Music 251 Final Project Proposal

Joudi Abou Ayed

Title: *Influence of Timbre of Arab Music Instruments on Microtonal Recognition*

Abstract

Being an element of sound structure, timbre can influence other elements such as pitch of the sound. Most listeners who were exposed or trained to the western music tuning system, are able to discriminate pitch intervals easily within the standard diatonic system. Previous studies, have worked on Arab musicians' abilities of pitch discrimination in general but not microtonal in specific. Previous research has shown the association between auditory perception and previous auditory experience, while other research studied timbre neurocognition. Our study combines timbre perception with previous specific auditory experience of microtonal pitches and scales in particular. Non-western music, and in our case Arab microtonal music, consists of different tuning intervals using quarter tones (or three-quarter tones to be exact). Arab music is traditionally played by Arab (non-western) instruments such as oud, nay, and riq. Such instruments contain very unique timbres, and because they are mainly played for Arab music and in Arab microtonal tuning, their timbre is associated with the microtonal character. That is the purpose of our study; to find out how the auditory perception abilities of microtonal pitch discrimination are affected by the auditory experience of timbre perception. Our study consisted of 1 experiment repeated twice (1 trial and 1 counted). Subjects were presented with a scale (western or Arab) played by either a sine wave, oud, or midi clarinet instrument. The subjects had to identify if the presented scale was Arab or Western. Subjects were divided into musicians and non-musicians (western and Arab). Our hypotheses is that Arab musicians and non-musicians would overall be able to identify Arab music scales despite the timbre better than those of western background. Results show Arab subjects performing better than western subject detecting Arab maqams with all the timbres, but western musicians performed better than Arab subjects and non-musicians with western scales despite the timbre. The oud caused subjects to choose scales as Arab despite the scale played being Arab or western. This concludes that timbre has an influence on microtonal perception.

Introduction

Microtonal music exists in several ethnic musical styles and consists of various unique elements such as instrumentation and timbre, and tuning system. While western music consists of 12 intervals (divided in semitones) within one octave, Arab music generally consists of 24 quarter tones in one octave (Abu Shumays, 2013). Arab music scales are called "maqams" or "maqamat" (plural for maqam) (Abu Shumays, 2013). Some maqams contain what is called "quarter tones" while in theory they are "three-quarter tones"

where the note is three-quarters apart from the next one. For example, E half-flat is between E flat and D natural which is three-quarter tones away from the next note which is F natural. Arab maqams also contain half sharps depending on the diatonic naming sequence of the scale/maqam (Abu Shumays, 2013). It's important to mention that for simplicity purposes and minimal research findings in that field, intonation was kept in the 440-tuning system. Following the 1932 international conference of Arab Music in Cairo of which the main decision was to normalize the tuning system of Arab music and set it to the equal-tempered 24-tone tuning instead of the previous microtonal system that could contain up to 12 microtones between a flat and a natural of one western pitch (Abu Shumays, 2013). Based on maqam tuning rules, some notes are tuned up or down depending on the scale and the octave they are played in (Abu Shumays, 2013). However, to keep things simple for the subjects and to maintain accuracy, we followed the 24 quarter-tones equal-tempered system. The authentic definition of a maqam would be that it is not considered a "scale" in the western term (Abu Shumays, 2013). A maqam consists of tetrachords called Ajnas (plural for Jins which means "type" or "genre" in Arabic) (Abu Shumays, 2013). Usually, a maqam would contain two or three ajnas (each jins containing 3 to 5 notes despite the "tetra" in the naming) (Abu Shumays, 2013). Each combination of jins or ajnas creates a maqam, and based on these diverse combinations we find maqams divided into families. For example, there is Rast family where there's maqam Rast (contains 2 Rast jins and one Nahawand jins) and under the Rast family we find maqam Yakah that consists of one Rast jins and one Bayati jins (Figure 5). Some maqams do not contain quarter tones, however, the intervals between the pitches are different from western scales. For example, maqam Nawa Athar contains a 3-semitone interval (between E flat and F sharp) shown in figure 1. On the other hand, there are maqams that, because of the new standardizing equal-tempered rules, now are exactly the same as some western modes. For example, maqam Nahawand in is exactly the harmonic minor scale (Figure 2), and maqam Kurd is the same as the Phrygian mode (Figure 3), and maqam Ajam (which in Arabic mean "foreign") is exactly the Ionian mode/ major scale (Figure 4).

