Title

Do musical scales interfere with the consolidated memories based on their emotional burden? A probable underlying cause to exacerbate mood disorders.

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Abstract

Introduction

Music is known as an impressive tool of inducing mood. Among a lot of potential mechanisms for such an effect, we decided to investigate whether the type of musical pieces we hear based on their emotional burden, may interfere with the type of the memories we consolidate in our long-term memory. We were to consider it as one of the possibly involved mechanisms in the pathogenesis of Depressive Disorders, by providing negative contents for mental rumination.

Methodology

This study was conducted in two phases.

We chose 4 classical musical pieces in different scales predicted to induce positive and negative feelings. These pieces were played for 50 cases. The reported feelings (after exclusion of probably depressed cases) were compatible with our predictions. We selected one positiveness and negativeness inducing pieces.

In the second phase, two oral and written fictional biographies containing equal number of happy and sad, major and minor stressors were given to participant. At the same time a piece from the selected pair was played, randomly. After 30 minutes, the participants were asked about what they could recall. The ratio of happy and sad were compared between the groups listening to different pieces.

Results

Only the ratio of real positive memories of written biography could hardly achieve statistical meaningfulness. All of the other P values were far from the significance threshold.

Conclusion

This study could not prove the hypothesis or provide any supportive evidence. However, for a certain conclusion, larger sample sizes and multifactorial methodologies are necessary.

Introduction

Music has powerful effects on the mind**.** Among hundreds of strategies, music is recognized, as an impressive method of inducing and regulating mood (1, 2, 3). In a study, participants listened to different types of music: (1) happy, (2) fearful, and (3) sad while self-reported ratings, psychological and physiological responses were measured. The results showed that, compared to the no-music control group, three types of music in experimental group had different effects on self-reported ratings of mood and measures of cardiac, vascular, and respiratory function. It shows that mood induced by music in compare to mood induced by other stimuli, is faster, stronger, more pervasive, and lasts longer (4).

Listener's internal mood and arousal levels are modulated by music, which may facilitate memory performance (5) For example, negative moods can make memory worse, while positive moods can improve memory (6). Furthermore, very high and low levels of arousal can inhibit memory, while moderate levels can boost memory (7). The 'context' of music, provides a memory cue, when reinstated (8). So, because of the reinstate of the contextual cue, hearing a piece of special music may arouse the recall of associated memories.

There is a great potential in music to evoke profound emotions in listeners (9). This potential is one of the primary motives for involving in music listening (10). It is "healing" part of music, which is used in music therapy (11). However, music does not have only beneficial and positive effects on emotional health. Music listening may also have counterproductive effects or even contributing to harmful emotion results (12). On the one hand, music listening may identify as a useful resource for decrease depressive symptoms. On the other hand, it may contribute to depressive emotion-regulation styles, like rumination. Music has the power to immerse listener, thus losing himself in it completely and lead him to feel helplessness (9). Sadness is an emotion usually associated with music (13) music-induced sadness like autobiographically-induced sadness that produced by real memories, has been shown to generate similar negative biases in cognitive processing (14). Music has a special role in most cultures (laments, funeral songs) that used in the contexts of mourning and loss (15-17). Such examples show that sad music, in addition to the positive experiences that are often referred to, may be associated with negative experiences. A recent qualitative study of Western listeners found a wide range of experiences relating to grief and low-intensity depression to be associated with music induced sadness. (18). So, it is important to explore the range of experiences and negative emotions evoked by listening to music as a cause of mood disorders.

The questions in our minds that motivated us to investigate for a correlation between the emotional burden behind musical pieces and types of the consolidated memories included curiosity about possibility of the role of musical scales in interference with the emotional burden of consolidated memories, and if proven to exist, whether such an effect may provide materials needed for mental rumination and subsequently lasting effects on mood; and lastly whether listening to music with specific emotional burden may trigger a prodromal phase before occurrence of mood disorders,

and become an underlying cause (even a minor one) to exacerbate mood disorders, instead of being a symptom of these affective fluctuations.

The current study tries to investigate the first ring of this probable causal chain, trying to know that whether the feeling behind musical pieces we hear may make a bias in the type of events we consolidate in our long-term memory, in favour of emotionally compatible memories. Such a study necessitated two separate phases, firstly to prove a common feeling induced by the selected musical pieces among cases with similar demographic background with the main participants, and secondly to evaluate the main hypothesis.

