Coll. Antropol. **35** (2011) Suppl. 1: 163–167
Short communication

# Comparison of Emotion Recognition from Facial Expression and Music

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**A B S T R A C T**

*The recognition of basic emotions in everyday communication involves interpretation of different visual and auditory clues. The ability to recognize emotions is not clearly determined as their presentation is usually very short (micro expressions), whereas the recognition itself does not have to be a conscious process. We assumed that the recognition from facial expressions is selected over the recognition of emotions communicated through music. In order to compare the success rate in recognizing emotions presented as facial expressions or in classical music works we conducted a survey which included 90 elementary school and 87 high school students from Osijek (Croatia). The participants had to match 8 photographs of different emotions expressed on the face and 8 pieces of classical music works with 8 offered emotions. The recognition of emotions expressed through classical music pieces was significantly less successful than the recognition of emotional facial expressions. The high school students were significantly better at recognizing facial emotions than the elementary school students, whereas girls were better than boys. The success rate in recognizing emotions from music pieces was associated with higher grades in mathematics. Basic emotions are far better recognized if presented on human faces than in music, possibly because the understanding of facial emotions is one of the oldest communication skills in human society. Female advantage in emotion recognition was selected due to the necessity of their communication with the newborns during early development. The proficiency in recognizing emotional content of music and mathematical skills probably share some general cognitive skills like attention, memory and motivation. Music pieces were differently processed in brain than facial expressions and consequently, probably differently evaluated as relevant emotional clues.*

***Key words:*** *emotions, facial expression recognition, gender specific, music*

## Introduction

Facial expressions are an important cue used extensively in social interactions in all human cultures[1]. Very brief contractions of facial muscles, lasting from a few dozens of milliseconds up to few seconds, specifically convey basic emotions like happiness, sadness, fear, disgust, surprise and anger[2]. Facial muscles are controlled by two different pathways: voluntary pyramidal and/or involuntary extrapyramidal connections. Both pathways are probably submissive to mirror neurons and lifelong training[3–6]. Involuntary component adds to each emotional expression a distinctive mark recognizable to skilled observers[7,8]. The ability of emotion recognition, as well as susceptibility to other people's emotions, is a part of a social intelligence. It is mostly lateralized to the right hemisphere in right handed population[9–12] and dissociated from facial identity deduction[13]. Although merely a minority are perfect at the recognition of emotions from facial expressions[14,15] and cheating decoding, this skill is a major tool for obtaining information about other people's intentions[16]. We see how valuable it is after people survive a stroke or a trauma which can severely limit the previous function[17,18]. The use of modern imaging techniques opened a new window in individual emotion understanding[19]. Recent studies about fear, anger and disgust which used imaging and post lesion recording gave rise to the understanding that those emotions are significantly different from each other in the distribution of neural activity; fear is connected with the activation of amygdalae[20,21], disgust with the insula/operculum and globus pallidus[22] and anger with lateral orbitofrontal

Received for publication November 4, 2009

cortex[23]. Although presented with the same characteristic facial expression in case of a positive and a negative unexpected outcome, an emotion of surprise has somewhat controversial neurological substrate mixed with the characteristics of other emotions, particularly fear[24]. Only one case of a patient with an isolated deficit in the recognition of a surprise had lesions of amygdalae which were extending toward a parahippocampal gyrus[25]. Likewise, contrary to the first findings, the neural activity is widespread rather than lateralized to one hemisphere[19] according to imaging studies of emotions. In this respect, the recognition as well as the production of a certain emotional expression on one's face employs a number of different neural systems selected and refined by social evolution.

The idea that we evaluate music primarily because it induces emotional effects in listeners appeared in the fourth century B.C. and is associated with philosopher Aristoxenus[26]. Leonard Meyer also considers music as a form of emotional communication[27], while Steven Pinker finds it to be an evolutionary byproduct of the adaptation for human language[28]. Listening to music elicits an activity in different regions of brain depending on various modalities of perception – from melody and rhythm to tonality, synchrony and perception of separate tones[26]. However, the answer to the question whether music induces emotions or not is still without scientific explanation because we do not know how to separate and evaluate the widespread activity observed in imaging techniques during active listening to music[29]. On the other hand there are data confirming universal cross-cultural recognition of basic emotions in music[30,31] and data confirming impairment recognition following accidental damage or surgical excision[32,33].

We assumed that the emotional content of music is less precisely communicated than the emotional expression on the face because it is not used in day to day personal interaction and is not under the same selective pressure. Face is a more frequent and reliable resource of valuable information about others while music usually does not refer to anyone in particular. Likewise, women are reported to be superior to men in recognition of emotional faces from infancy to adolescence[34], and we supposed similar difference in recognition of emotions in music. In an attempt to find any other easily accessible indicator of proficiency in recognizing emotions we looked for a link between mathematics and music. Musical training is beneficial for mathematical learning[35] and we wanted to investigate if higher grades in mathematics have any correlation with understanding emotional content of music.

