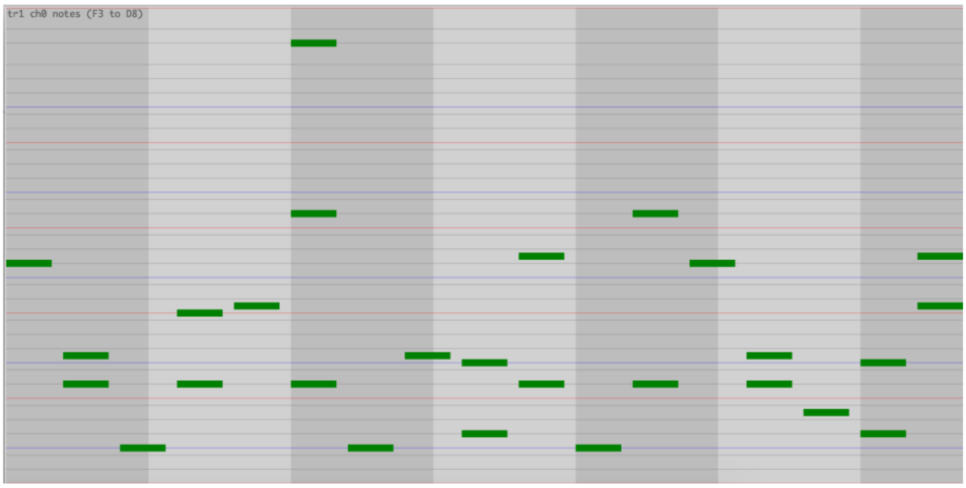


Figure D.18: The MIDI representation of 7 version of halfway melody .

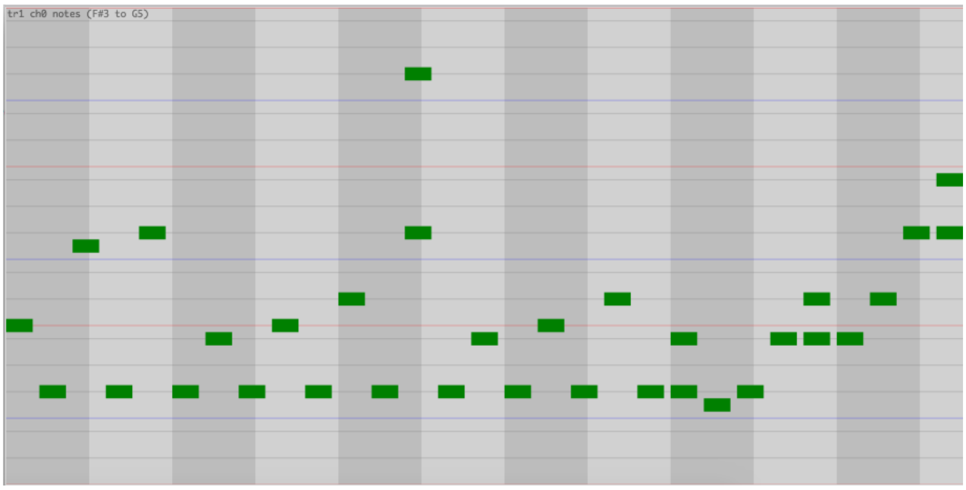


Figure D.19: The MIDI representation of 8 version of arrival melody .

