This is a repository copy of *Temperament Systems Influence Emotion Induction but not Makam Recognition Performance in Turkish Makam Music*.

Article:

Abstract

We tested how induced emotions and Turkish makam recognition are influenced by participation in an ear training classes, and if either is influenced by the temperament system employed. The ear training class was attended by 19 music students and was based on the Hicaz makam presented as a between-subjects factor in either unfamiliar Turkish Original Temperament (OT, pitches unequally divided into 24 intervals) or familiar Western Equal Temperament (ET, pitches equally divided into 12 intervals). Before the and after the class, participants listened to 20 music excerpts from five different Turkish makams (in both OT and ET versions). Emotion-induction was assessed via GEMS-25, and participants were also asked to identify the makam that was present in the excerpt. The unfamiliar original temperament was experienced as less vital and more uneasy before the ear training class, and recognition of the Hicaz makam increased after ear training classes (independent of the temperament system employed). Results suggest that unfamiliar temperament systems are experienced as less vital and more uneasy. Furthermore, being exposed to this temperament system for just one hour does not seem to be enough to change participants' mental representations of it or their emotional responses to it.

Keywords: Temperament systems, emotion induction, recognition performance

Temperament Systems Influence Emotion Induction but not Makam Recognition

Performance in Turkish Makam Music

There are various musical characteristics that are associated with cognitive processing of and emotional meaning in music. For instance, happy music tends to be higher in pitch, whereas sad music is often associated with lower pitch (Juslin & Laukka, 2003). Accordingly, numerous studies have been conducted which test the emotional qualities and recognition performance of music parameters including tonal, syntactic, and rhythmic features (Gabrielsson & Lindström, 2010; Juslin & Timmers, 2010; Dowling, 1984; Lui, Vessel and Kam, 2010). Despite being the foundation of syntactic pitch relations, from a pitch position in an octave to the musical phrase, to the best of our knowledge, the emotional qualities of temperament systems and the role of temperament systems on recognition performance have yet not been studied before.

In music theory, temperament systems are referred by different terms such as tuning systems or scale systems. Throughout this article, we are going to use the term *temperament systems* in order to be consistent with the historical distinction between pure intervals and tempered intervals (Rasch, 1983). Temperament systems describe culturally determined and idealised pitch relations (Kopiez, 2003). Usually, these pitch relations are based on consonance (Biby, 2003) and differ regarding the partition of the pitch continuum. For example, in Western culture, the most common temperament system is the twelve-tone equal-tempered system in which an octave is divided into 12 successive pitch spaces, each sounding half of the whole tone. The most noticeable differences among temperament systems from different cultures are the subdivision of a whole tone. For instance, the Indian Shruti 22 note system dominantly uses 22 divided pitches in an octave and in this approach, one whole step is formed by five unequally divided (from ratio 1:1 to 9:8) pitches.

In this study, we aimed to explore the role of temperament systems on emotion induction and recognition performance by presenting an unfamiliar musical syntax in familiar and unfamiliar temperament systems. For this reason, we chose Turkish makam music which is traditionally performed in an unequally divided 24 interval temperament system. In Turkish makam music, in comparison to the western equal temperament (ET) system, a whole step is divided into nine equal steps (with the Holdrian Comma), and a half step is divided into four equal steps. Each of these steps is called a coma; the smallest interval unit of the Turkish makam music system. As shown in Table 1, the original temperament (OT) system (known as Arel-Ezgi-Uzdilek) uses unequal intervals, meaning that the notes used are not divided equally within the octave. This means that not all nine comas that exist in a whole step are used.

In Western music, a scale is produced by obtaining a new tetrachord (a pitch set which includes four notes and three intervals units) above another tetrachord. However, Turkish *makam* music uses trichords, tetrachords and pentachords to produce scales and those chords are given names for their 'flavour' or melodic character at the note where they move melodically.

Table 1
The Original Turkish Temperament System Interval Names

Interval Names	Letter Signs of Intervals	Cent Values of Intervals	International Interval Names
Fazla	F	23.46	
Bakiye	B	90.22	*Limma*
Kucuk Mucennep	S	113.69	*Apotom*
Buyuk Mucennep	K	180.45	*Pythagorean Diminished 3rd*
Tanini	T	203.91	*Major 2nd*

Another vital component of Turkish music is the *makam* itself. A makam is a melodic texture consisting of progressions, directionality, tonal and temporary centres and cadences. It usually compares with the concept of a scale. From a perceptual perspective, makams contain additional melodic patterns which aid recognition their emotional expressivity, in addition to providing a sense of a tonic and dominant (Bozkurt, 2008; Yarman & Karaosmanoglu, 2014).

Temperament systems were studied particularly with respect to performance intonation (Loosen, 1995; Kopiez, 2003; Vurma & Ross, 2006). For instance, Loosen (1995) studied the preferred tuning systems by musicians and non-musicians through scales. He compared three different temperament systems (Pythagorean, 12 equal-tempered and just intonation) through a computer-generated diatonic C Major scale. Accordingly, temperament system preferences have been differentiated in accordance with participants' played instruments (where there more familiar system was preferred) and non-musicians showed no significant preference differences. Accordingly, these results indicate the relevance of learning and familiarity in the experience of temperament systems. Much research also examined tonal hierarchy sensitivity and expectations through familiar-unfamiliar stimuli pairings with familiar-unfamiliar participant pairings (Castellano, Bharucha and Krumhansl 1984; Demorest et al., 2008; Eerola, Louhivuori and Lebaka 2009; Curtis and Bharucha 2009). However, most of these cross-cultural studies, despite including comparative evaluations of pitch and melodic structures, did not include the temperament system as an experimental factor. Here, mostly, the 12 ET system was used or not explicit details about which temperament system was reported.