First phase

Methodology

We conducted this study among Iranian adults aged between 18 to 60, who do not currently suffer of depressive disorders, and do not report history of any major psychiatric illnesses including psychosis, suicidal behaviour, bipolar mood disorder, and any kind of developmental disorders.

For evaluation of our hypothesis, firstly we had to select some musical pieces. We decided to choose non-vocal pieces, because emotional burden of each word would make the analyses of the results extremely more complicated. We had two alternatives, first Iranian Classical Music, and Second Classical Music in its global meaning. We consciously excluded the other styles of instrumental music like jazz, because we were afraid that they lead to excitement and make it difficult to define a pure feeling.

We chose the second one, because although Iranian Classical Music is full of emotions, but it is not familiar for the youth, and they might get exhausted during listening that could interfere with the results. Eventually we decided to select some classical pieces. Conventionally it is believed that Musical Major Scales induce positive feelings while Minor Scales are used to express negative feelings. (20) This belief is not only based on public opinions, and there are some musicological and psychoacoustic theories about, discussing about dissonance, alterity of minor tones, clarity of major tones and uncertainty of minor scale, pitch height, instability of leading tones and familiarity along cultural history.(20) For a scientific research, this was not sufficient to rely on unproven theories that may vary among different cultures, but we needed proven results. We asked a professional to introduce us, some pairs of musical pieces, considering that each pair must be similar in orchestration, tempo (because excitement induced by a higher tempo could be confused with happiness or any other positive feeling) (21) and composition. We had to choose a pair similar in length also, because of not make an interruption to make the durations equal.

Indeed, music induced feeling is highly predisposed to be influenced by cultural aspects, so musical pieces which make a positive or negative feeling in a western European population, won't necessarily do the same in an Oriental population. Accordingly, we designed a questionnaire to

detect the feelings that they make Iranian people sense. We played 2 final pairs for a group of 50 cases, aged 18 to 60. We asked them to describe their feeling through an inventory containing these responses: Happiness, Sadness, None, any other feeling. Almost all of them replied other feeling and described their feelings by ambiguous sentences like "A boat floating on the see", for at least one piece from four. These invaluable definitions were extremely sentimental but not practical. So, we changed the inventory into 3 choices, including: Any kind of positive feeling, any kind of negative feeling and none. We excluded the samples who completed the first edition of the inventory. We although added a screening instrument of depression, because of potential bias that existence of depression could make in the outcomes. The Center for Epidemiologic Studies Depression Scale has been validated among Iranian elders by Malakouti et al. The reported negative predictive value of 98% indicated that ignoring the matter of age, this questionnaire is a good screen tool for ruling out the depressed guys.(22) Unfortunately, we couldn't find any other brief screening tool for this purpose in Farsi validated among the youth, so this tool was the best choice. We analyzed the results both before and after exclusion of cases with the scores of 6 and higher in CES-D.

Results

The results were sadly shocking; not about the feeling induced by the musical pieces, but because of 13 cases reporting symptoms of depression severe enough to obtain the score of 6 or higher by the CES-D screening tool. Consequently, the self-reported feelings were assessed after exclusion of these 13 cases. The responses of the left 37 cases were statistically evaluated in two ways: simple and conservative:

We had two samples who answered to all pieces by positive feelings. We already knew one of them who had a strong familial history of Bipolar Mood Disorder. Another three samples had answered to all pieces in contrast with routine answers. One of them explained that she had answered in a wrong sequence. By consideration of overlap between these extremely different responders and depression screening results, and in addition to who answered positively to all of the four pieces, there were three cases with uncertain condition. We concluded that these potential malperformances of assessments, in observation of accurate completion of the forms and exclusion of cases with probable elevated mood may made the results biased. Although this interference in results was against blindness, we made analyses twice and in the "conservative way" we reassessed the results with exclusion of these three samples, to clarify that if it had been a methodological error due to not excluding people with probable elevated mood or mistaken sequence of answering, we had to repeat the whole assessment. Fortunately, the outcomes remained the same after exclusion, and indicated that the feelings among Iranian guys were similar to what we predicted at the time of selection, according to the induced feelings among Europeans and based on the opinion of our musicology expert. The pieces were played in a fixed sequence to all of the participants, but

firstly arranged in a random way. The names of the pieces and the induced feeling and P-values of statistical analyses are mentioned in the table no.1.

As seen in the table no. 1, the first and fourth musical pieces could induce positive feelings while the two others could make negative feelings, statistically significantly, and in both ways of analyses. These results were compatible with our predictions about the induced sentiments.