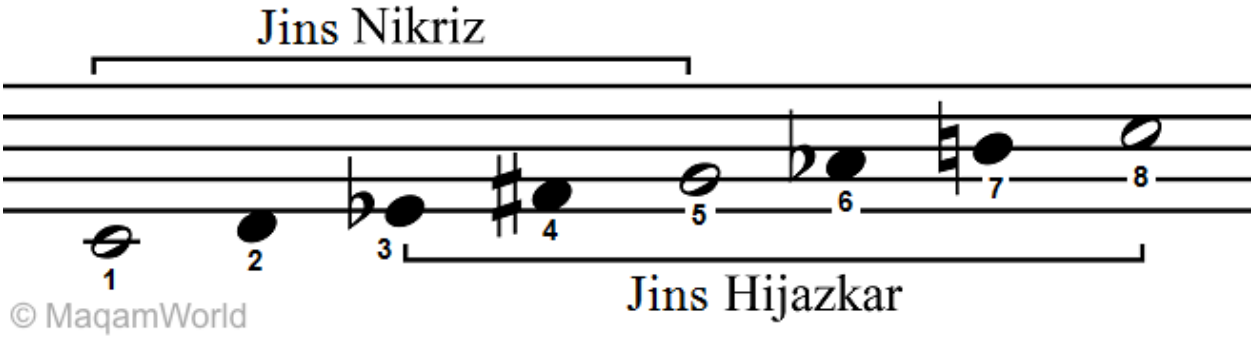

Figure 1: Maqam Nawa Athar divided into two jins explained by Maqamworld.com

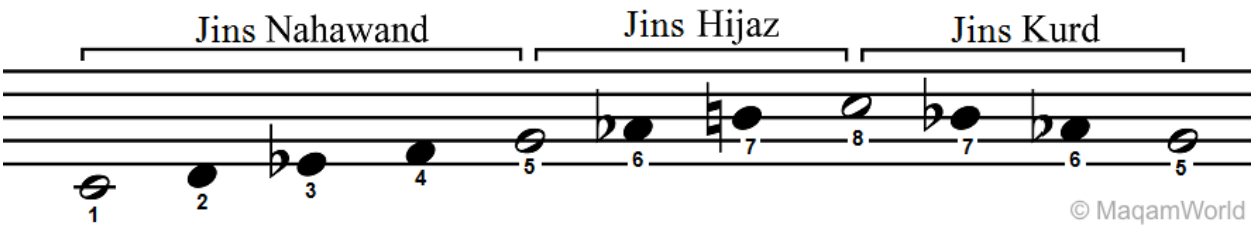

Figure 2: Maqam Nahawand divided into three jins explained by Maqamworld.com

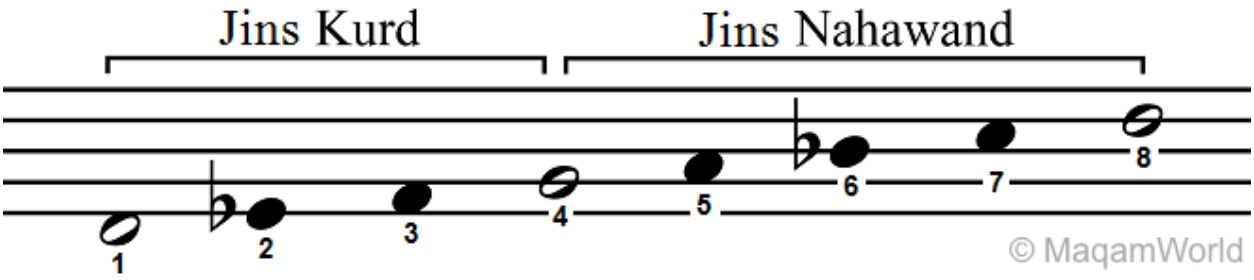

Figure 3: Maqam Kurd divided into two jins explained by Maqamworld.com

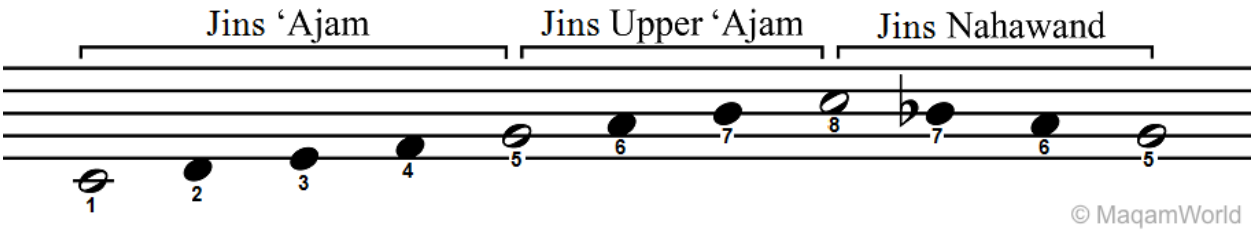

Figure 4: Maqam Ajam divided into three jins explained by Maqamworld.com

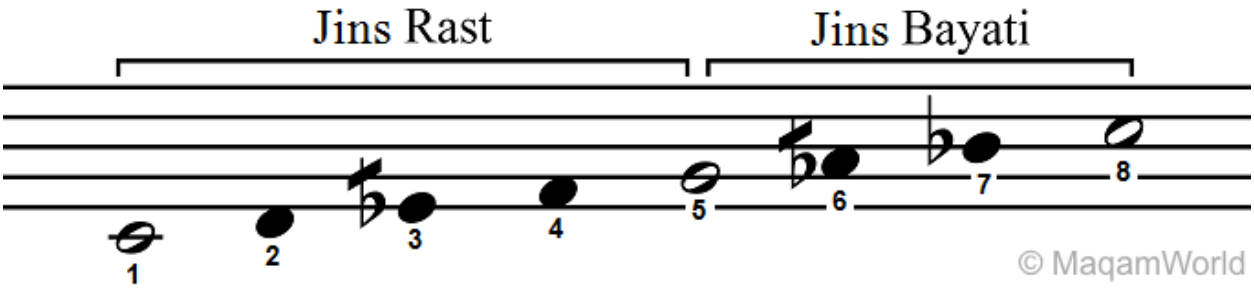

Figure 4: Maqam Yakah (under Rast family) divided into two jins explained by Maqamworld.com

Besides the unique tonal character of Arab music, the instruments used to play such music have a distinct auditory timbre. Traditional Arab music instruments, such as “oud”, “qanoun” and “nay”, have been linked to Arab music especially classical/ traditional/ genuine Arab music (Globson et al., 2016). Modern Arab music (popular Arab music) has replaced some “traditional” Arab instruments with western instruments such as the guitar and synthesizers (Globson et al., 2016). Maqams with western notes and characters are

commonly used in popular Arab music (Globson et al., 2016). This is particularly interesting for our study because it poses the question of effect of exposure to Arab music, both traditional and popular, on the perception of timbre and how that could affect pitch/tonal character discrimination. Popular Arab music is still Arab music that uses maqams and sometimes manually tunes their instruments to fit the quarter tone or mix between traditional and western instruments. Thus, even non-musicians who are exposed to popular Arab music on the radio have better training in differentiating maqams and western scales despite the timbre of the instrument being Arab or western.

Previous findings on the influence of musical training on pitch discrimination have proven that individuals with previous musical training have better pitch differentiation than non-musicians (Micheyl et al., 2006). In Micheyl et al.'s study, focuses on comparing pitch discrimination threshold between musicians and non-musicians. The definition of musicians in this study was defined as classical musicians with more than 10 years of experience playing an instrument every day (Micheyl et al., 2006). The main purpose of that study was to know the amount of training the non-musicians need to reach the optimal level of pitch discrimination (Micheyl et al., 2006). What makes this study different from ours is that the subjects were presented with two tones and they had to choose which one is higher in pitch (Micheyl et al., 2006), while our study focuses on the use of quarter tones and timbre. However, doing the present study with the results of Micheyl et al.'s study in mind, helps with the formation of the hypotheses and the very interesting question of whether musician would do better than non-musicians overall despite their cultural background or would the non-musician subjects with Arab background do better than even the musicians with western background.

A study by Richard Parncutt and Annabel J. Cohen (1995) examines identification of microtones in the cent system. This study poses the question of what is the limit of microtonal identification and if musical experience has a positive impact on microtonal pitch discrimination (Parncutt and Cohen, 1995). The study consisted of two experiments on 30 subjects (half musicians and half non-musicians). The results showed that the overall performance was better with larger scale steps intervals (larger cents) than with smaller ones and that musicians were able to identify pitches separated by smaller cent steps intervals better than non-musicians (Parncutt and Cohen, 1995). Parncutt and Cohen's study (1995) proves that musical experience does not have a positive effect on pitch discrimination between semitones but also in smaller microtonal intervals.

Regarding timbre, previous studies such as the one by Allan Vurma focuses on the analysis of timbre sensitivity over the response bias of different type of instrumentalists. His study compares the sensitivity and response bias of pianists and string players. The subjects had to discriminate between two pitches/tones with different timbres (bright and dull) (Vurma, 2014). Their results have shown that string players had

higher sensitivity and their perception was less influenced by the change of timbre and pitch shift than pianists (Vurma, 2014). This is particularly interesting because based on the nature of the two instruments, string players, since they play without frets and have to maintain tonality, therefore, have access to microtones whereas pianists are more exposed to the equal tempered semitones system.