Previous research shows that the acquisition of musical knowledge begins from the prenatal period (Partanen et al., 2013) and differs based on the cultural background of a listener (McDermott et al., 2016; Patel & Demorest, 2013). Despite some contradictory findings and theories, the theory of auditory statistical learning (Vapnik, 1998) provides the

most comprehensive set of explanations for listeners' musical mental representations. Accordingly, the theory of statistical learning predicts that listeners acquire musical knowledge about statistical regularities in music through passive exposure to them (Huron, 2006). Based on this knowledge, listeners form expectations that can be violated or confirmed while listening to music.

Statistical learning in music has been studied in many ways including research on tonal (Creel, 2011), melodic (Cuddy and Lunney, 1995; Tillmann, Bharucha and Bigand, 2000) and rhythmic (Barwick, 2002; Schultz, et al., 2013) expectations. Furthermore, the role of expectation violations has been tested within also a cross-cultural contexts (Lynch and Eilers, 1991; Krumhansl and Sheppard, 1979; Curtis and Bharucha, 2009; Raman and Dowling, 2016; Polak, London and Jacoby, 2016; Demorest et al., 2008; Balkwill and Thompson, 1999). Several authors have suggested that moments of melodic expectation violations are linked to emotional responses to music (Huron, 2006; Meyer, 1956; Narmour, 1990) and recognition performance in music (Boltz, Schulkind & Kantra 1991), as violations of expectations might be perceived as arousal-inducing & emotional and might cause better recall performance. Egermann et al. (2013) were able to confirm the hypothetical link between expectation and emotion: Accordingly, those musical events that were statistically difficult to predict for a computational algorithm (simulating statistical learning in listeners), lead to increases of continuous arousal ratings, a decrease in valence ratings, and increases in physiological arousal.

Aims and Research Questions

We aimed to show that temperament systems might play in a relevant role in mental pitch representations and hence for expectations. This suggestion is based on our proposal that temperament systems act as an ecosystem of all possible musical pitch relations and

expectations. Accordingly, in this exploratory study, our underlying research questions were the following:

- RQ1: *Does the temperament system in which a Turkish makam is presented influence a listeners' emotional response to it?*

- RQ2: *Are listeners able to recognise a Turkish makam after attending an ear training and does this recognition depend on the temperament system employed in the training?*

- RQ3: *Do listeners' emotional responses to the unfamiliar temperament system change through exposure in ear training?*

We, therefore, predict that unfamiliar temperament systems lead to different emotional responses compared to familiar temperament systems (due to an increase in pitch-based expectation violations). Furthermore, in line with the theory of statistical learning, we hypothesise that listeners' cognitive and emotional responses change through exposure to the temperament systems in ear training.

Method

Experimental Design

We employed a mixed between- and within-factorial design in this study. A pre-training experiment examined participants' emotional responses to five unfamiliar makams presented in their original temperament system and an adapted equal temperament version of them. In addition to that, we also tested whether participants were able to identify the name of the makam correctly.

Subsequently, participants were randomly assigned to one of two different one-hour long ear training class that focused on the general features of the *Hicaz* makam. One version of the training employed the 24-interval OT system and one the 12-interval ET system. In a subsequent post-training experiment, all participants rated the emotional responses to the

same makam excerpts once more that were presented in the pre-experiment and completed another makam identification task.

Participants

19 music students who were enculturated in the Western temperament system participated in this study (mean age=23 years, SD=4.8 years, ten males; formal music education mean=11 years, SD=5 years). Except for one (excluded from analysis), all other participants were unfamiliar with makam music.

Musical Stimuli

We asked five Turkish makam music experts to suggest makams and two songs per makam that match the nine different emotional qualities of the GEMS-25 scale first-order factors (Zentner et al., 2008). Despite some overlaps across experts' suggestions, there was no full agreement on makam and emotion pairings among experts. However, we chose among those makams suggested by experts a total of five makams: Huseyni, Mahur, Saba and Mustear Makams and two songs in according to these makams.

Accordingly, we selected two excerpts per makam and created its Original Temperament (OT) and Equal Temperament (ET) versions. In order to produce 12-interval ET versions, we adapted the makams which were originally in the 24-interval OT based on the nearest pitch principle.

In addition to that, in order to test for a potential effect of timbre (not shown here), we created three different versions of each stimulus using three different instruments (see Table 2 for full stimulus characteristics) resulting in a total of 60 stimuli. All stimuli were monophonic and were created via Mus2 Turkish notation and Finale software. In order to

eliminate the effects of other structural features on emotion induction, temperament versions

of all excerpts did not include any accentuation or articulation.

Table 2
Stimulus Characteristics

Excerpt Number	1	2	3	4	5	6	7	8	9	10
Makam Name	Hicaz		Huseyni		Mahur		Saba		Mustear	
Tempo (bpm)	144	122	100	114	132	128	87	72	66	60
Time Signature	7/16	5/8	4/4	10/8	8/8	2/4	20/4	6/4	9/8	8/8
Duration (in seconds)	68	84	61	42	59	68	27	66	32	33
Instrumentation versions	Oud, Piano, Kanun		Oud, Piano, Kanun		Oud, Piano, Kanun		Oud, Piano, Kanun		Oud, Piano, Kanun	
Temperament versions	OT, ET		OT, ET		OT, ET		OT, ET		OT, ET	

Procedure

The pre-training experiment was conducted in a listening laboratory and embedded into an

online questionnaire. Here, participants were asked to rate their emotional response

retrospectively to each stimulus presented in random order, using the GEMS-25 questionnaire

(Zentner, et al., 2008). Each instrumentation version was only randomly presented once to

each participant, creating an additional between subjects factor. Since since it did not

significantly influence participants' we are not presenting the related results here.

