The Musical Brain Study Day

Top 50 Chamber Classics and why we love them

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TRANSCRIPT

Psychology and musical features underlying emotional expression in music
Professor Tuomas Eerola

IAN RITCHIE: Welcome back. Very briefly, because he doesn't require very much introduction, Tuomas Eerola is Professor of Musical Cognition at Durham University, and it's wonderful to have him with us. This will be the first time that he has been a speaker at one of The Musical Brain events. You are hugely welcome, Tuomas, to talk with us about psychology and musical features underlying emotional expression in music, so over to you. Thank you.

TUOMAS EEROLA: Thank you, Ian, for having me here, and of course it's a great pleasure to be in such an interesting combination of talks and wonderful performances. It's a real honour. So, music can really have a strong hold on our emotions, and nothing makes this case better than the performances we have just witnessed. The beginning of the Shostakovich movement performed by Ian, Marisol and Raphael brought a lump to my throat. It is part of the pleasure of these study days.

My talk will aim to shed some light on how music induces emotions and what kind of device it uses to express them. I will be building on top of some of the psychophysical and neurological solutions and will try and put these themes into the context of the audience nominated chamber music examples which we are here for.

Let's start with a wonderful example from Debussy, the Scherzo from his String Quartet in G Minor. You will be able to see a simple, naive visualisation of the expressed emotions, so to speak, of the performance. This visualisation is based on a simple computer model which listens to music as we do. It does the same kind of things as we do. It extracts various acoustic and musical parameters while it is listening to music, and the model has some knowledge of what we do with these kind of features, starting with dissonance, tonality, articulations and all of that. It has knowledge about how these might be connected to the emotional expression, so it makes an attempt to convey something to you. In effect, the model gives you a very rough estimation of the arousing qualities of the music in the vertical axis and the continuum between positive and negative on the horizontal axis. That is a real simplification but bear with it for a minute, we will talk about it more later on. Let's listen to a recorded performance by an eminent string quartet.

[Music played.]

That is a useful exercise for getting into the right mood of things later on. In the second part of this talk, I will explain the ideas behind the model in more detail, and we will get to explore the shortcomings and why such models might be useful as tools for exploration.

First of all, I would like to give a summary of the findings in the psychology of emotions in music, just very briefly. So, we know that music is able to express emotions very effectively and very delicately in a nuanced fashion. Children, and even infants in some cases, are able to recognise the most basic emotional qualities of music. There have been a small number of studies which even indicate that some of these emotions can be recognised across cultures as well, which is not that surprising, if we keep in mind that we are able to recognise some of the expressive characteristics in speech across cultures as well. Not the meaning, but whether the speaker is in a very angry state, or in a different kind of state. Of course, this is related to the acoustical cues being used, and actually the cues themselves are giving hints of what the physiological state of the talker is, or show the expressive characteristics of that state. In angry speech, we tend to have completely different dynamics to normal speech, and if we are really depressed then we slur words together.

All of these acoustic characteristics are connected to underlying notions of how we actually experience the emotions. This code is within us and it's sort of implied that this is hard-wired because I refer to studies across different cultures. But why should it be so important for us? Of course, knowing the emotional state of another person is really vital social information for us, so that's why we are extremely sensitive to the slightest variations in voice and timbre. This has direct ramifications for music as well.

Moving back to the more general aspects, music not only expresses emotions but it is also able to induce proper emotional experiences in us. In fact, if you look at the research in peak experiences in general, music has been emphasised as being a special case. Abraham Maslow, a leading American psychologist, suggested in the 1960s that the easiest way of getting peak experiences are through music and through sex. The expressed and induced emotions don't always go hand in hand, so you can have music expressing something, but it doesn't do the trick for you, and of course that is something which is important to recognise, realise and come to terms with.

I am sure that you have all been in situations where music is being played in a shopping centre and it's meant to be joyful, or whatever, and it's really irritating. I think that is the best example of the separation of the two. The other thing about the induced emotional experiences is that they tend to be much more delicate than the ones that you just recognise. They tend to be more related to contextual and individual factors, so they are more dependent on you, where you are and what's happening at the time. Let me try to expand this a little bit further next.

When we think about the different ways music is able to have an emotional effect on us, a rather complicated picture actually emerges. Of course, music itself is the obvious source, although when we start to think about all the different types of music we have at our disposal, so to speak, from rave techno music to the polyrhythms of Steve Reich, one begins to wonder whether there is anything within the music that would lead to consistent responses across people. But perhaps there is. As pointed out already by Michael, with respect to some of the low-level physiological things like the connection of dissonance with displeasure, for example, these are things which are simply within us. Many of the expressive devices utilised in music have tangible connections in physiology and neurology. I will just play you one very short clip at this point.