Being exposed to a certain genre of music that come with its own tuning system affects many areas of auditory perception (Globerson et al., 2016). However, despite the various studies done regarding how microtonal exposure background affects pitch perception, not much was done around Arab music scales (maqams). On the other hand, despite numerous timbre perception studies, very little was done focusing on the perception of Arab music instruments' timbre. This is the main purpose of this study, to answer the following questions; can early and daily exposure to Arab music and Arab music instruments affect the perception of microtonal Arab scales (maqams and ajnas)? Can familiarity with maqams played with both Arab and western instruments help identify the nature of the scale more accurately?

Our design focuses on presenting Arab and western scales stimuli played by different "instruments" and computer-generated tones. The subjects would have to identify if the presented scale is "western" or "Arab". This would help answer our most important question; can non-musicians with Arab cultural background do better than western musicians? If they do, then this proves our hypotheses that despite musical training, cultural background influences accuracy in microtonal scale recognition despite the timbre presented.
The dilemma is the contradicting hypotheses we have that we'll either find that musicians will do better than non-musicians and that musicians with Arab music background would perform better than western non-musicians, or that individuals with Arab cultural background (which means with early and almost daily exposure to Arab microtonal music) would do better than subjects with western background despite the musical training experience they have.

Our first hypotheses is that musicians would be able to discriminate quarter tone scales better than non-musicians due to their long-term musical training. Therefore, we expect lower error rates from musicians despite the timbre.
Our second hypotheses which would contradict our first hypotheses is that participants with Arab background would be able to identify maqam scales correctly despite the timbre. However, we expect that non-musicians would mistake western scales as Arab maqams when played with the oud. In general, we expect that western scales would be mistaken to Arab maqams when played by the oud and vice versa.
We also believe that between musicians and non-musicians, Arab musicians would perform well overall than western musicians since they are exposed to both music theory concepts and timbres.

Methods

Participants

The study had 5 participants; 4 of western background. The subject with Arab background is a non-musician participant. Musician participants have a mean of 16 years of experience playing music of diverse genres. Participants were asked to fill a short survey in the beginning of experiment to document more of their background and music listening patterns. Participants were 1 female and 4 males. They confirmed in the survey that they listen to music every day, 2 participants said they listen to music actively while the other 3 said that they listen to music actively (intentionally) and passively (taking in whatever is playing in the car or the store). The participant with Arab background marked that they listen to both Arab and western music.

Stimulus

The experiment contained 45 audio sequences; 4 maqams with quarter tones (bayati (Fig.5), rast (Fig.6), sikah (Fig.7), saba (Fig.8)), 2 maqams with unique pitch intervals but no quarter tones (hijaz (Fig.9), nawa-athar (Fig.1)), 3 maqams that have the exact same sequence interval spacing as western scales (nahawand = harmonic minor (Fig.2); kurd = phrygian (Fig.3); ajam = major (Fig.4)), and 6 western scales (dorian (Fig.10), lydian (Fig.11), mixolydian (Fig.12), locrian (Fig.13), minor (Fig.14), phrygian 'repeated' (Fig.15)). Each scale was played by three instruments: oud, midi clarinet generated through the audio coding language called Chuck, and a sine wave also generated by Chuck. Participants did the experiment through a survey link that contains the sounds and choice options (Arab or western). The subjects used their own computers and personal headphones or earphones. It was advised from the participants to perform the experiment in a quiet setting; however, we did not have much control over that factor. It's important to mention that some participants were from middle eastern countries where the internet connection is not ideal therefore it would slow down the experiment process and thus, exhaust the subject which would affect the results. All the samples followed the notation and the keys in the figures in this report.

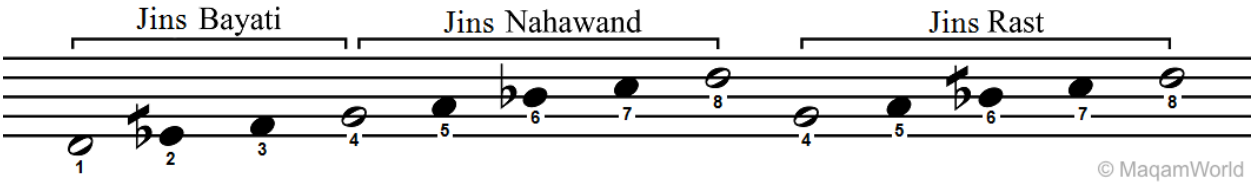

Figure 5: Maqam Bayati (from maqamworld.com)

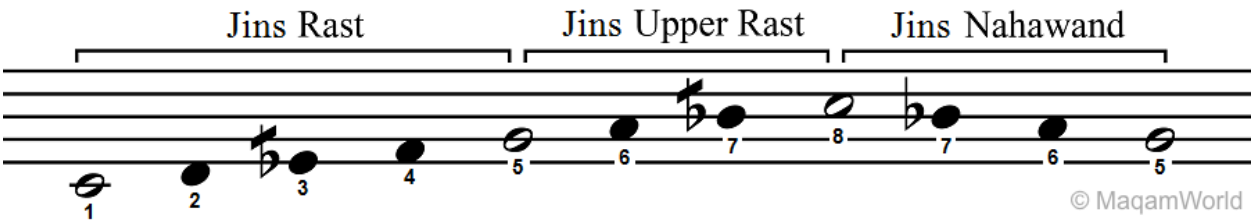

Figure 6: Maqam Rast (from maqamworld.com)

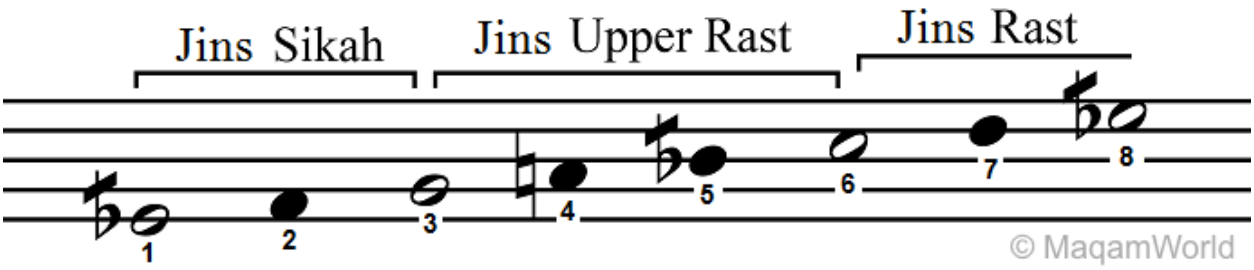

Figure 7: Maqam Sikah (from maqamworld.com)

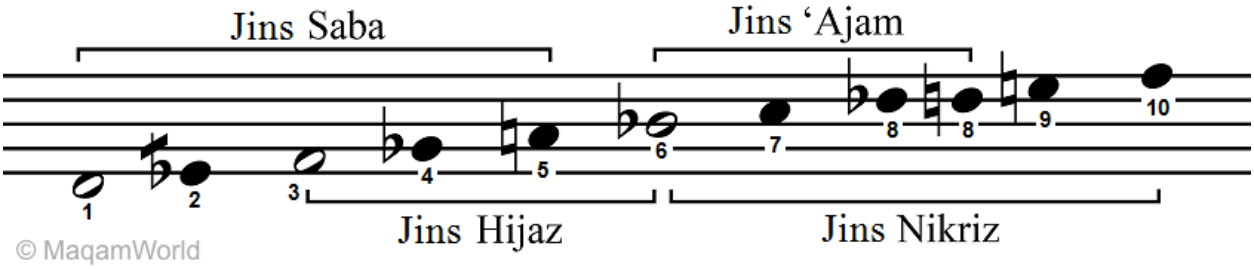

Figure 8: Maqam Saba (from maqamworld.com)