Conclusion

Conclusively, not only we found an evidence supporting that emotional feelings behind musical scales and their instrumental pieces get perceived similarly, independent of cultural factors, also we could select a pair of musical pieces just to initiate the main phase of our study. The selected pair were: The "Waltz of the Flowers", a piece from the second act of “The Nutcracker”, a ballet composed by Tchaikovsky in D Major and “Adagio for Strings” by Samuel Barber, from the second movement of his “String Quartet, Op. 11”, in B♭ minor.

Main phase

Introduction

All we had done so far was the initial phase that enabled us to use these selected pieces to evaluate our main hypothesis. As mentioned above we tried to evaluate whether the type of listened musical pieces about the feeling they induce may interfere with the consolidated memories in this pattern that sad or happy event be more predisposed to register in long term memory.

Methodology

In the main phase of the study we presented two factitious biographies to cases. One of them was presented orally, and the other one was written. Both of the biographies included seven positive and seven negative stressful events. According to the tables derived of invaluable study by Helmes et al.(19), we chose 3 major and 4 minor stressors of each positive and negative groups. None of the stressors was presented during first and last two lines of biographies, preventing the primacy and latency effect on the results. The duration of both of the selected musical pieces were seven minutes and half. We recorded the oral biography by a female voice and synched it with both of the pieces, from the beginning. The oral narration lasted for 3 minutes and half and the sample had access to the written biography as soon as it ended, printed on a A4 paper and in middle sized Persian font. After completion of this step, the written biography was taken back, and samples had 20 to 30 minutes (less than an hour) for walking around and refresh, but they were not allowed to talk about the biographies.

After this interact, samples were asked to tell us all they remembered about two stories, respectively. The interviewer had a checklist including all events mentioned in the biographies, in addition to columns for recording false memories differentiated in their emotional burden, positive

or negative, and neutral real memories. (The ambiguous events were explained indirectly in the biographies to clarify their emotional burden). The list of stressors used in each story is written in the table no.2.

Similar to the first phase, we used CES-D to exclude cases suspicious to depressive disorder. The samples were different than the cases intended in the first phase.

Analyses

We defined 4 parameters to assess among samples: true Memories with Positive Emotional Burden (MPEB) to All Memories (AM), True Memories with Negative Emotional Burden (MNEB) to AM, true and false MPEB to AM, and True and false MNEP to AM. These four parameters were compared between two groups, about oral biography, written biography and altogether.

After acquisition of results, the data were assessed by Smearnov test in terms of normal distribution. Independent T Test was utilized for comparison between means among normally distributed results, while, means which were not normally distributed were compared by Mann Withney‘s U test.

Results

The first adverse results detected at the level of analyses was shocking rate of depression. Although the samples differed from the previous phase, exactly similar to the first phase, we had to exclude 13 cases, equal to 26% of samples, due to CES-D score of 6 or higher, indicating of potential depression.

We analyzed the results twice, with and without potentially depressed cases. Not only almost none of the parameters showed significant differences statistically, but also, they did not distort toward meaningfulness. The only parameter that hardly showed significant difference was “Real Positive Memories/All Memories” in “written biography”, after exclusion of potentially depressed cases. (P Value: 0.049)

Conclusion and Discussion

The hypothesis is not proven. Considering the P Values (except the only significantly changed parameter), and their far distance from significance threshold, it does not seem that this single significant finding to be due to a real effect, rather than being an accidental result of “multiple comparison error”. By the way according to these results, indicating only significant outcome to following positive feeling induced music and about positive memories, we can suggest evaluation of the effect of include listening to joyful and happy music in treatment schedule of depressed patients on the rate and speed of recovery. Of course, cultural issues in music selection is the most important concern in methodology.

In one of the earliest studies making relationship between memory and music induced affects, Taniguchi in 1991 played sad or bright music for the participants, at the same time of presentation of words and non-words. He reported that the moods induced by the played musical pieces had congruent effects on recall of negative or positive personality trait words, interpretation and response time. His assumption has been that the emotions behind musical pieces could induce mood changes in the participants. (23)

The same assumption has been the base of the study of Chopra et al. in 2008, when they used exposure to sad music to trigger dysfunctional thoughts, trying to assess the level of salivary cortisol in remitted depressed cases after what they have called "mood challenge". (24)