[Music played.]

I hate to stop it, but I will play that again in a few seconds. It was a very moving piece for cello and piano by Bloch. We, as listeners, are all different - we have different moods, different personality traits, music preferences, life histories, all of which are crucial to emotional engagements with music. In the work done in my lab, we know we have established that moods and personality traits, for instance, are known to systematically bias your recognition and experience of emotions.

Finally, it's not only the music that needs to be considered; it's the situation. The situation in which one hears and listens to music has an impact on our emotions. Sometimes the music can be perfect but an irritating social situation or bad acoustics, or something else might ruin the emotions completely. Other times these things could be secondary if you are in an emotionally vulnerable situation and just happen to hear a piece of music at a certain time.

So, it is actually the interaction between these three - the music, the listener and the situation - which you need to have in balance. All of them need to be well aligned to actually have a real emotional experience. To complicate matters a little bit further, there is another layer to all of this, because music triggers memories, as Michael already mentioned, and these memories may lead to rather different emotional experiences, in terms of what the music is actually expressing.

You might remember a particular situation in life in which you heard some music, but this can be completely detached from the actual music and what it means to you or is conveying in the first place. An example of this could be when you have long-lost friends staying at your place and you are listening to music together. We tried to estimate the power of this mechanism recently in a laboratory experiment. In this experiment, we played the previously heard Prayer by Earnest Bloch (From Jewish Prayer no. 1). I will play just 40 seconds of this and then I can explain what we did.

[Music played.]

I will stop it there. I noticed that there was at least one person in the audience who flipped! You did go to the movies during the 1980s! So let me explain this to the rest of the audience. The music was actually not an original performance, it was a synthesised performance. So, for half of the participants, we slightly modified the theme. We kept the harmonies, articulation and all of the musical aspects intact, except we changed it slightly so that it had a Princess Leia theme from Star Wars in it. Those who caught the theme were really laughing - it had a reverse effect. They also experienced different physiological reactions. I think that makes the point quite nicely. Memories really can override anything that music can actually express. I think that's the message.

Another mechanism mentioned by Michael was expectations, where your brain automatically predicts the structure, mood, or harmonic textures. Several studies have suggested that the most potent emotional reactions are obtained in locations of the works where expectations are violated. For instance, the experiences of chills often

occur at the places where sudden harmonic shifts take place. In terms of emotions, I think I need to explain a little bit in order to pave the way for coming back to the computer model. When we are talking about the emotions expressed or induced by music, there is actually a wide spectrum of different emotions, and I think colour analogy is quite appropriate here.

So, very commonly, psychologists and music psychologists use basic emotions. We like to talk in colour, about red, blue and green. We like to talk about happiness, sadness, tenderness, fear, and all of these are sort of discrete. It's not the full story. We know from colours that we have millions of different hues, so if we think of emotions in more of a gradient, nuanced fashion, we can actually implement them in terms of luminance and wavelength. This allows a huge number of finer descriptions such as navy blue, salmon or whatever. In the same way, we can underline and explain the emotional reactions by having two core affective dimensions, which are often called valence or arousal, and these are linked directly to the comparison of the nervous system. Positive valence is known to emotions and negative valence is sleepy, low energy. This is another dimension fundamental to keeping the homeostasis functional. As Michael already said, when we are dealing with art, maybe the colours are even more complex. You have a combination of colours which can't really be explained by a combination of two dimensions, so this has been a convincing argument which demonstrates that music engages in more subtle and complex ways. This is maybe something that the aesthetic emotion models are taking care of.

Aesthetic emotions such as wonder, transcendence or melancholy are quite often encountered in concert situations, for example, but not really catered for in neuropsychology, so to speak. We acknowledge that this is truly intricate and if I reduce the emotions in chamber music masterpieces to two fundamental dimensions, you realise that I am probably leaving out quite a lot. I would not really be focusing on the actual feelings these works can generate, merely displaying some of the expressive characteristics these works are able to convey. So there is a very firm caveat there.

However, it's still fascinating to question whether there is anything in music itself that obeys specific patterns, in terms of the expressive content, and this is the subject of the second part of the talk, which I will spend more time on. Links between musical content and emotions have been drawn for thousands of years. Aristotle gave a detailed description of the emotional ethics in the different modes. He drew inspiration from Plato's *The Republic* and suggested that the Mixolydian mode made people sad, whilst there were other connections made to the Phrygian mode. Perhaps this culminated in the *Doctrine of Passions*, the *Affektenlehre*, which was labelled with codified meanings to convey love, hatred, desire, sorrow and joy.