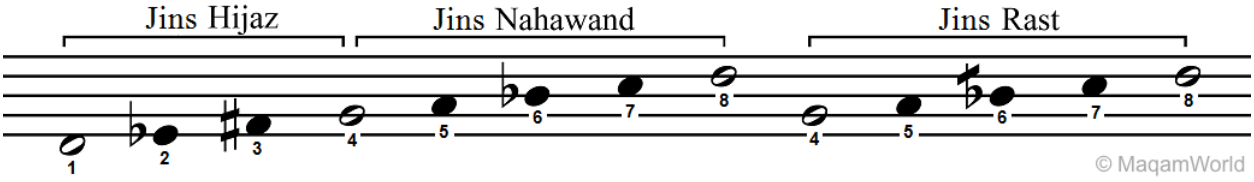

Figure 9: Maqam Hijaz (from maqamworld.com)

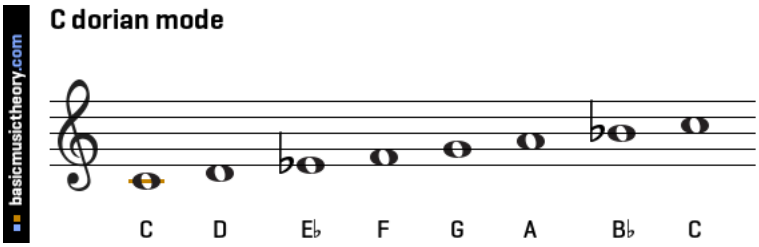

Figure 10: C Dorian (from m.basicmusictheory.com)

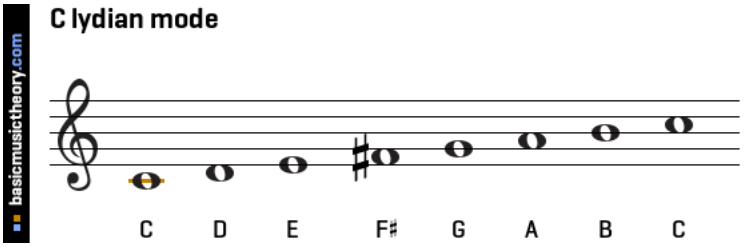

Figure 11: C Lydian (from m.basicmusictheory.com)

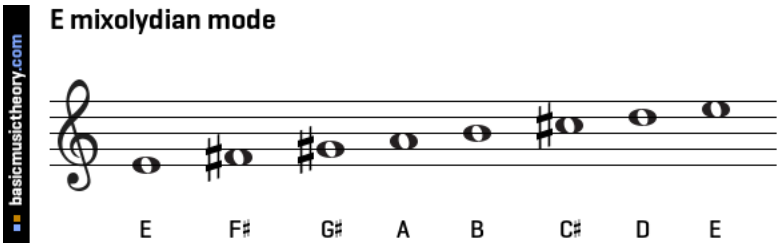

Figure 12: E Mixolydian (from m.basicmusictheory.com)

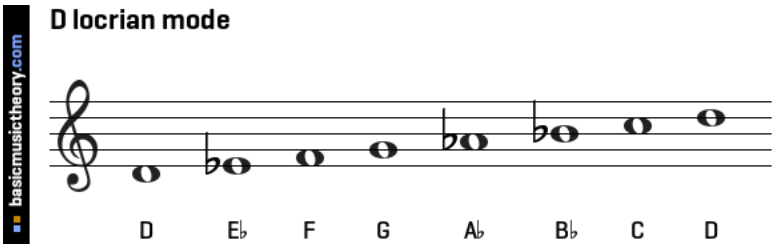

Figure 13: D Locrian (from m.basicmusictheory.com)

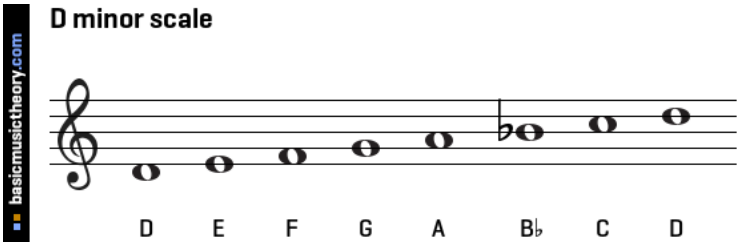

Figure 14: D Minor (from m.basicmusictheory.com)

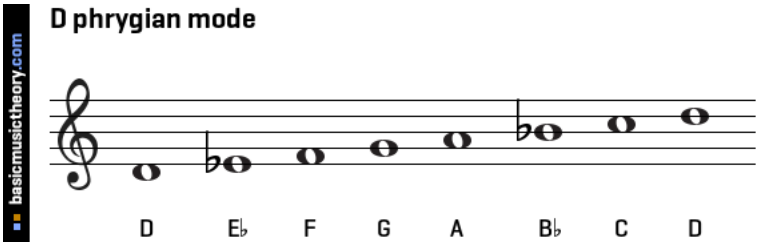

Figure 15: Phrygian (repeated) (from m.basicmusictheory.com)

Procedures

Each note is 1 second, thus, each scale/maqam was 8 seconds long. The experiment contained a total of 45 scales/maqams; each scale is played by oud, clarinet, and a sine tone. Therefore, altogether the experiment time is 6 minutes. The experiment was repeated twice so it is a total of 12 minutes. However, we have no control on how many times the subject would decide to repeat the sequence, and thus, we don't have much control on the exact time it took for each subject.

Data collection and Analysis

We collected data as the error rate of each scale. We compared the error rate (in percentage) of every instrument/timbre for every scale sequence. For example, for maqam Bayati, we have a plot comparing the error rate of Oud, clarinet, and sine wave.

Results

Trial 1:

Results of the first trial show that subjects were mostly correct with quarter tone maqams played by the Oud and Clarinet. We notice maqam Bayati as the most confusing with all three timbres. Error rate was low of the Oud with maqams that do not contain quarter tones, however it's higher with the other timbres. We notice varying results between correct and error rates for the mixed maqams/scales that are theoretically the same as western scales. Overall correct rate is high for the western scales. We find some errors with the oud playing western scales.

Trial 2:

We find the error rate lower with quarter tone maqams on the second trial. The highest error rate is with the sine wave timbre when it comes to quarter tone maqams. With maqams that do not contain quarter tones, the error rate remains relatively low. For mixed scales, we technically cannot point what is correct or error because these scales are both western and Arab maqams. However, we notice that in the second trial subjects answer with Arab when the scale is played by Oud the most, then less with the clarinet, and the least with the sine tone. With western scales, we find similar results to the first trial. Subjects tend to call the scale Arab when it's played by Oud but overall the error rate is low.