Furthermore, they were asked to identify the name of the *makam* from a list of 10 different

makams or select an `I do not know` option. In order to increase absorption in music,

participants wore active noise cancellation headphones. All the experiment sessions, lasted

approximately 25 minutes per participant.

Subsequently, participants were randomly assigned to one of two groups in order to

attend a one-hour long ear training class. One participant group received a music-theoretical

introduction to the *Hicaz* makam in OT and the other group in ET. Both ear training sessions

were run in a normal classroom setting and were about one-hour-long. On the day after the

ear-training sessions, all participants participated in the same listening experiment like the one before attending the class.

Ear Training Classes and Content

We selected Hicaz *makam* as the makam taught in the ear training (Figure 1). The ear training classes were devised based on the demands of the temperament system. The focus of both classes was to expose participants to the features of the selected *makam*. To do this we used Hicaz makam's traditionally defined syntactic movement characters. We created and used some well-known solfeggios which were based on tetrachord and pentachordal components of the Hicaz makam. The class was based on a gradual approach and started from basic four-note tetrachord solfeggio to a full characteristic of Hicaz makam solfeggio. To be consistent with participants' formally taught ear training methods, we did not use solmisation in vocalisations. Instead of solmisation, all participants vocalised solfeggios with a *'na'* syllable. Participants were also familiarised with some theoretical and cultural features of Turkish Makam music. Except for the use of a different temperament system, all ear training materials were identical in both classes which were also taught by the same teacher in order to eliminate any teaching style differences.
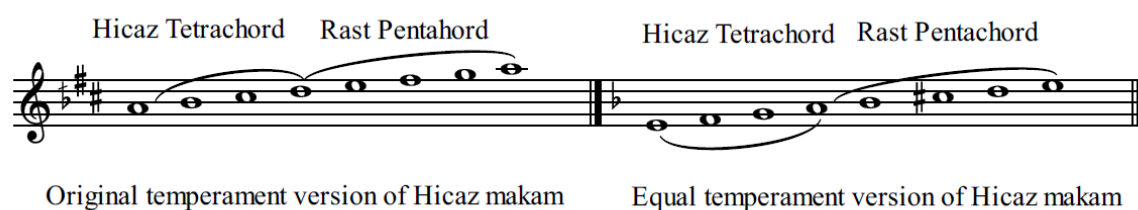

Figure 1. Hicaz makam example in the Original Temperament and Equal Temperament.

Note: *Although corresponding to the same tonic pitch frequency as ET, the OT version of the Hicaz makam has been shown on A note in G clef due to traditional notation and diapason differences between ET and OT.*

Results

Effect of Temperament System and Makam Type in Pre-Experiment

In order to reduce the number of dependent variables and increase the interpretability of results, we reduced the GEMS-25 questionnaire to the three underlying second-order factors Sublimity (combining Wonder, Transcendence, Tenderness, Nostalgia, Peacefulness), Vitality (combining Power and Joyful Activation), and Unease (Tension and Sadness) by producing a mean score for each second-order factor. We then employed a hierarchical linear modelling procedure in order to test for significant effects on these three emotion factors (using the *Mixed* procedure in SPSS). All estimations are based on restricted maximum likelihood with compound symmetry heterogeneous covariance structure (which produced overall the best AIC fit indices).