## Participants and Methods

A total number of 177 students, 90 of which were fifth graders of elementary school (early puberty age) and 87 third graders of high school (late puberty age) from Osijek (Croatia) were included in the study (Table 1). All participants were asked to fill out an anonymous questionnaire in order to determine their ability to recognize emotions from facial expressions and emotional content of classical music pieces.

**TABLE 1**
CHARACTERISTICS OF STUDENTS INCLUDED IN THE STUDY BY SCHOOLS

| | N (%) of students | | Total | p* |
|---|---|---|---|---|
| | Elementary school (N=90) | High school (N=87) | | |
| Gender: | | | | |
| Male | 51 (56.7) | 37 (42.5) | 88 | 0.060 |
| Female | 39 (43.3) | 50 (57.5) | 89 | |
| Mathematics grade: | | | | |
| Excellent (5) | 31 (34.4) | 7 (8.0) | 38 | |
| Very good (4) | 33 (36.7) | 23 (26.4) | 56 | |
| Good (3) | 15 (16.7) | 23 (26.4) | 38 | <0.001 |
| Fair (2) | 9 (10.0) | 31 (35.6) | 40 | |
| Poor (1) | 2 (2.2) | 3 (3.4) | 5 | |

* $\chi^2$-test

The questionnaire consisted of three parts. The first part included basic information about examinees such as age, gender, hand domination, grade in mathematics and musical background. In the second part students were given eight photographs of different facial expressions representing eight emotions: worry, happiness, sadness, surprise, anxiety, anger, fear and jealousy. A professional male actor was the model for all photographs and emotions were expressed according to Ekman's description[36]. Some characteristic features are listed as follows: worry – vertical wrinkles in the middle of the forehead and tension around the mouth; happiness – pulled lip corners superiorly and posteriorly, lowered outer corners of the eyebrows with a help of outer portion of muscle orbiting eyes; sadness – downward-drawn mouth corners, eyes looking downwards and upper eyelid droop; surprise – curved and high-raised eyebrows, horizontal wrinkles across the whole forehead, wide opened eyelids and dropped jaw; anxiety – produced on internal tension and characterized with wide open eyes, raised eyebrows and a tension around the mouth with biting of the inner or outer side of a lower lip; anger – brows lowered and drawn together, vertical lines between brows, dilated nostrils, lips pressed firmly together or open and tensed; fear – produced on external threat as the brows raised and drawn together, wrinkles just in the centre of the forehead, upper eyelids raised, opened and slightly tensed lips; jealousy – a raised lower eyelid and a lower lip. The students were asked to match each photograph with the corresponding emotion from the given list of randomly ordered emotions. A set of 8 musical selections (Table 2) was presented to the students. All excerpts were chosen from classical literature by the principal investigator, who has formal musical education background, appreciating suggestions from the studies already published[37].

**TABLE 2**
LIST OF EMOTIONS AND MUSICAL SELECTION

| Emotion | Musical piece |
|---|---|
| Anxiety | N. Rimsky-Korsakov: Flight of the bumblebee |
| Surprise | M. Mussorgsky: Pictures at an Exhibition (Gnomus) |
| Worry | D. Shostakovich: Symphony No. 11 (Movt. II) |
| Fear | M Mussorgsky: Night on Bald Mountain |
| Sadness | L. von Beethoven: Symphony No. 7 (Movt. II) |
| Anger | G. Verdi: Requiem (Dies irae) |
| Jealousy | G. Bizet: Carmen (Habanera) |
| Happiness | J. Brahms: Symphony No. 2 (Movt. IV) |

The final selection of excerpts was made after consultations with a professional musician who is also a string instrument music teacher with a Masters of Music degree. The students were asked to match each music piece with the corresponding emotion from the identical set of emotions listed in the same order as in the second part of the questionnaire. Each correct answer was given one point.

### *Statistical methods*

The categorical data were presented as absolute and relative frequencies. The scores were described by a median and interquartile range. The $\chi^2$-test was used for the comparison of frequencies and the Fisher exact test where appropriate. The Wilcoxon signed rank test was used to compare visual and auditory emotion recognition scores within the subgroups of students. The Mann-Whitney test was used for the comparison of scores between subgroups of students. The Jonckheere-Terpstra (J-T) test was used for the comparison of scores between ordered subgroups. All *p* values were two-tailed. Confidence intervals (CI) were estimated at the 95% level and calculated using the statistical package Confidence Interval Analysis (CIA) (version 2.0.0, Trevor Bryant, University of Southampton, UK). The analyses were conducted using SAS software (version 8.2, Cary, NC, USA), with significance level set at $p<0.05$.