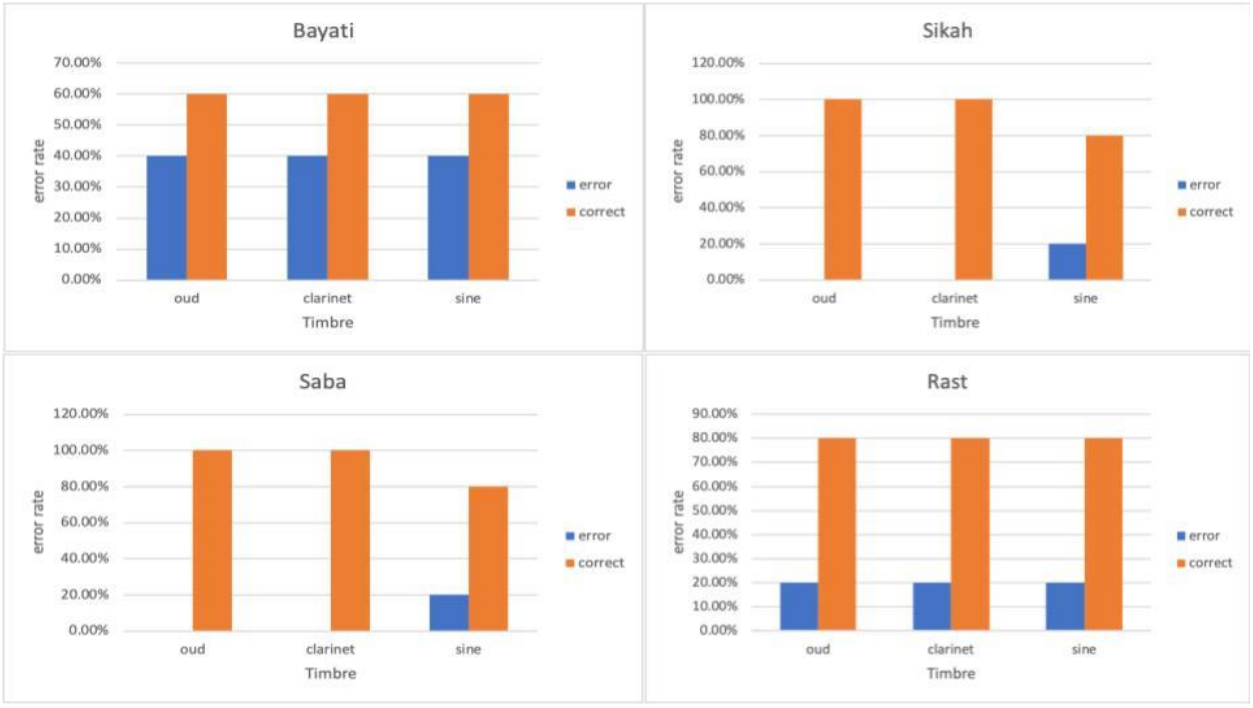

Figure 16: Error Rate (%) of Maqam Scales with Quarter Tones (Trial 1)

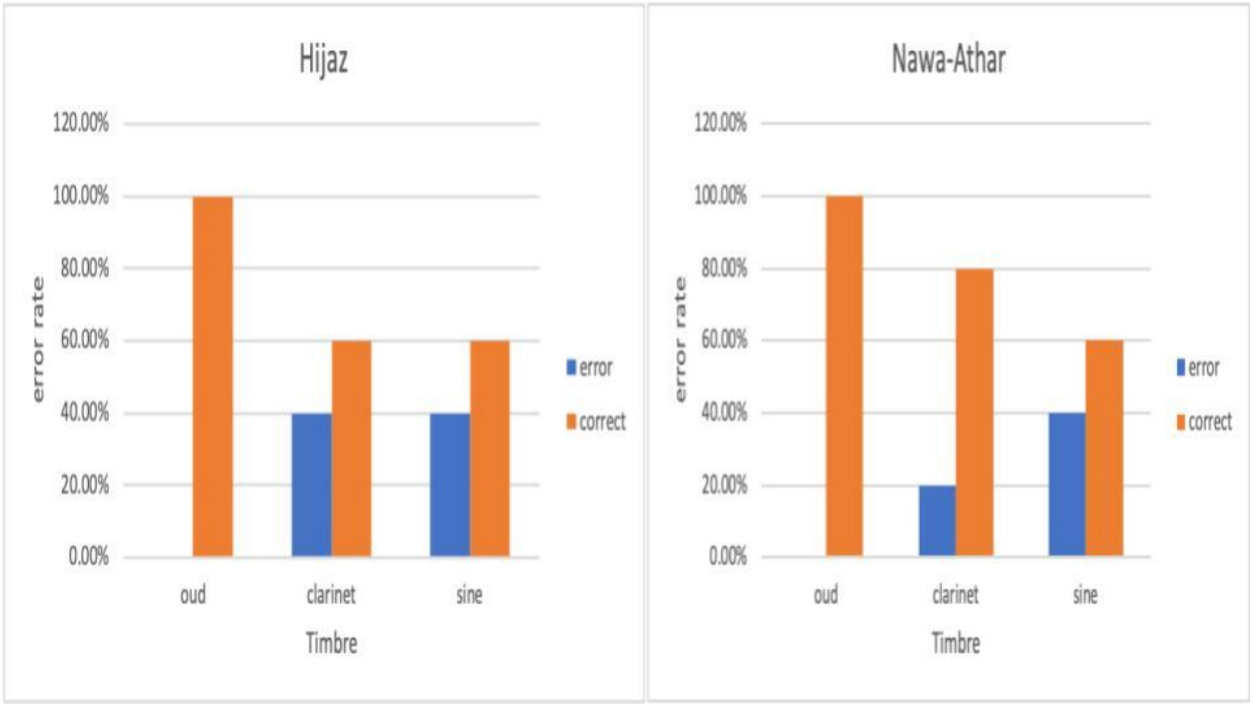

Figure 17: Error Rate (%) of other non-quarter tone Maqams (Trial 1)