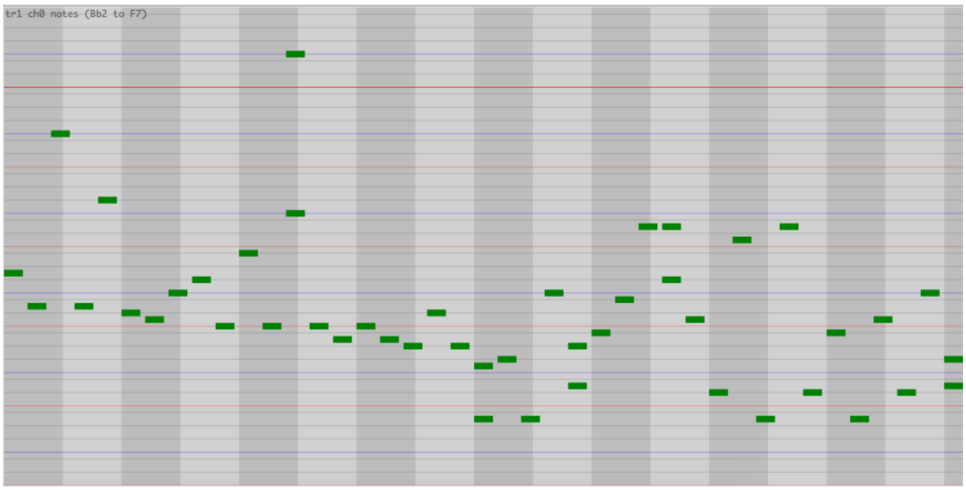


Figure D.20: The MIDI representation of 8 version of departure melody .

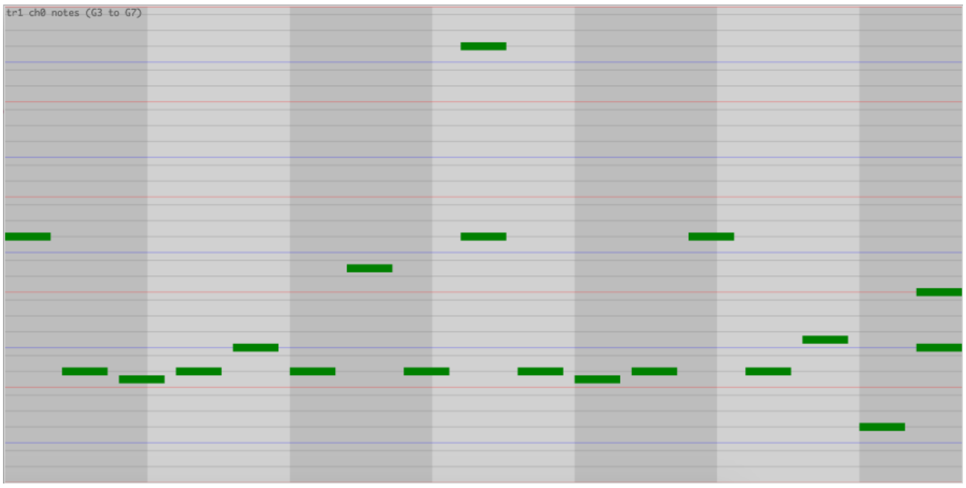


Figure D.21: The MIDI representation of 8 version of halfway melody .

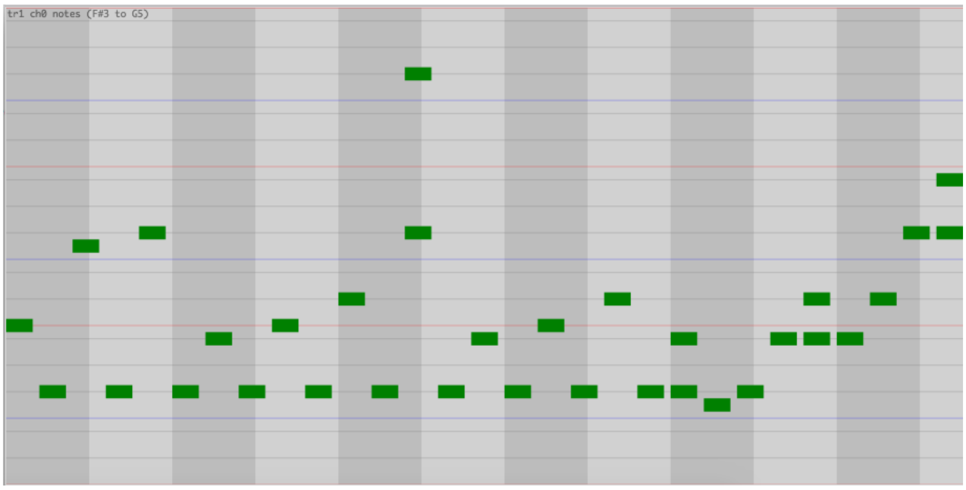


Figure D.22: The MIDI representation of 8 version of arrival melody .