Figure 2A presents the mean intensity of the second-order sublimity factor in the Pre-training experiment (before the ear training class) separated by stimulus temperament system and makam type. According to our hierarchical linear model, neither temperament system ($F(1,153)=0.23$, $p=.64$) nor makam types ($F(4,153)=1.47$, $p=.21$) influenced experienced sublimity. The interaction between temperament system and makam type interaction was also not significant ($F(4,153)=0.51$, $p=.73$).
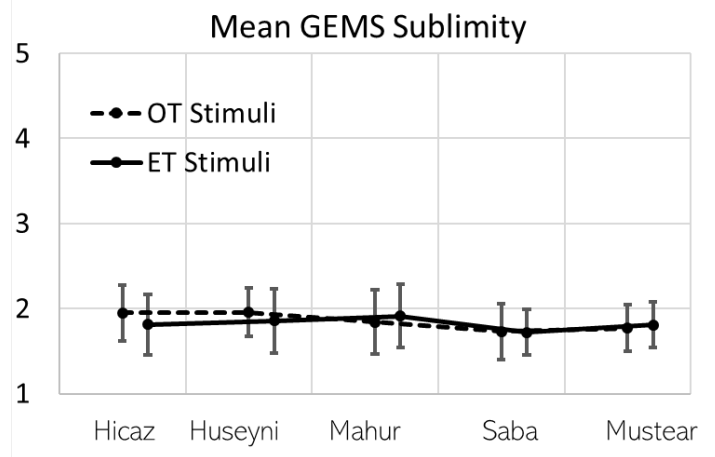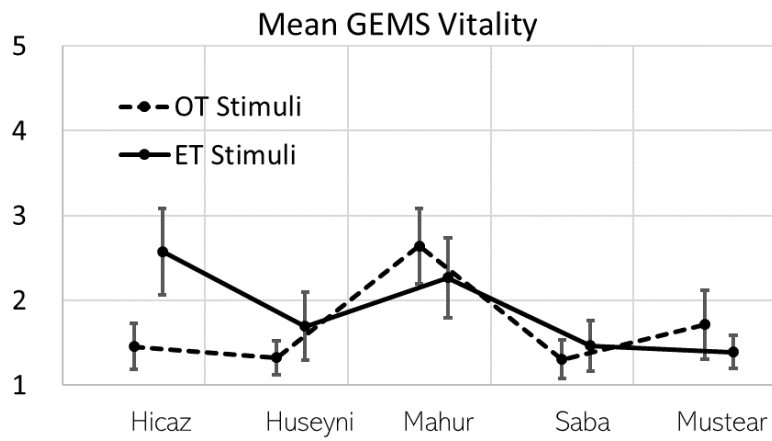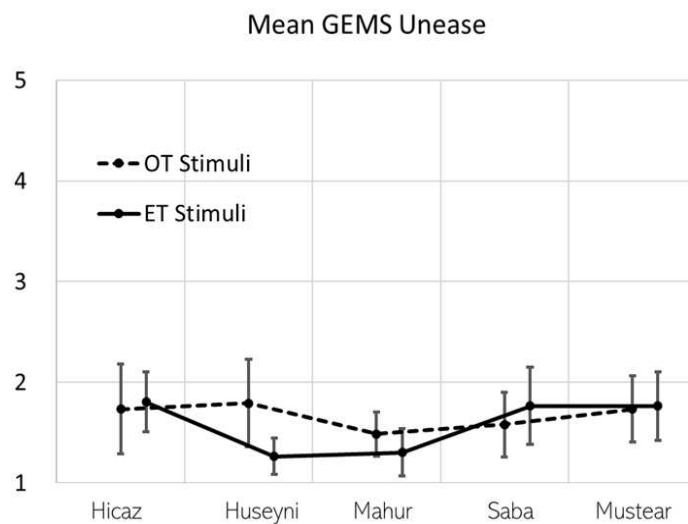
A – Sublimity

B – Vitality

C - Unease

Figure 2. Mean intensity of second-order GEMS factors in Pre-Experiment separated by stimulus temperament system and makam type with 95% CI.

Figure 2B presents the mean intensity of the second-order vitality factor in the Pre-training experiment separated by stimulus temperament system and makam type. According to our model, temperament system $(F(1,153)=6.80, p<.01)$ and makam types $(F(4,153)=28.47, p<.001)$ influenced vitality significantly. The interaction between temperament system and makam type interaction was also significant $(F(4,153)=13.29, p<.001)$. The Hicaz and Mahur makams were experienced as more vital than all other three makams. All makams' vitality ratings also differed in accordance with their temperament system. While generally, ET makam versions were mostly experienced as more vital than their OT versions (apart from the Mahur and Mustear makam), this effect appeared to be strongest for the *Hicaz* makam: Fixed effects estimates indicate the ET version of was experienced as significantly more vital $(b=1.44, t=5.27, p<.001)$ compared to the OT version.

Figure 2C presents the mean intensity of the second-order uneasiness factor separated by stimulus temperament system and makam type. According to our linear model, the temperament system did not $(F(1,153)=1.66, p=.20)$ but makam types did $(F(4,153)=4.53, p<.001)$ influence uneasiness significantly. The interaction between temperament system and makam type interaction was also significant $(F(4,153)=3.50, p<.01)$. This indicates that equal temperament version of the Huseyni makam was experienced as less uneasy than its original version.

Effect of Ear Training and Temperament System on Hicaz Makam Recognition

We asked our participants the name of the makam presented in the pre and post-training experiments. We expected that there was an increase in Hicaz makam recognition performance after the ear training and tested if this depended on the temperament systems employed in the training and listening experiments. In order to test this, we used a generalised linear mixed model with the probability of recognising the Hicaz makam correctly as an outcome variable. Only the experimental factor time was significant $(F=6.678,$

p<.01), indicating that generally the recognition rate improved after the ear training class

(Figure 3). However, no other experimental factors or interactions were significant, indicating

that recognition performance did not depend on the temperament system employed in the ear

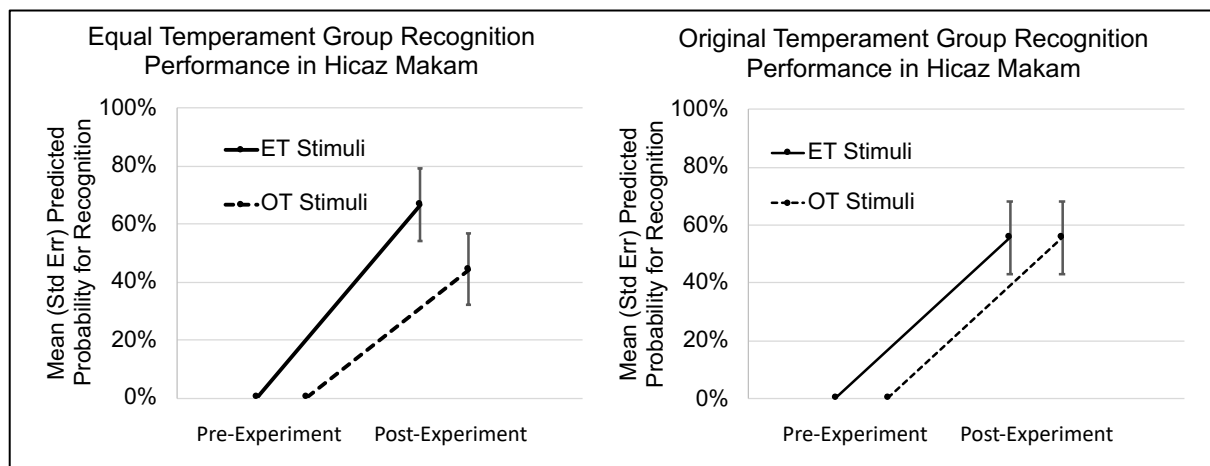training class or for stimulus presentation (see Appendix A).

