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original article

A study on the effect of music listening on people with high neurotic tendency as evidenced by negative affective scores and physiological responses

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background
Music listening has been found to be effective in reducing stress levels with different participant samples. Relatively little evidence has been obtained from people with high neurotic tendency (HNT), whose dispositional psychological characteristics might dampen the effect of music listening. This study therefore tried to examine the immediate effect of music listening in reducing stressful feelings of participants with either high or low neurotic tendency.

participants and procedure
Seventy-nine undergraduate participants who were identified as having either HNT or low neurotic tendency (LNT) accomplished a stressful task before listening to a comforting music piece. Negative affect (NA) scores and heart rate were measured at different phases.

results
Results in a within-subjects analysis showed that the stressor and music listening could significantly alter the stressful feeling of both participant groups. Although the percentage changes in heart rate were similar between the groups, the changes of NA score which were measured after either the stressful task or the music listening session were consistently lower in the HNT group than the LNT group.

conclusions
The divergence revealed a loose connection between the subjective feelings and the bodily changes in the HNT group, which could be important for clinicians and practitioners to take into consideration in psychology when evaluating the stressful feelings for their clients with HNT.

key words
stress; heart rate; music; neurotic

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authors' contribution – A: Study design · B: Data collection · C: Statistical analysis · D: Data interpretation · E: Manuscript preparation · F: Literature search · G: Funds collection

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BACKGROUND

Music listening is a popular activity across human societies, eliciting emotional experiences in various contexts. Different musical elements, such as major and minor chords, can evoke varying levels of pleasantness (Fang et al., 2017; Parncutt, 2014). Factors such as tempo, frequency, and rhythmic structures also influence physiological and emotional responses in listeners (Ley-Flores et al., 2022; van Dyck et al., 2017). For example, lower sound levels are associated with decreased heart rates (Shoushtarian et al., 2019), while slower tempo music can decrease heart rate, and vice versa (Bretherton et al., 2019; Sugunna & Deepika, 2017). Such synchronization is also observed in studies on cross-modal perception, consistently highlighting the tendency to maintain congruence between stimuli and corresponding bodily and psychological responses (e.g., Bigliassi et al., 2013; Lo et al., 2021; Lo & Lai, 2022; Wiltermuth & Heath, 2009).

Music has been widely utilized in therapeutic contexts to regulate emotions, drawing upon the interconnected relationship between music, emotional experiences, and bodily responses. This regulatory effect has been observed across different age groups and contexts (Groarke & Hogan, 2015; Kuan et al., 2018; Lilley et al., 2014; North et al., 2000; Saarikallio & Erkkilä, 2007; Wu et al., 2017). Physiological studies have demonstrated that music listening can reduce skin conductance and help restore heart rate and blood pressure to normal levels (Chafin et al., 2004; Sandstrom & Russo, 2010). A meta-analysis of 102 physiological studies also consistently supported the stress-reducing effects of music listening (de Witte et al., 2020).

Numerous investigations have shown the effect of music listening on stress reduction in different contexts. Hence, the question arises whether such manipulation would yield similar effects in individuals with different psychological characteristics.

POTENTIAL INDIVIDUAL DIFFERENCE

In Eysenck's personality model, participants with relatively high neurotic tendency (HNT) are found to be more emotionally unstable (Bowen et al., 2011) and vulnerable to stressors (Norris et al., 2007). They may experience nervousness, which makes them feel anxious and react excessively (Muris et al., 2005). People with HNT were also found to use less adaptive coping strategies when dealing with stressors (Fuenzalida et al., 2004). For example, chronic pain patients with HNT might adopt passive coping strategies in handling their stress and pain, which resulted in higher intensity of pain experiences (Montoro & del Paso, 2015).

Music listening is commonly used as a strategy to calm and regulate emotions, including in individuals with high need for tension (HNT) (Lilley et al., 2014). However, the effects of music on stress reduction in individuals with HNT are mixed. On one hand, participants with HNT reported that music listening helped them regulate their emotions (Getz et al., 2014). A meta-analysis of 13 correlational studies also indicated a small to medium effect of music listening on stress reduction in individuals with HNT (Miranda & Blais-Rochette, 2020). On the other hand, research suggests a trait-congruency pattern in which individuals with HNT prefer music with negative affective elements and are more likely to experience sadness in music. This may pose a risk of maladaptation, leading to avoidance and worsening mood (Alluri et al., 2022; Cotter et al., 2018; Mathes, 2022; Vuoskoski & Eerola, 2011).