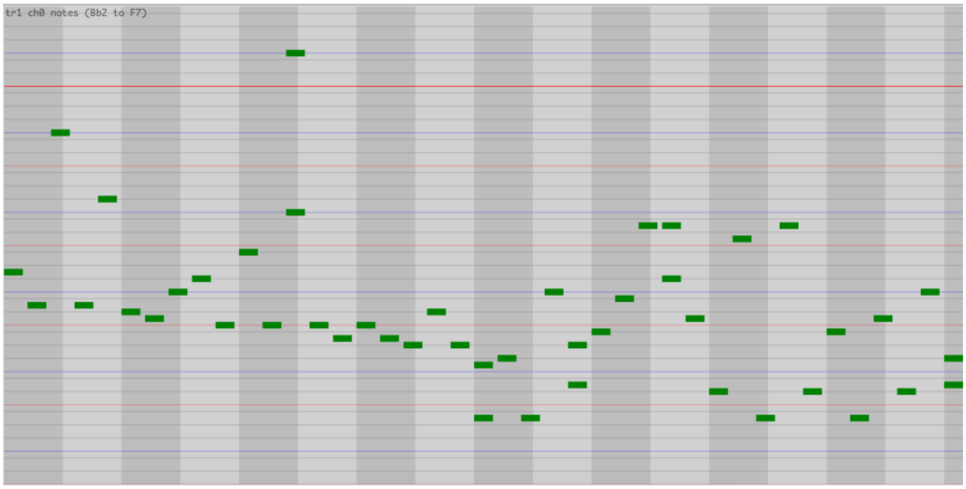


Figure D.23: The MIDI representation of 8 version of departure melody .

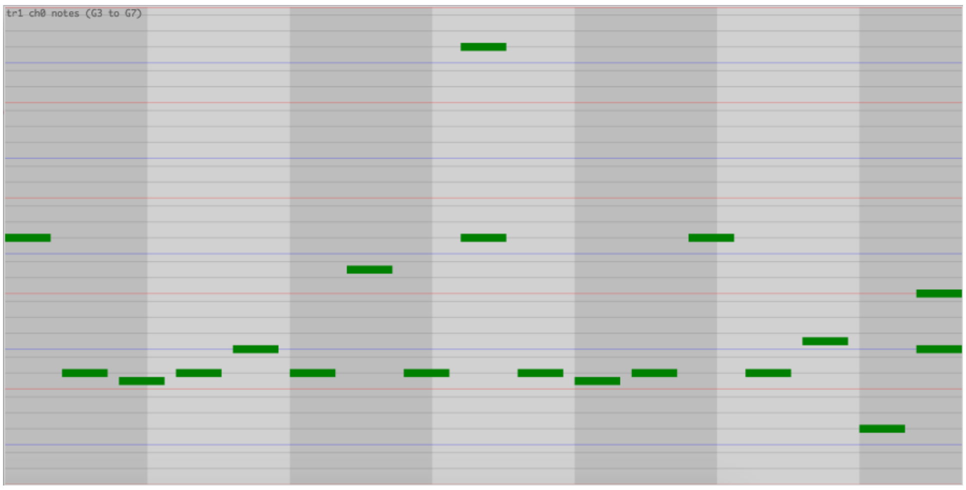


Figure D.24: The MIDI representation of 8 version of halfway melody .

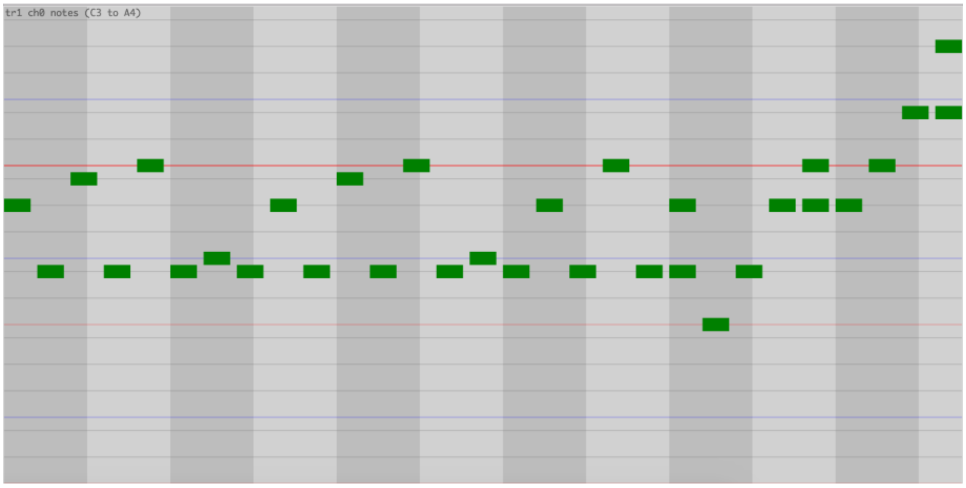


Figure D.25: The MIDI representation of 9 version of arrival melody .