Figure 3. Predicted Hicaz makam Recognition Probability separated by Time (Pre vs Post Experiment), Ear Training type and Stimulus Temperament system.
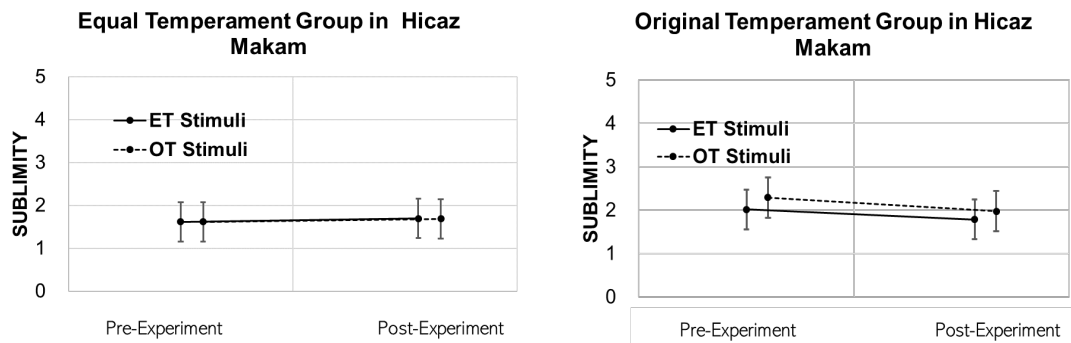
Effect of Ear Training on Emotional Experience of Hicaz Makam

As we noticed a change in participants' ability to recognise the previously unfamiliar

Hicaz makam, we then subsequently tested, if the ear training leads to any associated changes

in their emotional experience of this makam. For this reason, we again estimated a linear

mixed model for each of the three second-order GEMS factor ratings, using only data for the

Hicaz makam. We excluded the other makams from the modelling approach. The first

justification behind this is the only potential hypothesis of change for makam was for Hicaz

makam. Furthermore, exploratory analyses (not shown here) for other makams indicate that

any of the other makams emotional impacts did not change as a function of the ear training

and temperament system.

Even though Figure 4A indicates that the experience of sublimity might have

decreased after the ear training for the OT participant group (which is also indicated by a

non-significant trend in the interaction of the factors time and ear training group), no experimental factor and no interaction was significant when modelling sublimity (see Appendix B).

A – Sublimity

Equal Temperament Group in Hicaz Makam

Original Temperament Group in Hicaz Makam

B - Vitality

Equal Temperament Group in Hicaz Makam

Original Temperament Group in Hicaz Makam
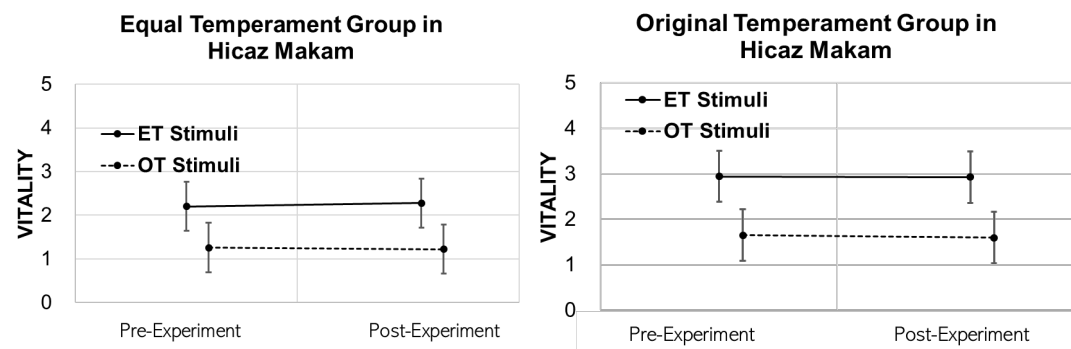
Figure 4. Mean experience of three second-order GEMS factors for Hicaz makam separated by Time (Pre vs Post-Experiment), Ear Training type and Stimulus Temperament system with 95% CI.