Apart from the correlational studies, experimental evidence also showed inconclusive results in the effectiveness of music listening in participants with HNT. For example, patients felt less stress when they listened to music during an endoscopy operation, compared with the control group (El-Hassan et al., 2009). Yet, the neurotic level of those participants was not tested, and it was therefore uncertain whether the effect of music listening could be confounded by the level of neuroticism. Kallinen and Ravaja (2004), on the other hand, showed that participants with neurotic tendency showed high left temporal alpha activation, which suggested calmness and relaxation, after listening to music. Their neurological responses were also in line with their verbal reports, which showed senses of positivity and pleasantness. Both physiological and verbal responses illustrated that music listening could be effective in promoting a sense of psychological comfort in people with high neurotic tendency. Nevertheless, participants in that study were not exposed to any stressor before listening to the comforting music. In other words, it was still unknown whether music listening could have an immediate effect in reducing the stressful feeling of people with high neurotic tendency who just experienced the stressors. In another two-week treatment study, elderly participants reported a higher level of relaxation and better sleeping quality after practicing music relaxation exercises than after muscular relaxation exercises (Ziv et al., 2008). Similarly, there was no control of the stressor being experienced by the participants during the treatment time. Also, participants' reports were based on their overall feelings of stress and anxiety in the testing period but were not specifically checked immediately after any stressor was experienced.

PRESENT STUDY

Stress can serve as a motivator, but excessive stress can harm work performance and social interactions (Mattarella-Micke et al., 2011). Music listening has been found effective in reducing stress in various contexts and participant samples. However, its impact on individuals with HNT remains uncertain. The present study aimed to provide experimental evidence on the immediate effects of casual music listening on stress reduction in individuals with high or low neurotic tendency. There are two objectives in this study. Firstly, the current study aimed to provide experimental evidence on the immediate effects of casual music listening on stress reduction in individuals with high or low neurotic tendency. Participants in both groups were exposed to a standardized stressor and then listened to widely used music. It was expected that regardless of neurotic tendency, music listening would result in lower negative affect scores and heart rate compared to measures taken after exposure to the stressor. Furthermore, the effectiveness of music listening might differ between the groups, with individuals with HNT potentially underestimating its stress-reducing effects in their written responses, despite physiological indicators suggesting otherwise. Therefore, the second objective of the present study was to look into the potential difference in the effectiveness of music listening between participants with HNT and participants with LNT. The study collected written responses (negative affect scores) and physiological responses (heart rate) to examine the impact of music listening. It was hypothesized that music listening would be similarly effective in reducing stress for individuals with low and high neurotic tendencies, as indicated by the change in heart rate. However, participants with HNT were expected to show a lower rate of decrease in negative affect scores compared to participants with low neurotic tendency.

PARTICIPANTS AND PROCEDURE

PARTICIPANTS

Seventy-nine native undergraduates (females: 50, males: 29) were recruited to take part in this study so as to fulfill their course requirement. The age of the participant ranged from 18 to 25 years. Participants were first required to complete a revised version of the Eysenck Personality Questionnaire (EPQ-RSC; Qian et al., 2000), which differentiated them into two groups, i.e., the HNT group and the LNT group, based on the sample median (Ivkovic et al., 2007). In all, 40 participants (females: 30, males: 10) were assigned to the HNT group and the remaining participants (N = 39, females: 28, males: 11) were assigned to the LNT group.

MATERIALS

Positive and Negative Affect Schedule (PANAS). Participants in this study were required to judge how well the twenty words denoting different emotions in the Positive and Negative Affect Schedule (PANAS) describe their present feelings on a 5-point scale. Positive and negative affective scores are the summation of the rating scores of the corresponding vocabularies. Both scores are found to be highly reliable in showing participants' affective states in different studies (e.g., PA: $\alpha = .89$, NA: $\alpha = .85$, in Crawford & Henry, 2004; PA: $\alpha = .94$, NA: $\alpha = .94$, in Potter et al., 2000).

Music stimuli. A piece of pure music, Pachelbel's Canon in D major, which lasted for around 8 minutes and has been widely used as a musical piece in inducing relaxation (e.g., Chafin et al., 2004; Parada-Cabaleiro et al., 2021) was adopted in the present study. It was presented on a Windows-based desktop computer with the default media player via the given earphones to the participants after a stressful task in this study.

PROCEDURE

Each participant was asked to sit in a quiet laboratory throughout the study. After completing the EPQ-RSC questionnaire, participants were asked to calm down for three minutes. They were then required to fill in the PANAS form, and their heart rate was also measured at the same time, which served as the baseline measure (i.e., T1). The present study adopted a Sing-a-Song Stress Test (SSST) in which participants were asked to sing his or her favorite song in front of a video recorder (Brouwer & Hogervorst, 2014). SSST was found to be positively correlated with stress in terms of increased skin conductance and heart rate and has therefore been adopted in different studies as a reliable source of stress (Jump & Dockray, 2021; Toet et al., 2017; van der Mee et al., 2020). To further strengthen the stress level of the SSST, participants in this study were told that the recording would be uploaded on YouTube.

The PANAS form was again required to be finished together with the measurement of the heart rate after the singing task (i.e., T2). A piece of pure music, Pachelbel's Canon in D major, was then played via the provided earphone to the participants at a comfortable volume level. After listening to the music, a third round of the PANAS form was required to be finished and heart rate was also measured (i.e., T3). A debriefing session was conducted after the completion of the experiment. If the participants disagreed with the deception element in the procedure (i.e., no video was really recorded), corresponding data would be withdrawn from the analysis. No data were withdrawn in this study. Furthermore, no participant was able to guess the present research hypothesis after finishing the study before being debriefed.