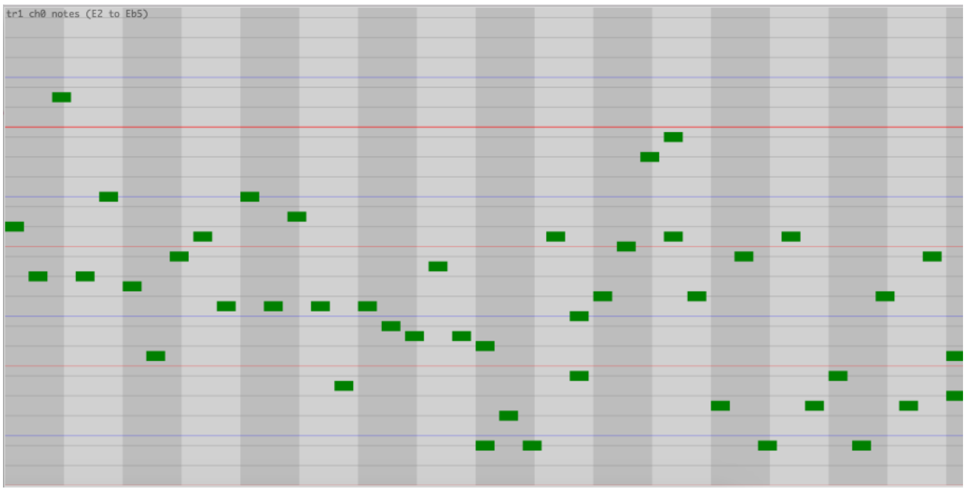


Figure D.26: The MIDI representation of 9 version of departure melody .

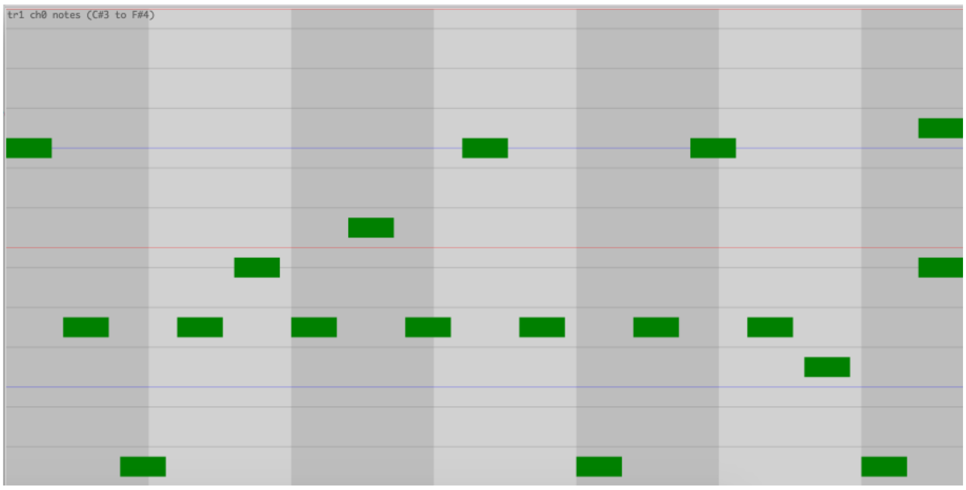


Figure D.27: The MIDI representation of 9 version of halfway melody .