Figure 4B shows again (like in the Pre-Training experiment) that generally, the ET was experienced more vital than the original ($F(1,48)=74.910$, $p<.001$). However, all other factors and interactions were not significant (see Appendix C).
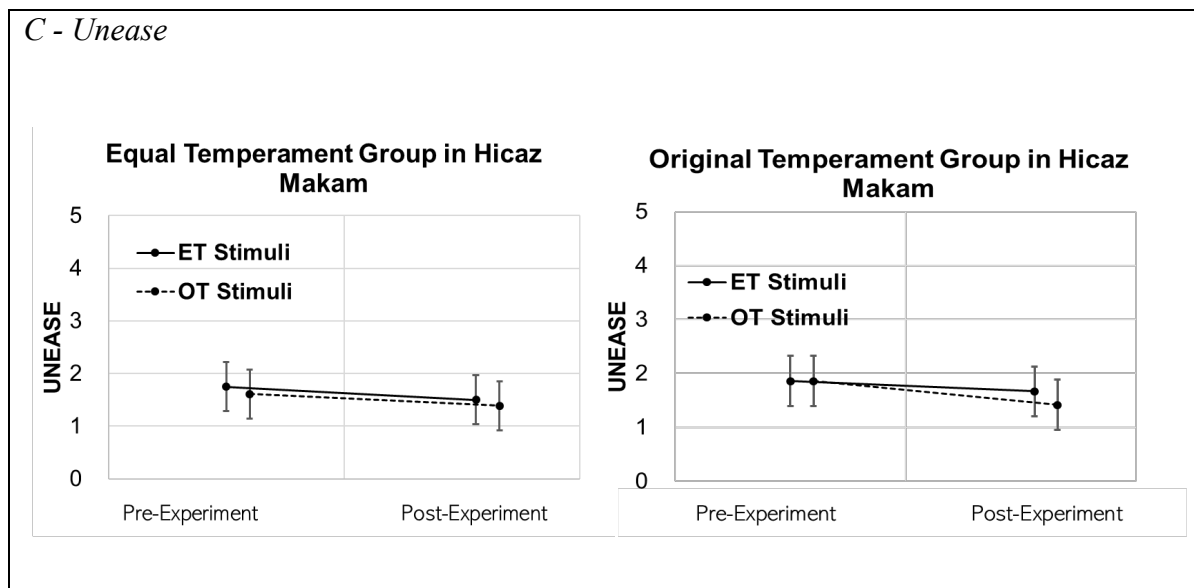
For the experience of unease, only the time factor was significant, indicating that generally, exposure to the makam decreased the experience of this feeling (Figure 4C), no other factor or interaction was significant (Appendix D).

Discussion

We tested the effects of temperament systems on emotion induction and recognition performance through adapting an unfamiliar temperament system to a familiar temperament system. The results demonstrate that different makams induced different emotions and the intensity of these emotional qualities also changed according to the presented temperament system (RQ1). As expected, recognition rates of the Hicaz makam increased from pre to post-experiment (RQ2). However, this increase did not depend on the temperament system employed in the training or listening experiment. Being exposed to the Hicaz makam during

the ear training did decrease the experience of its uneasiness (comparing ratings in pre- and post-experiment). However, this change did also not depend on the tuning system employed (RQ3).

Previous cross-cultural music cognition studies showed that musical expectations are biased by culture (Demorest et al., 2016). Demorest and colleagues hypothesised that listeners in an out-of-culture memory task might attempt to use in-culture schemata to organise culturally unfamiliar music rather than a new, more appropriate construct. This idea is supported by findings like those of Curtis and Bharucha (2009), who presented listeners with music stimuli that exploited their cultural biases, leading to incorrect recall responses for culturally unfamiliar music. Demorest, Morrison, Jungbluth, and Beken (2008) compared American with Turkish participants, and they found a positive effect of in-culture familiar music characteristics on music memory performance. In the pre-training experiment, our participants also had less cognitive schemata available to process the OT stimuli (compared with their ET versions). Therefore, without any OT temperament schemata, the OT versions might have been experienced as less vital and less positive. Furthermore, we only observed an increase in general cognitive schemata for makam syntax as a result of the ear training, indicated by an increase in the makam recognition rate. Here, we did not observe a benefit of stimuli where temperament of stimuli was congruent.

We also only observed a general, temperament-independent decrease in the experience of uneasiness for the Hicaz Makam. This general reduction of unpleasant feelings after exposure might also be similar to the mere exposure effect, described by Zajonc (1968), which has been shown in music (e.g. Peretz, Gaudreau, Bonnel, 1998; Halpern and Mullensiefen, 2008; Mungan, Akan and Bilge, 2019). We assume that the duration of the exposure in the one-hour long class might not have been long enough also to change

listeners' mental representation of the temperament system employed. Therefore, the latter variable showed no visible effects on post-experiment responses.

In terms of emotion studies in music, the pitch factor is a more ambiguous structural factor than factors such as tempo and loudness, as its relationship with emotion is less clearly defined (Gabrielson and Lindstrom, 2010). Therefore, studying the emotional qualities of temperament systems in different cultural contexts might give new insights into understanding how a pitch is linked to emotion. Our study shows that, generally, unfamiliar temperament systems are experienced as less vital and more uneasy. Furthermore, being exposed to this temperament system for just one hour does not seem to be enough to change participants' mental representations of it or their emotional responses to it. Further longitudinal experiments with larger sample size would need to be conducted, where the amount of exposure is substantially increased. This research could also introduce an additional experimental factor by also recruiting participants from Turkey who should have a generally higher cultural familiarity with makam music. This would allow differentiating long-term cultural exposure differences from short-term exposure differences through the ear training class (OT vs ET). Nevertheless, the study presented here, to our best knowledge, is the first experiment to show that temperament systems have an effect on emotion induction, illustrating their general psychological relevance for understanding our every-day experienced responses to music.

References

Balkwill, L. L., & Thompson, W. F. (1999). A cross-cultural investigation of the perception

of emotion in music: Psychophysical and cultural cues. *Music Perception 17(1)*, 43–

64.

Bartok, Bela (1976). *Bela Bartok's Folk Music Research in Turkey*, Budapest: Akadémiai

Kiado

Bartok, Bela (1976). *Turkish Folk Music from Asia Minor*, (B. Suchoff, Ed.). Princeton:

Princeton University Press.

Barwick, L. (2002). Tempo bands, metre and rhythmic mode in Marri Ngarr'Church

Lirrga'songs. *Australasian Music Research*, (7), 67.