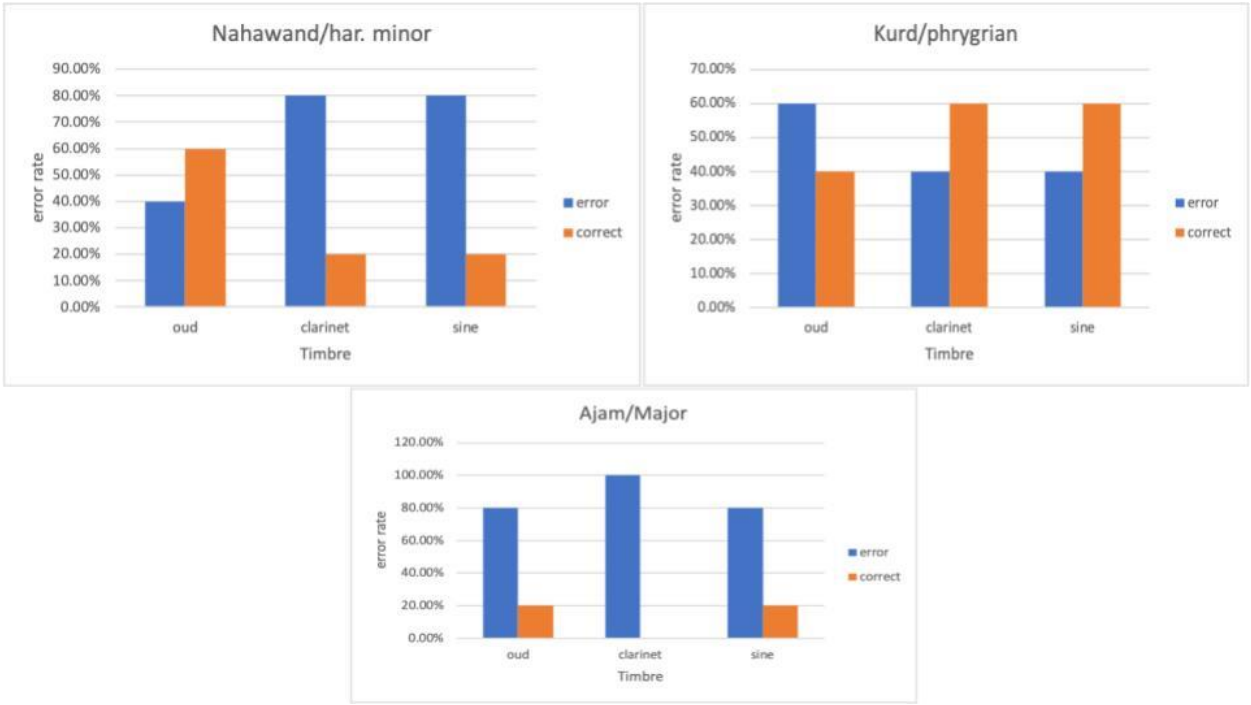

Figure 18: Error Rate (%) of mixed Maqams with western scales (Trial 1)

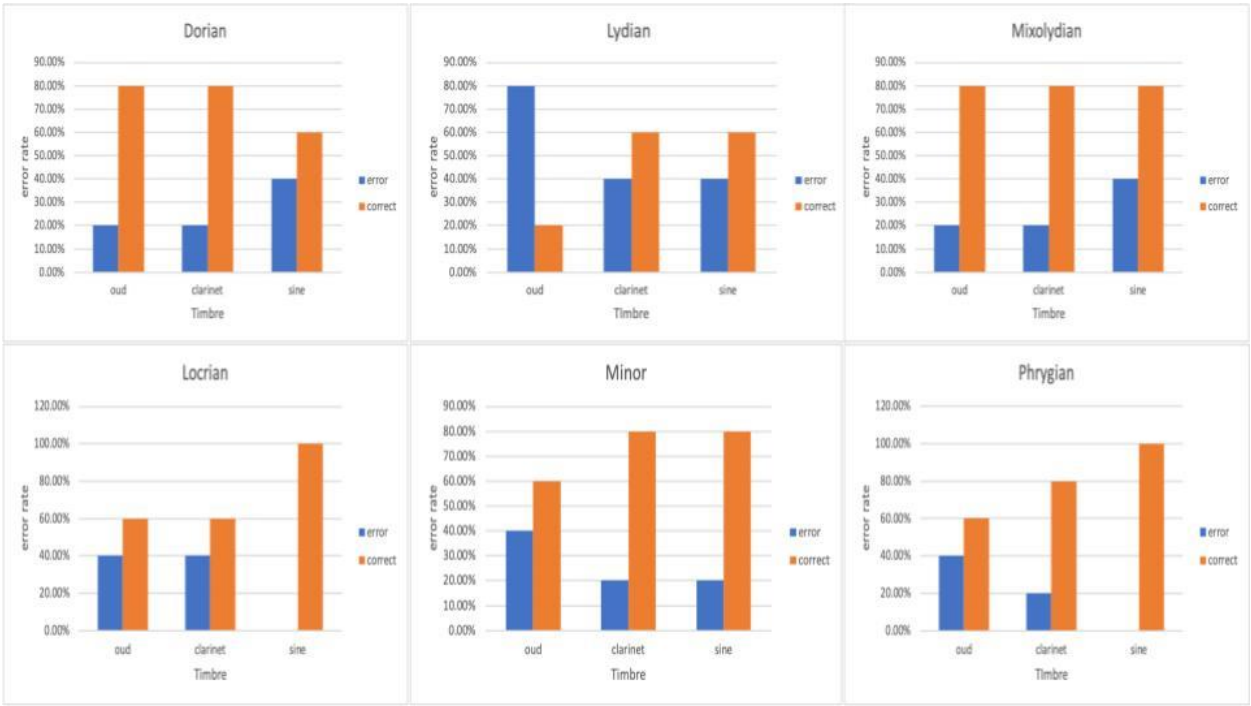

Figure 19: Error Rate (%) of Western scales (Trial 1)