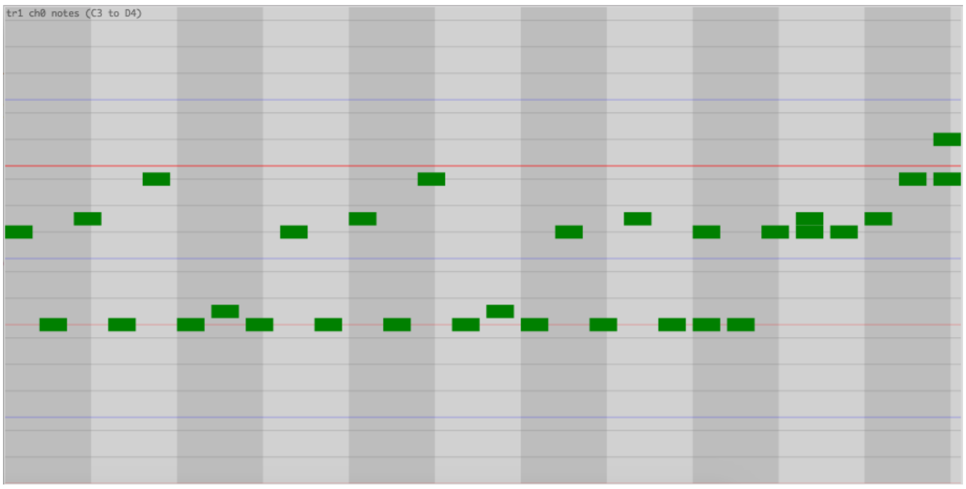


Figure D.28: The MIDI representation of 10 version of arrival melody .

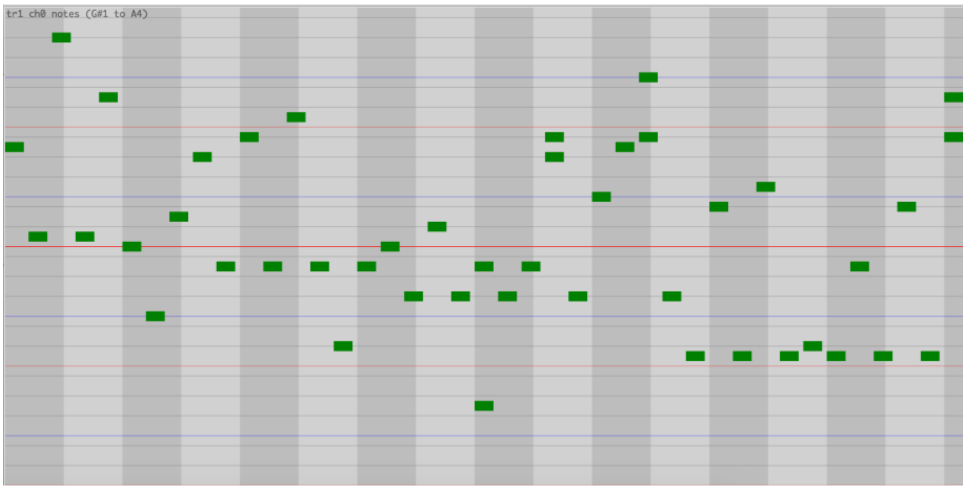


Figure D.29: The MIDI representation of 10 version of departure melody .

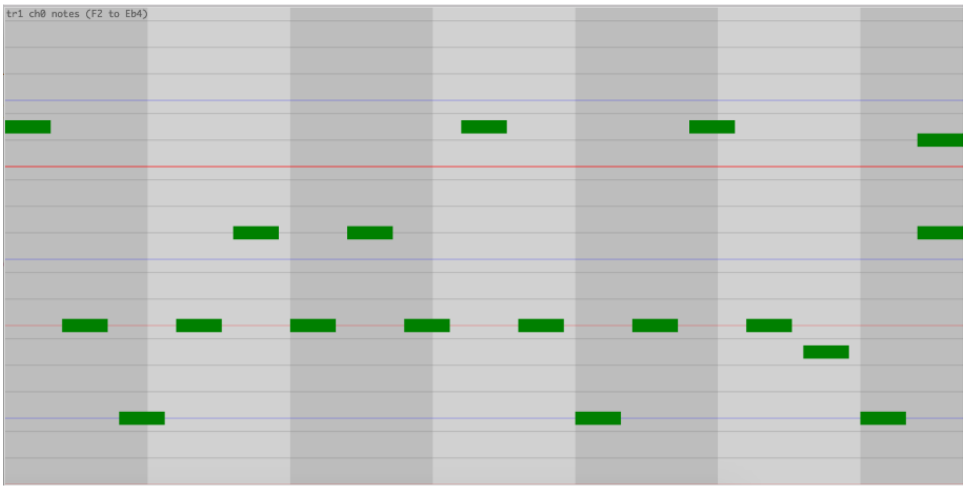


Figure D.30: The MIDI representation of 10 version of halfway melody .