## Results and Discussion

There were 88 (49.7%) boys and 89 (50.3%) girls included in the study. High school students had significantly different distribution of grades in mathematics than elementary school students ($\chi^2$-test, $p<0.001$) (Table 1). 32 elementary school participants and 28 high school participants had musical training.

A median number of correct answers in recognizing emotions from facial expressions was 5 (95% CI 5 to 6). Emotion recognition based on classical music pieces was significantly less successful (median number of correct answers 2; median difference 3; 95% CI of the difference: 2 to 3; Wilcoxon's signed rank test $p<0.001$).

The high school students were more successful in recognizing emotion from facial expression than primary school students (median score 6 *versus* 5; median difference 1; 95% CI of the difference 0 to 1; Mann-Whitney test, $p=0.020$). Both groups of students achieved a similar score in recognizing emotions expressed in music pieces (median score 3 *versus* 2; median difference 0; 95% CI of the difference 0 to 1; Mann-Whitney test, $p=0.075$).

The girls achieved better score than the boys in recognizing emotions from both facial expressions (median 6 *versus* 5; 95% CI of the difference 0 to 2; Mann-Whitney test, $p=0.001$) and those expressed through music pieces (median 3 *versus* 2; 95% CI of the difference 0 to 1; Mann-Whitney test, $p=0.020$).

In the group of high school students the success rate in recognizing emotions from music pieces increased with the increase of grades in mathematics (J-T test, $p=0.006$), while such increase was not observed in the elementary students' group (J-T test, $p=0.057$).

Elementary and high school participants with and without a musical training were equal in recognizing emotions from musical pieces (Mann-Whitney test, elementary school: $p=0.257$; high school: $p=0.860$). Participants with and without musical training were also equal in mathematical grades (Mann-Whitney test, elementary school: $p=0.595$; high school: $p=0.563$).

Happiness was the best recognized emotion from both facial expressions (98.3% correct answers) and music pieces (53.1% correct answers), and the only emotion recognized from music pieces by more than half of the students (Table 3). Students were the least successful in recognizing anxiety from facial expressions (39.0% correct answers) and surprise in music pieces (only 13.0% correct answers).

Facial expressions of emotions were selected and adapted to serve in an everyday social interaction during million years of evolution[38], much before the development of language[39,40], but probably in parallel to communicative gestures[41]. Music is also a new invention, accompanying the development of the language and rarely used in individual interaction. The finding that emotions expressed

**TABLE 3**
SUCCESS IN RECOGNIZING EMOTIONS FROM FACIAL EXPRESSIONS AND MUSICAL PIECES BY EMOTIONS

| Emotion | Number (%) of students with accurate emotion recognition | | Proportion difference (%) | 95% CI |
|---|---|---|---|---|
| | From facial expressions | From musical pieces | | |
| Anxiety | 69 (39.0) | 53 (29.9) | 9.1 | –0.2–18.1 |
| Surprise | 105 (59.3) | 23 (13.0) | 46.3 | 37.0–54.4 |
| Worry | 60 (33.9) | 27 (15.3) | 18.6 | 9.9–27.0 |
| Fear | 100 (56.5) | 36 (20.3) | 36.2 | 26.3–45.0 |
| Sadness | 135 (76.3) | 82 (46.3) | 30.0 | 20.8–38.4 |
| Anger | 168 (94.9) | 59 (33.3) | 61.6 | 53.5–68.3 |
| Jealousy | 106 (59.9) | 62 (35.0) | 24.9 | 15.1–33.9 |
| Happiness | 174 (98.3) | 94 (53.1) | 45.2 | 37.2–52.7 |

on the face are better recognized is not surprising because they are also more practiced starting from the first month of life[42]. The finding of female superiority in recognizing emotions has already been published[34,43]. We suppose that a gender difference originates from the mother-child connection already established by mutual exchange of emotions during the first few postnatal months.

The participants who had better grades in mathematics were also better at recognizing emotions expressed through music pieces. In our survey music pieces were presented in sequence, while faces could be compared in parallel, so that the task of detecting emotions in music was more difficult and required the ability of memorizing and comparing. A cognitive base of mathematics is a spatial ability defined as an ability to perceive, store, recall, create, edit and communicate spatial images[44]. Music has no spatial dimension and we suppose that the association between recognizing emotions in musical works and mathematics could be indirect, reflecting the difference between the participants in some ability which is generally required for both functions such as attention, capacity of working as well as long term memory, system of generating associations, etc. On the other hand, deduction of emotions from music works and mathematics could share the same ability of handling multivariable functions and insight into abstract structures.