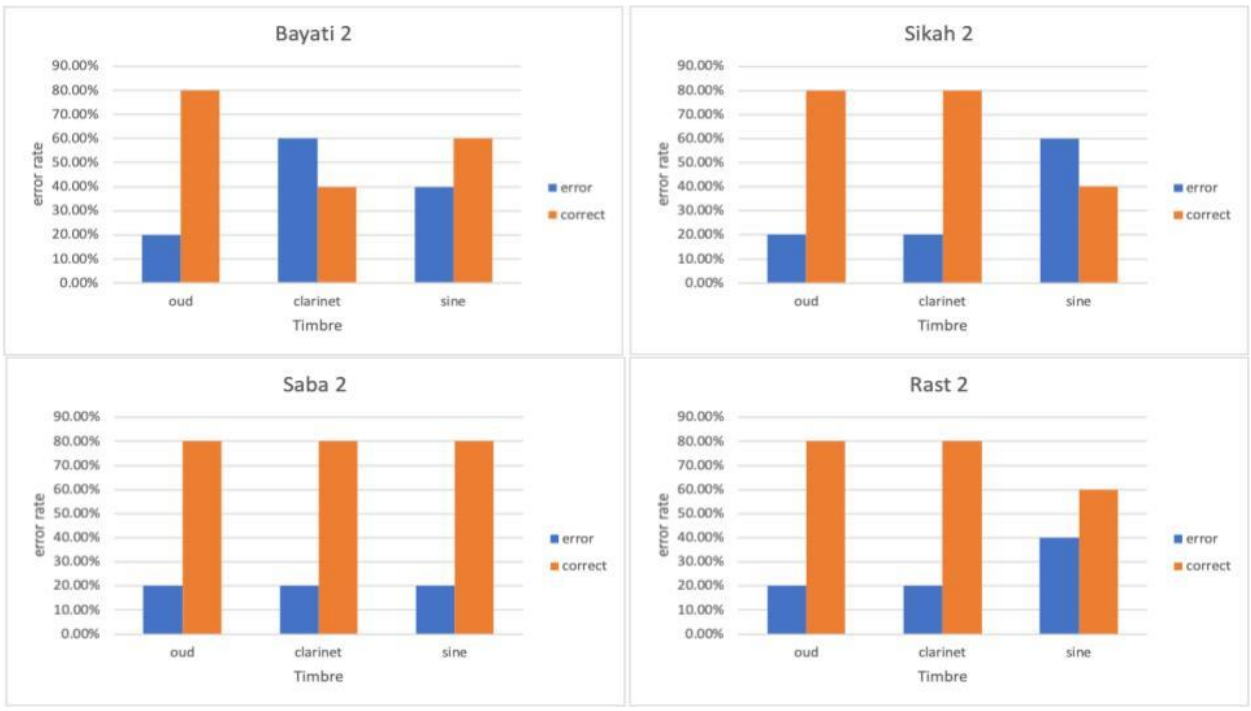

Figure 20: Error Rate (%) of Maqam Scales with Quarter Tones (Trial 2)

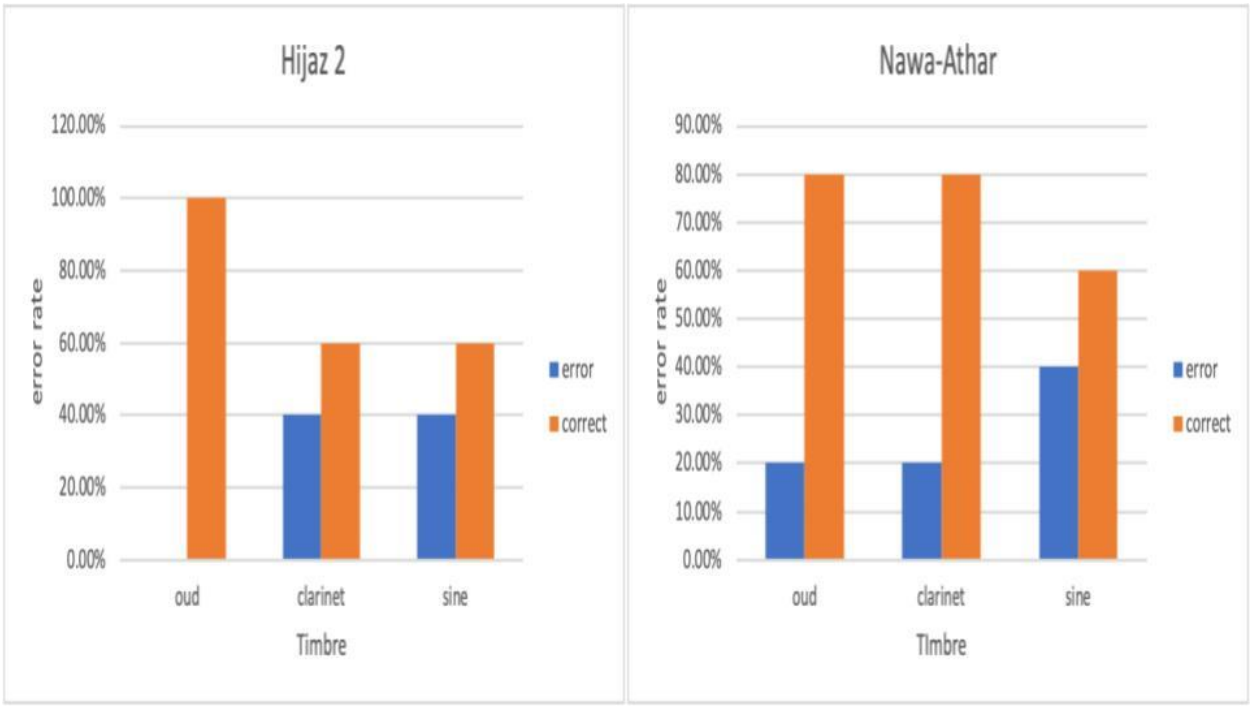

Figure 21: Error Rate (%) of other non-quarter tone Maqams (Trial 2)

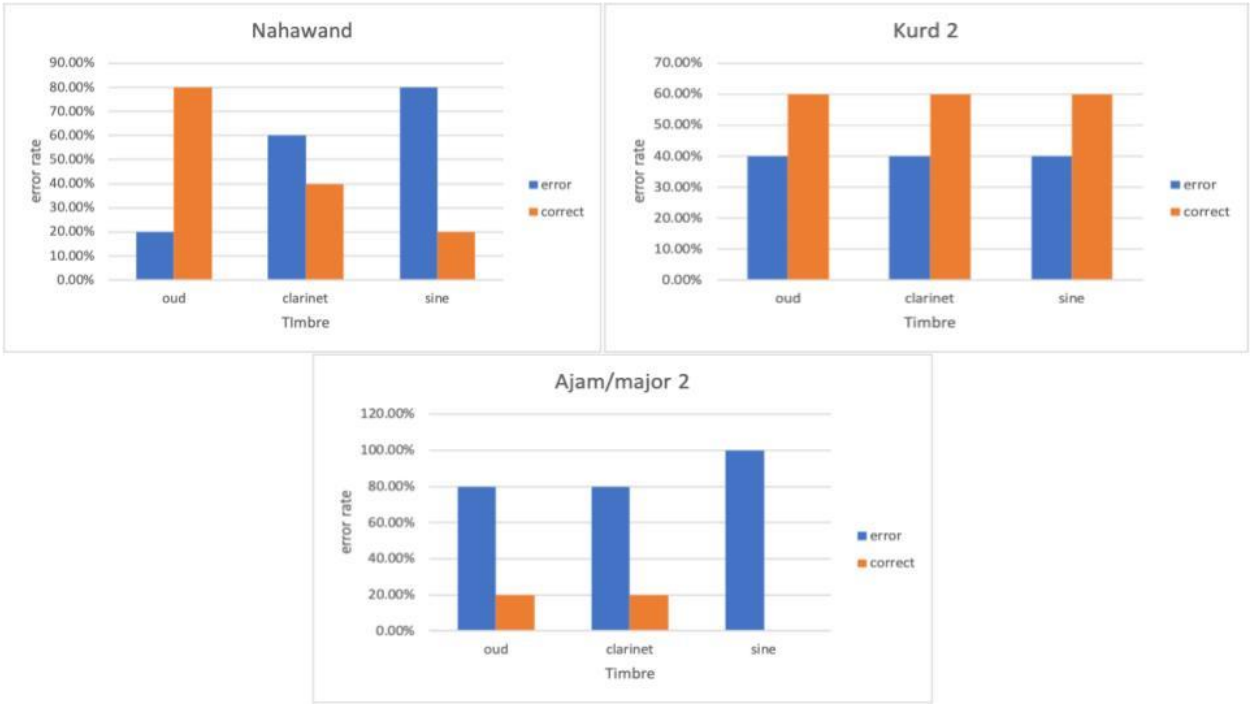

Figure 22: Error Rate (%) of mixed Maqams with western scales (Trial 2)