Bibby, N. (2003). Tuning and temperament: Closing the spiral. In J. Fauvel, R. Flood & R.

Wilson (Eds.), *Music and mathematics: From Pythagoras to fractals* (pp. 13-28).

Oxford: Oxford University Press.

Boltz, M., Schulkind, M., & Kantra, S. (1991). Effects of background music on the

remembering of filmed events. *Memory & cognition*, *19*(6), 593-606.

Bozkurt, B. (2008). An automatic pitch analysis method for Turkish maqam music. *Journal

of New Music Research*, *37*(1), 1-13.

Castellano, M. A., Bharucha, J. J., & Krumhansl, C. L. (1984). Tonal hierarchies in the music

of north India. *Journal of Experimental Psychology: General*, *113*(3), 394-412

Creel, S. C. (2011). Specific previous experience affects perception of harmony and

meter. *Journal of Experimental Psychology: Human Perception and

Performance*, *37*(5), 1512.

Cuddy, L. L., & Lunney, C. A. (1995). Expectancies generated by melodic intervals:

Perceptual judgments of melodic continuity. *Perception & Psychophysics*, *57*(4), 451-

462.

Curtis, M. E., & Bharucha, J. J. (2009). Memory and musical expectation for tones in cultural context. *Music Perception: An Interdisciplinary Journal*, *26*(4), 365-375.

Demorest, S. M., Morrison, S. J., Jungbluth, D., & Beken, M. N. (2008). Lost in translation: An enculturation effect in music memory performance. *Music Perception: An Interdisciplinary Journal*, *25*(3), 213-223.

Demorest, S. M., Morrison, S. J., Nguyen, V. Q., & Bodnar, E. N. (2016). The influence of contextual cues on cultural bias in music memory. *Music Perception: An Interdisciplinary Journal*, *33*(5), 590-600.

Dowling, W. J. (1984). Musical experience and tonal scales in the recognition of octave-scrambled melodies. *Psychomusicology: A Journal of Research in Music Cognition*, *4*(1-2), 13.

Eerola, T., Louhivuori, J., & Lebaka, E. (2009). Expectancy in Sami Yoiks revisited: The role of data-driven and schema-driven knowledge in the formation of melodic expectations. *Musicae Scientiae*, *13*(2), 231-272.

Egermann, H., Fernando, N., Chuen, L., & McAdams, S. (2015). Music induces universal emotion-related psychophysiological responses: Comparing Canadian listeners to Congolese Pygmies. *Frontiers in Psychology 5*, 1341.

Egermann, H., Pearce, M., Wiggins, G., McAdams, S. (2013). Probabilistic models of expectation violation predict psychophysiological emotional responses to live concert music. *Cognitive Affective Behavioral Neuroscience*, *13*(3), 533-553.

Gabrielsson, A., & Lindström, E. (2010). The Role of Structure in the Musical Expression of Emotions. In P. N. Juslin & J. A. Sloboda (Eds.), *Handbook of Music and Emotion: Theory, Research, Applications* (pp. 367-398). : Oxford University Press.

Halpern, A. R., & Müllensiefen, D. (2008). Effects of timbre and tempo change on memory for music. *The Quarterly Journal of Experimental Psychology*, *61*(9), 1371-1384.

Huron, D. (2006). *Sweet Anticipation*. Cambridge: MIT Press.

Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and

music performance: Different channels, same code?. *Psychological bulletin*, *129*(5),

770-814

Juslin, P. N., & Laukka, P. (2003). Emotional Expression in Speech and Music: Evidence of

Cross-Modal Similarities. *Annals of the New York Academy of Sciences*, *1000*(1),

279-282.

Juslin, P. N. (2013). From everyday emotions to aesthetic emotions: Towards a unified theory

of musical emotions. *Physics of life reviews*, *10*(3), 235-266.

Kopiez, R. (2003). Intonation of harmonic intervals: Adaptability of expert musicians to

equal temperament and just intonation. *Music Perception: An Interdisciplinary

Journal*, *20*(4), 383-410.

Krumhansl, C. L., & Shepard, R. N. (1979). Quantification of the hierarchy of tonal functions

within a diatonic context. *Journal of experimental psychology: Human Perception

and Performance*, *5*(4), 579.

Loosen, F. (1995). The effect of musical experience on the conception of accurate

tuning. *Music Perception: An Interdisciplinary Journal*, *12*(3), 291-306.

Loui, P., Wessel, D. L., & Kam, C. L. H. (2010). Humans rapidly learn grammatical structure

in a new musical scale. *Music Perception: An Interdisciplinary Journal*, *27*(5), 377-

388.

Lynch, M. P., Eilers, R. E., Oller, D. K., Urbano, R. C., & Wilson, P. (1991). Influences of

acculturation and musical sophistication on perception of musical interval

patterns. *Journal of Experimental Psychology: Human Perception and

Performance*, *17*(4), 967.

McDermott, J. H., Schultz, A. F., Undurraga, E. A., & Godoy, R. A. (2016). Indifference to

    dissonance in native Amazonians reveals cultural variation in music

    perception. *Nature*, *535*(7613), 547.

Mungan, E., Akan, M., Bilge, T.M. (2019). Tracking Familiarity, Recognition, and Liking

    Increases with Repeated Exposures to Nontonal Music: MEE-Revisited. *New Ideas in*

    Psychology, *54*, 63-75.

Narmour, E. (1990). *The analysis and cognition of basic melodic structures: The implication-*

    realization model. University of Chicago Press.