A mere exposure to music fosters implicitly acquired tonal knowledge[45], but also elicit a change in the perception what is often used in musical therapy to overcome difficulties in learning or emotional burden. In our case, mathematical grades were more significant for test scoring of emotional recognition than musical training.

The result that happiness is the most recognizable emotion from facial expressions as well as in music pieces has been previously published[46]. Surprisingly, the fact that anger is the second best recognized emotion is probably due to the survey's design. We used a male actor rather than a female and it is known that anger is better noticed on male faces[47]. We also found that fear, worry and anxiety have low recognition if presented on a male face, but this result might be different in case of a female face.

Recognizing emotions from music pieces had a significantly different pattern from the one observed from faces; happiness was followed by sadness and jealously. Some previous studies found cross cultural recognition of three basic emotions in music: happiness, sadness and fearfulness[48]. Our participants had a multiple choice of emotions. Jealously, anger and anxiety were better recognized than fear.

Listening to the music pieces shares some of the same cues used for listening to the spoken language[49–51]. One word of a spoken language, in a right context might powerfully transmit emotions of, for example, surprise or fear, which is called prosody. A few tones would probably have the same power. In our case music pieces were listened to for a minute, which is much longer than it is required to transmit a single emotion. In addition to the existing collections of songs offered to be used in experiments on extracting emotions from music[52] there is still a need to establish a database containing a very short music variations which would reflect basic emotions tested with an imaging technique.

We suppose that in normal communication participants use a mixture of cues coming from auditory and visual stimuli which they follow and evaluate differently. Humans are not precise in deducting either one of them. The best example is that we make big mistakes in guessing emotions from face alone[14]. Also, we could be limited to just one set of cues like in the case of blind or deaf people and consequently be more precise in others. Examining weather the signals coming from different cues are conflicting or not, might be more valuable in terms of evolutionary psychology than any single and particular information coming from separate senses.

Contrary to the studies of emotions expressed on faces, the studies of emotions induced or recognized in music still suffer from a lack of objective measurements[53]. We should not neglect the fact that the recognition of emotional content of a music piece also requires certain experience and practice. The mastery of that skill is not under the same selection pressure as the mastery used in everyday communication.

## Acknowledgements

This work was supported by Croatian Ministry of Science, Education and Sports grant numbers: 219-0061194-2158 and School of Medicine in Osijek.

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## USPOREDBA PREPOZNAVANJA EMOCIJA IZRAŽENIH NA LICU I U GLAZBENOM DJELU

### S A Ž E T A K

Prepoznavanje osnovnih emocija u svakodnevnoj komunikaciji uključuje interpretaciju različitih vidnih i slušnih znakova. Sposobnost prepoznavanja emocija nije jasno utvrđena jer im je izričaj obično kratak (mikroekspresije), a samo prepoznavanje ne mora biti svjestan proces. Pretpostavili smo da je prepoznavanje emocionalnih izraza lica selekcionirano u odnosu na prepoznavanje emocija predstavljenih glazbom. Kako bismo usporedili uspješnost u prepoznavanju emocija predstavljenih izrazom lica ili u klasičnoj glazbi proveli smo istraživanje u koje je bilo uključeno 90 učenika osnovnih škola i 87 učenika srednjih škola iz Osijeka (Hrvatska). Sudionici su trebali povezati 8 fotografija s različitim emocijama iskazanim licem i 8 djela klasične glazbe s osam ponuđenih emocija. Prepoznavanje emocija u klasičnoj glazbi bilo je značajno manje uspješno od prepoznavanja emocija s izraza lica. Učenici srednjih škola značajno su bolje prepoznavali emocije s izraza lica od učenika osnovnih škola, a djevojčice su bile bolje od dječaka. Uspješnost prepoznavanja emocija u glazbenim djelima bila je povezana s višim ocjenama iz matematike. Osnovne emocije prepoznaju se mnogo bolje na licu nego u glazbenim djelima vjerojatno zbog toga što je prepoznavanje lica jedna od najstarijih komunikacijskih vještina u ljudskom društvu. Ženska prednost u prepoznavanju emocija vjerojatno je selektirana uslijed potrebe za komunikacijom sa novorođenčetom tijekom ranog razvoja. Vještina prepoznavanja emocija u glazbenim djelima i matematika vjerojatno dijele neke iste općenite mentalne sposobnosti kao što su pažnja, pamćenje i motivacija. Glazbeni isječci drugačije su procesirani u mozgu od izraza lica i vjerojatno uslijed toga različito vrednovani kao odgovarajući pokazatelji emocija.