The potential effect of emotional burden of musical pieces on mood has been used as obvious fact in the design of fMRI study conducted by Oetken et al in 2017. They investigated the influence of mood on self-evaluation in healthy participants and used what they have considered as happy, sad and neutral music and instructed them to immerse themselves in the mood of the piece they were hearing. (25)

The mood inducing effect of music has been also the methodological assumption in Jahanitabesh et al.' work about the sadness and ruminative thinking, as they describe it in the words of "emotionally evocative music". (26)

Guhn et al also used what they presumed exposure to "sad music" in addition to sad pictures and scripts with individualized autobiographical content, as their method for induction of negative mood in the assessment of affective and cognitive reactivity in patients affected by chronic depression. (27)

Some other studies worked basically on this assumption that different musical pieces may provoke different feelings in audiences. Lee et al in 2016 reported that different genres of music may induce different psycho-physiological responses, for example 10 minutes of tense and sad music increases the activity of parasympathetic system in the cases with higher levels of anxiety. On the other hand, their study revealed that simultaneous listening effects occurs about joyful and peaceful musical pieces as reduction of subjective anxiety and depression, which led to their recommendations to music interveners. (28)

Yoon and Rottenberg in the report of their research on music preference among in depression mentioned that both depressed and control cases reported increased relaxedness and decreased happiness following listening to sad songs. Also depressed participants are attracted by sad music due to seeking for calmness. (29)

Bogt et al. published the article derived of their study in 2021 indicating that 17% of the participants who were aged between 12 and 16 reported increased sadness by listening to sad music when they already felt sad. The multivariate linear regression revealed that higher levels of depressiveness is related to more deteriorative effects of sad music. (30)

Koelsch et al following their accurately designed study than even considered the potential effect of tempo, reported that type of heard music (heroic versus sad) may influence the thought content during mind-wandering state. Their results showed that heroic musical pieces evoke "empowering" and "more positive, exciting, constructive, and motivating thoughts" while sad ones lead to "more calm or demotivating" and "more relaxing or depressive thoughts". They have made such a practical conclusion that their presented results could have implications in both clinical and health populations, to promote wellbeing in daily life or as a therapeutic purpose. (31)

Sachs et al in their comprehensive systematic review discuss about the neuroscience of music perception. (32) The main purpose of their review was to focus on the pleasure induced by sad musical pieces. Alongside, they mention that the brain areas involved in the processing of sadness may also participate in the processing of the feelings that are induced by music. Compatible with the content of their review, they point to the study of Brattico et al. in 2011 indicating that listening to sad pieces rather than happy ones is associated with activation of the head of caudate and thalamus, (33) while the later one is proven to be activated in processing of sad faces. (34) In addition, the subjectively reported sad pieces could activate hippocampus and amygdala, (35) and parahippocampal gyrus. (36) This finding can be considered as a promising evidence for potential correlation between the process of memory consolidation and emotional content of musical pieces, because of the role of these areas in memory encoding. (37) Conclusively and paradoxically, Sachs et al present potential benefits of sad musical pieces in the treatment of depression via regulation of mood and amelioration of related symptoms. Although this claim is not directly against the hypothesis of our study, but seems to be contrary to what we tried to assess as the practical conclusion of our study, as we considered the possibility of sad musical pieces as a potential mechanism in the pathogenesis of depressed mood, while this study suggests them as therapeutic alternatives for this purpose. Meanwhile, the relation between musical scale, minor versus major, with emotional burden of the musical pieces has been considered by two of the studies investigated in this review, as we did. (38, 39)

Our study tried to investigate a probable mechanism involved in the memory consolidation and consequent pathogenesis of depressive mood disorders, via the emotional feelings induced by music. As far as we could search, there was not any published study in English literature that have focused on the type of memories consolidated in the mind and the heard musical pieces, as we did. But nowadays, there is no doubt about the influence of musical pieces and the feelings behind them on the simultaneous mood. Another advantage of our research is that it is the only study (based on our review in the literature) that had investigated the emotional content of the pieces used in the methodology, prior to the main study, and by another sample group.

The non-proven hypothesis of distortion of emotional burden of recalled memories, was only one of the potential mechanisms in the influence of music in the pathogenesis of mood disorders. So, although the P Values are not even suggestive for a trend toward our hypothesis, we can't reject the probability of such a relationship between these two. If the only significant result be suggestive

of a relationship, it would be an influence in positive direction, and potentially beneficial effect in complement treatment alternatives, not as a probable causal finding in the pathogenesis.