However, particularly nowadays, music psychologists and musicologists have started to verify some of these notions, partly because only in the last, say, 15 years have there been tools that enable us to study real performance. This includes the audio and the kind of sound of the music itself, which is very important for emotions. Such work typically starts by having listeners evaluate a large amount of music in terms of the emotions.

Then, after this, you have to have some ideas of what to look for. Next, you extract

physical descriptions of the music, by computer, from the musical signal itself. This may describe the volume, but also the harmony or key. The extraction itself is dynamic - it evolves in time and is able to pick out small details, all the details that performers are actually making in the performances, and is not really limited to the score or the expressive markings in it. Let me give you a flavour of this. I will try to visually explain this line of research a bit more and expand this a little bit. We can take a small fragment of Beethoven's String Quartet No. 13, Op. 130 and extract how bright the sound is, how dissonant, how rough, the tonal clarity, et cetera, at each given time. I will just play you a bit of it so you a sense of what is going on.

[Music played.]

Okay, you can see lots of things happening and these are not the only features that can be expressed. Moving on...

[Music played.]

Sorry, I didn't actually explain this example, I clicked too fast on it, but that was a model which emulates our sense of key centres. Its perceptual model is also validated in neuroscience and it estimates the key at any given time and how well defined the key is. It's a separate field, but the information from these models can be used in estimating how clear the tonal centres are, and so on. Anyway, when you are building these kind of models, you emulate how listeners are behaving, emulate the auditory periphery, auditory cortex, and derive a number of different features. You might have features which correspond to some of the terms used quite often in music theory or you can have something that you know people are saying is what angry music sounds like. You have to have some data that you can train your features with. Then you take your statistical model and put the features in the blender. If you are lucky, you get the recipe. So, for anger you would need high dynamics, lots of dissonance, an ambiguous key, pulse clarity, spectral spread, et cetera. Then you would get something that might sound like this after the model has analysed it.

[Music played.]

You get the idea. Or if you want something like scary music, it would have very high dynamics, very sharp attacks, hugely ambiguous keys, high register, and so on. It might sound something like this.

[Music played.]

Maybe that was not a good example but I think the principle is there, and that's how the models typically operate. Now, I think you have an overall sense of how things are being done. Let us take a simple version of this. Normally, when you do these kind of things, you use quite a number of features with quite complicated models. Just to amuse ourselves and try to probe whether these are useful at all, I have a version which only has about five to six features. It is really a basic model that can run in real time. Let's listen to a few of these chamber music classics from the top 50 and try to think about what the model is doing. You might want to actually think about what the five features are. I will be asking you whether you will be able to reverse engineer the model, so there is a test for you coming up in a few moments! Let's take the first

example from Franz Schubert, String Quartet in C Major, second movement.

[Music played.]

Okay, let's give you more examples to use, so you will be able to decode the whole thing. Of course, I am biased and I had to slip in one of the Sibelius examples, so let's get it in! These are the very sombre opening bars of the D Minor String Quartet, *Voces Intimae.*

[Music played.]

Moving on to the next example, a bit more dissonant maybe. What about Bartok? Bartok would be a challenge!

[Music played.]

Quite confused! That was a challenging one for the poor model, I guess. We will finish off with one more example. Let's go back to the Beethoven trio, from near the end of the second movement.

[Music played.]

Okay, enough of that. I will ask the question of how it did it a little bit later, just to conclude that, as you saw, it is at least possible for the model to pick up some expression in a sensible fashion. I am not claiming it's very accurate or anything, but you can see that the actual acoustic content or the acoustical qualities relate to something that we find plausible and also funny. It's quite naive but that's also quite interesting in itself.

Of course, the question that needs to be asked is how robust, how solid, how successful are these kind of models? If you look at the literature and the studies that have been carried out recently, for example, in film music, the expression is often exceedingly well explained by such models. In classical music, which is not actually studied that much, for some reason, and only concentrates on early to late Romantic music, the model has also been quite useful. In popular music, this is a different story, because the amount of music examples now that we have at our fingertips is tremendous. It's huge. It's staggering. We now get access to Spotify and Love Film, sources of all the popular music, 22 million or 36 million tracks, so we have been accessing these and using quarter of a million tracks in the models, so you get an unprecedented amount of information from that. You can use models for that kind of music which are fairly different in comparison to classical music.

We have tried to do something a bit more interesting and work out whether there are any underlying cues in music of different cultures. When we exposed the models to, for example, improvisations by musicians from North India, Japan and Sweden, we found that actually we can predict some of these expressed emotions with the acoustical cues. The listeners from the different cultures are able to pick up these cues, so it's not only the models that can do these tricks.