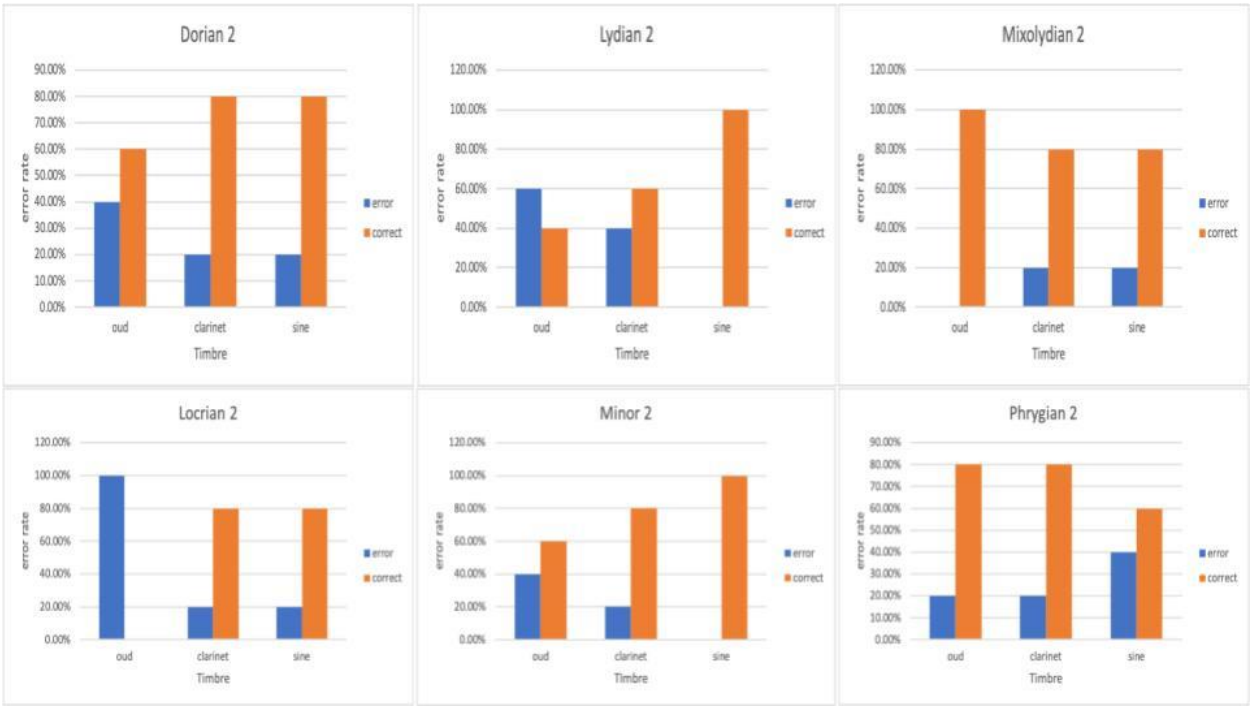

Figure 23: Error Rate (%) of Western scales (Trial 2)

Discussion

We notice two factors that changed in the results between the two trials; overall improvement and decrease

in the error rate, and more confusion with the oud timbre. What would help us understand timbre influence on pitch perception would be the mixed maqams and scales because there are no right or wrong answers since the scales are identical. However, what we will look at is which timbre was chosen as western and which one was chosen as Arab. This also applies on western scales. The overall low error rate with the western scales is affected by having the majority of the subject of western background. We had only one subject with Arab cultural background. They're a non-musician and seemed to be doing well with maqams but had the highest error rate with western rate.

The first noticeable result is the low error rate with quarter tone maqams. Despite the timbre, subjects tend to choose the quarter tone scales as Arab. We even notice an improvement from the first trial to the second. This means that despite the background of the subject, quarter tones are apparent even when played by a clarinet or a sine wave tone.
Secondly, we notice a significant high percentage of subjects choosing mixed scales as Arab when played by the Oud in both trials. This confirms our main hypothesis that timbre does affect the perception of quarter tone pitch. Even when the scales did contain quarter tones, subjects still chose them as Arab when played by the oud. Even with western scales, some subjects selected them as Arab when played by the oud. With the clarinet, the error rate was lower than with the oud, however we did notice a tendency to choose clarinet played scales as Arab. There are two factors that could affect these results; the first is that the clarinet midi audio would sound like the Arab instrument "nay" which would help subjects identify maqams but would confuse some with mixed and western scales. The second factor is that if the subject was exposed to more Arab than western scales throughout the experiment before they reached a particular mixed or western scale, they would be inclined to choose it as Arab as well.

We find that our hypotheses were proven correct because the subject with the Arab background (non-musician) was doing better than the rest of the subjects (musicians and non-musicians) with Arab maqams, however they did not do well with western scales. Thus, due to the lack of musical training, especially with western music theory, non-musician subjects with Arab background that are exposed to Arab music on daily basis tend to do well with identifying Arab music scales despite the timbre presented but not so well with western scales. This contradicts with a section of our hypotheses because even when we find that participants with Arab backgrounds do better than the rest of the subjects but only with Arab maqams and actually, they had the highest error percentage with western scales. This proves the importance of previous musical training in pitch discrimination (Michyel et al., 2006) and timbre sensitivity (Vurma, 2014).

The potential issue that our data could have is the number of subjects and having no control over the audio

setting of the experiment. It would be preferred to do similar experiment using the original microtonal tuning system, however it would create complications in simplifying the data results.

Conclusion

We can concluded, with the limited data we have, that timbre and pitch are correlated and timbre affects pitch perception in the microtonal Arab context. We also conclude that our study confirms that previous auditory experience affects the perception of such correlation, in our case it's in the microtonal Arab music maqams context. The experiment could further be improved by having more accurate Arab maqams so that mixed maqams would not sound exactly the same as western scales. Even maqams that are not in common with western scales yet do not contain "quarter tones" would not sound the same.

References

Eitan Globerson, Taiseer Elias, Nadia Kittany, Amir Noam, Pitch discrimination abilities in classical Arab-music listeners, *Applied Acoustics*,Volume 102, 2016.

Micheyl, C., Delihommeau, K., Perrot, X., & Oxenham, A. J. (2006). Influence of musical and psychoacoustical training on pitch discrimination. *Hearing Research*, *219*(1–2), 36–47.

Parncutt, R., Cohen, A.J. Identification of microtonal melodies: Effects of scale-step size, serial order, and training (1995) Perception & Psychophysics, 57 (6), pp. 835-846.

Sami Abu Shumays, *Maqam* Analysis: A Primer, *Music Theory Spectrum*, Volume 35, Issue 2, 2013, pp. 235–255.

Vurma, A. Timbre-induced pitch shift from the perspective of Signal Detection Theory: The impact of musical expertise, silence interval, and pitch region (2014) Frontiers in Psychology, 5 (JAN), art. no. Article 44, .