Parker, S. (2008). Béla Bartók's Arab music research and composition. *Studia*

    Musicologica, *49*(3-4), 407-458.

Partanen, E., Kujala, T., Tervaniemi, M., & Huotilainen, M. (2013). Prenatal music exposure

    induces long-term neural effects. *PloS one*, *8*(10), e78946.

Patel, A. D., & Demorest, S. M. (2013). Comparative music cognition: Cross-species and

    cross-cultural studies. In D. Deutsch (Ed.), *The psychology of music* (pp. 647-681).

    San Diego, CA, US: Elsevier Academic Press.

Peretz, I., Gaudreau, D., & Bonnel, A. M. (1998). Exposure effects on music preference and

    recognition. *Memory Cognition, 26*(5), 884–902.

Polak, R., London, J., & Jacoby, N. (2016). Both isochronous and non-isochronous metrical

    subdivision afford precise and stable ensemble entrainment: A corpus study of Malian

    djembe drumming. *Frontiers in Neuroscience 10*, 285

Raman, R., & Dowling, W. J. (2016). Real-time probing of modulations in South Indian

    classical (Carnatic) music by Indian and Western musicians. *Music Perception* 33(3),

    367– 393.

Rasch, R. A. Description of regular twelve-tone musical tunings. Journal of the Acoustical

    Society of America, 1983c, 73, 1023-1

Scherer, K. R. (2004). Which emotions can be induced by music? What are the underlying mechanisms? And how can we measure them?. *Journal of new music research*, *33*(3), 239-251.

Schindler, I., Hosoya, G., Menninghaus, W., Beermann, U., Wagner, V., Eid, M., & Scherer, K. R. (2017). Measuring aesthetic emotions: A review of the literature and a new assessment tool. *PloS one*, *12*(6), e0178899.

Schmuckler, M. A. (1997). Expectancy effects in memory for melodies. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *51*(4), 292.

Schultz, B. G., Stevens, C. J., Keller, P. E., & Tillmann, B. (2013). The implicit learning of metrical and nonmetrical temporal patterns. *Quarterly Journal of Experimental Psychology*, *66*(2), 360–380.

Shiloah, A. (1993). The dimension of music in Islamic and Jewish culture. Aldershot: Variorum.

Tillmann, B., Bharucha, J. J., & Bigand, E. (2000). Implicit learning of tonality: a self-organizing approach. *Psychological review*, *107*(4), 885.

Vapnik, V. (1998). *Statistical Learning Theory*. John Wiley&Sons. Inc*,* New York.

Vurma, A., & Ross, J. (2006). Production and perception of musical intervals. *Music Perception: An Interdisciplinary Journal, 23*, 331–344

Yarman, O., & Karaosmanoglu, M. K. (2014). "Yarman-36 Makam tone-system" for Turkish art music. *Journal of Applied and Engineering Mathematics*, *4*(2), 175-199.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*(2, Pt.2), 1-27.

Zarate, J. M., Delhommeau, K., Wood, S., & Zatorre, R. J. (2010). Vocal accuracy and neural plasticity following micromelody-discrimination training. *PLoS One*, *5*(6), e11181.

Zentner, M., Grandjean, D., & Scherer, K. R. (2008). Emotions evoked by the sound of

music: characterization, classification, and measurement. *Emotion*, *8*(4), 494-

521.Bartok, Bela (1976). *Turkish Folk Music from Asia Minor*, (B. Suchoff, Ed.).

Princeton: Princeton University Press.

Appendix A

Fixed Effects for Recognition rates of Hicaz Makam

Variable	F	df1	df2	p
Time (Pre vs. Post-Experiment)	6.678	1	64	<.01
Temperament System	.018	1	64	.30
Ear Training	<0.001	1	64	.99
Time*Ear Training	<0.001	1	64	.30
Temperament System*Ear Training	<0.001	1	64	.99
Time*Temperament System	.018	1	64	.30
Time*Temperament System*Ear Training	.018	3	33	.30

Appendix B

Fixed Effects for Sublimity Factor Responses to Hicaz Makam (Pre- and Post-Experiment)

Variable	F	df1	df2	p
Time (Pre vs. Post-Experiment)	1.189	1	48	.28
Temperament System	1.690	1	48	.20
Ear Training	1.723	1	16.0	.21
Time *Temperament System	0.063	1	48	.80
Time*Ear Training	3.884	1	48	.06
Ear Training*Temperament System	1.801	1	48	.19
Time *Temperament System*EarTraining	.044	1	48	.84

Appendix C

Fixed Effects for Vitality Factor Responses to Hicaz Makam (Pre- and Post-Experiment)

Variable	F	df1	df2	p
Time (Pre vs. Post-Experiment)	.005	1	48	.95
Temperament System	74.910	1	48	<.01
Ear Training	2.856	1	16	.11
Time *Temperament System	.077	1	48	.78
Time*Ear Training	.043	1	48	.84
EarTraining*Temperament System	1.386	1	48	.25
Time *Temperament System*EarTraining	.019	1	48	.89

Appendix D

Fixed Effects for Unease Factor Responses to Hicaz Makam (Pre- and Post-Experiment)

Variable	F	df1	df2	p
Time (Pre vs. Post-Experiment)	8.889	1	48	<.01
Temperament System	1.800	1	48	.19
Ear Training	.250	1	16	.62
Time * Temperament System	.356	1	48	.55
Time*Ear Training	.200	1	48	.66
EarTraining * Temperament System	.356	1	48	.55
Time * Temperament System * Ear Training	.556	1	48	.46