In addition, as evident in the table no.3, although still far from the significance threshold, p-values tend to be less after exclusion of potentially depressed cases; Does it mean that a tiny relationship might be found if sample size increases for many times? Another interesting point is that the only significant or close to significant outcomes belong to written and positive memories, both true and false in addition to true. I may lead us to conclude that written practices focused on achievements and positive event in psychotherapeutic interventions may play efficient roles in treatment and specially prevention of recurrence of depressive disorders. Absolutely larger and highly designed studies are needed for a concrete conclusion.

Last but not least, although depression rate is a sidelong finding of our study, but it is critically high (up to 26% among 100 adult samples) and necessitates urgent attention by mental health policy makers.

Limitation

Limited number of cases, being restricted to instrumental (vs. vocal) musical pieces, short interval period between exposure and assessment, not individually important event, modality of exposure (reading and listening instead of experiencing), and very simplified protocol are the main limitations. Although the results did not even show any trend toward meaningfulness, any change in the factors mentioned above may lead to a great difference in the outcomes of the study. Briefly, further studies with larger sample sizes and more complex methodologies are necessary for a certain conclusion.

Conflict of interest

There isn’t any conflict of interest to declare.

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Name of piece	APF (%)	ANF (%)	Others (%)	P value	APF (%)	ANF (%)	Others (%)	P value
La Traviata*	33 (89.2)	1 (2.7)	3 (8.1)	0.00	31 (91.2)	0 (0.0)	3 (8.8)	0.00
When I am laid in earth**	7 (18.9)	16 (70.3)	4 (10.8)	0.00	4 (11.8)	26 (76.5)	4 (11.8)	0.00
Adagio for Strings***	7 (18.9)	22 (59.5)	8 (21.6)	0.003	4 (11.8)	22 (64.7)	8 (23.5)	0.00
Waltz of the Flowers****	28 (75.7)	3 (8.1)	6 (16.2)	0.00	26 (76.5)	2 (5.9)	6 (17.6)	0.00

APF: Any Positive Feeling, ANF: Any Negative Feeling, Others: any other feeling.

* La traviata (The Fallen Woman) is an opera in three acts by Giuseppe Verdi in F Major

** When I am laid in earth from the opera Dido and Aeneas by Henry Purcell in G minor

*** Adagio for Strings by Samuel Barber in B♭ minor

**** Waltz of the Flowers by Tchaikovsky in D Major

Table no.1: The results of analyses on the feelings reported by participants when listening to selected musical pieces.

Type of Stressor	Oral Biography		Written Biography	
	Happy	Sad	Happy	Sad
Major	Marriage	Death of his father at childhood	Marriage	Divorce of her parents
	Birth of his children	Getting fired of work	Birth of her children	Death of her child
	Setting up a factory	Death of his wife	Setting up her private atelier and academy	Myocardial infarction
Minor	Job promotion	Judicial problems	University entrance	Shutting down the atelier
	Buying a suitable House	Immigration of his children	Exhibition in Paris	Loan with difficult pay back conditions
	Marriage of his children	Pecuniary loss in factory	Marriage of her child	Retirement of her husband
	Birth of his grandchild	Death of a close friend	Moving to an area with desirable climate	Immigration of her child

Table no.2: List of stressors mentioned in biographies.

Memories of:	Group	Normal Distribution in Tchaikovsky Group	Normal Distribution in Barber Group	P Value	Normal Distribution in Tchaikovsky Group	Normal Distribution in Barber Group	P Value
Written Biography	RP	Yes	Yes	0.379	Yes	Yes	0.049
	RN	Yes	No	0.719	Yes	Yes	0.278
	TP	Yes	Yes	0.495	Yes	Yes	0.072
	TN	Yes	No	0.662	Yes	Yes	0.270
Oral Biography	RP	No	Yes	0.424	No	Yes	0.241
	RN	No	No	0.739	Yes	Yes	0.607
	TP	No	Yes	0.845	Yes	Yes	0.263
	TN	No	Yes	0.435	Yes	Yes	0.181
Both	RP	Yes	Yes	0.894	Yes	Yes	0.215
	RN	Yes	Yes	0.954	Yes	Yes	0.695
	TP	Yes	Yes	0.986	Yes	Yes	0.238
	TN	Yes	Yes	0.697	Yes	Yes	0.447
RP: Real Positive Memories/All Memories, RN: Real Negative Memories/All Memories, TP: Total Positive Memories/All Memories, TN: Total Negative Memories/All Memories.							

Table no.3: The results of analyses on the recalled events.