Finally, maybe the most surprising thing that we have been doing in the work in my

lab is that when you take away the musical content and study instrument sounds, people are still able to describe different kinds of emotional expression in them. This even happens when you take isolated, boring instrument sounds that are identical in terms of pitch, duration and loudness, but have the characteristics of the instrument itself intact. This happens just as well as you can probably discriminate between the kind of tension and non-tension in, say, flute and saxophone, if you think about just the sound.

[Music played.]

There is plenty of information already there without any other information. It is different layers, and these kind of findings emphasise the importance of the timbre in the whole thing.

Let me start to summarise and come to the conclusions. In fact, for these kind of studies and this kind of approach, it would be easy to make a recipe book, so to speak, of emotions in music that worked well. Actually, the model that we were seeing is the simplest one that you can think of. A couple of spoonfuls of this and a bit of dynamics, add dissonance, dynamics, timbre, shake well and half an hour later you have it!

What's quite interesting is that you could make a copy of the book for speech. You could make a recipe of emotion for expression in speech as well, and just change a few of the features slightly, because the harmonic features are not really present in speech. You have speech rate and you have more pitch, pitch directions, and so on. This really underlines the overlap between the domains, and that's something I want to emphasise. If we look at the overlap between speech and music expression, which has been studied quite a lot during the last ten years, we can detect the expressed emotions to a similar degree in both music and in speech. The features that we will be using for this are partly different but there are a lot of shared features which makes some of the interesting things possible.

Maybe, for the final remarks about the psychology of emotions in music, let me summarise this. It's a complex situation and you have to pay attention because it has things other than music in it. Memories play a fundamental role but I would say that, if you are looking for the features in the music, they are connected to something quite robust, something within us. Our physiological states give rise to different kinds of cues, and that's why the cues are similar across different cultures. We have the same kind of experiences which is why it's interesting.

However, as a final comment, even though I have very much simplified all these expressions and the two dimensions and everything else, it's actually quite interesting to look more closely at the indecision and the fluctuation of the simple model faces with chamber music. It doesn't necessarily speak about the shortcomings of the model. It can't decide where it is, or whatever but it lays down the complex emotional narrative which music is able to create. Shostakovich's Piano Trio No. 2 in E Minor, Op. 67, was the perfect example of this complexity - a culmination of these kinds of clashes. You get almost schizophrenic combinations of effects occurring at the same time and taking dominance.

I thought it might be a fun exercise, seeing as we just heard the Shostakovich

performed live in a very exquisite manner, if you just listen to one bar of that and see how this kind of schizophrenia, almost teasing the different influences, comes into play. We will expose the poor suffering model to this complex music. Then I will come to my conclusions.

[Music played.]

The purpose of doing that is to emphasise that of all these masterpieces encompass the gamut of emotional expressions, and maybe that's something that I want to connect to the question Ian Ritchie posed to all of us: why do we love these pieces? That's the final slide. So why do we love them? It's a difficult question, of course, but my take on the matter would at least contain some issues that relate to the fact that these performances are able to pull us through sequences of expressions that are appealing, interesting and emotionally contagious. Just like Ian Brown talked about the conversation and intimacy, they need to be able to pull us close. The emotional narrative explains some of the resonances these pieces of chamber music have on us and why we derive such a delight and satisfaction when we are taken on an emotional ride, particularly when it's such a rollercoaster of a ride rather than a walk in the park.

Some of these works actually do the rollercoaster within 15 minutes, like a masterly novel by Anton Chekhov or film by Ingmar Bergman, but in these very intense 10-15 minute movements, they are able to do something that in a book or film takes hours or days. That's one of the secrets of the appeal of the whole thing. I think Michael really emphasised this point by showing the non-temporal art forms, visual arts and architecture, as not having the same capacity in this sense. So these master works utilise our acute sensitivity to emotional narrative by mimicking the signals that we send out when we experience emotions, and our emotional empathy just can't help but log on to these buttons over time. This richness, I believe, is one of the reasons we have grown to love these pieces and these works so dearly. Thank you.

IAN RITCHIE: Thank you very much. That was a wonderful, wonderful talk. I am sure we are itching to ask questions, but I think what would be sensible would be to now introduce Stephen Johnson, to continue this strand that we are on. Then we will be all gathering for a final session, and let us ask, and indeed answer and discuss these matters then. I hope that's acceptable. We'll have an opportunity for the questions and answers in a more collective manner in due course. So, Stephen, welcome.