Table 1

Means (and standard deviations) of the NA and PA scores, heart rate at different measurement periods, and the percentage change in NA score and heart rate between the participant groups

Record time	Participant group	NA	PA	Heart rate	% change in NA	% change in heart rate
Baseline (T1)	HNT	22.08 (7.50)	25.50 (6.53)	87.12 (13.24)		
	LNT	16.44 (4.24)	23.20 (6.17)	83.92 (12.80)		
After SSST (T2)	HNT	24.42 (7.69)	24.88 (6.45)	108.46 (10.50)	13.97 (2.65)^{S}	25.93 (14.63)^{S}
	LNT	20.56 (5.41)	22.36 (6.40)	105.72 (19.22)	28.29 (8.49)^{S}	25.94 (14.63)^{S}
After music listening (T3)	HNT	19.69 (6.75)	25.00 (6.72)	85.19 (12.39)	−17.52 (13.48)^{M}	−21.43 (8.70)^{M}
	LNT	13.72 (4.78)	21.52 (6.37)	76.28 (11.67)	−32.18 (7.83)^{M}	−26.39 (13.21)^{M}

Note. NA – negative affect; PA – positive affect; HNT – high neurotic tendency; LNT – low neurotic tendency; SSST – Sing-a-Song Stress Test. Figures of the rate of change with a superscript ‘S’ refer to the comparison between T1 and T2, whereas figures of the rate of change with a superscript ‘M’ refer to the comparison between T2 and T3.

Table 2

Reliability scores of the PANAS between participant groups

Record time	Participant group	NA	PA
Baseline (T1)	HNT	0.89	0.91
	LNT	0.86	0.84
After SSST (T2)	HNT	0.88	0.90
	LNT	0.83	0.91
After music listening (T3)	HNT	0.93	0.93
	LNT	0.87	0.90

Note. PANAS – Positive and Negative Affect Schedule; HNT – high neurotic tendency; LNT – low neurotic tendency; SSST – Sing-a-Song Stress Test.

RESULTS AND ANALYSIS

Descriptive findings are reported in Tables 1 and 2. At first, repeated measures ANOVAs were conducted to look into the effects of the manipulations of the SSST and music listening between the participant groups in terms of participants’ NA score and heat rate. After that, the potential difference in their effectiveness between the participant groups, as reflected by the rate of change of participants’ NA score and heart rate, could be further investigated via the between-subjects analyses and regression analyses.

MAIN EFFECTS OF SSST AND MUSIC LISTENING

SSST (comparison between T1 and T2). A repeated measures ANOVA with Greenhouse-Geisser correction was adopted to examine the main effect of the manipulation of the SSST (i.e., between T1 and T2) on the NA score and heart rate of the participants in both groups. A significant main effect of SSST was found as indicated by an increase in participants’ NA score ($F(1, 77) = 31.29$, $p < .001$, $\eta_p^2 = 0.39$, power = 1.00) and their heart rate ($F(1, 77) = 208.88$, $p < .001$, $\eta_p^2 = 0.81$, power = 1.00). There was no significant interaction effect in both analyses (NA score: $F(1, 77) = 2.36$, $p = .126$; heart rate: $F(1, 49) = 0.02$, $p = .883$), which suggested that the SSST was effective in both groups of participants.

To further study the main effect of the SSST on participants’ score in positive affect, i.e., PA, another repeated measures ANOVA was conducted. The main effect of the SSST was not found to be significant ($F(1, 77) = 2.33$, $p = .104$), which suggested that the SSST did not significantly increase or decrease participants’ PA scores, compared with their baseline measures.

Music listening (comparison between T2 and T3). A significant main effect of music listening showed that there was a significant reduction in participant’s NA score ($F(1, 77) = 66.33$, $p < .001$, $\eta_p^2 = 0.58$, power = 1.00) and heart rate ($F(1, 77) = 205.54$, $p < .001$, $\eta_p^2 = 0.81$, power = 1.00). The interaction effects were non-significant in both analyses (NA: $F(1, 77) = 2.20$, $p = .136$; heart rate: $F(1, 77) = 2.82$, $p = .133$).

Furthermore, participants’ PA scores were found not to be significantly affected by music listening ($F(1, 77) = 0.86$, $p = .360$). Given that participants’ PA scores were relatively stable throughout the experimental procedures, the further analyses would mostly focus on their NA scores and heart rate in this study.

DIFFERENCE IN THE EFFECTIVENESS OF SSST (T1 AND T2) BETWEEN GROUPS

In order to investigate the potential difference in the effectiveness of SSST between the participant

Table 3

Unstandardized and standardized regression coefficients for the models of the percentage change in NA score and heart rate

Condition	Dependent variables	Variable	B	*SE* B	β	Adjusted R^2
After experiencing the stressor, i.e., T1 and T2	% change in NA score	EPQ-RSC score	−.02	.01	−.25*	.05
	% change in heart rate	EPQ-RSC score	.00	.00	.11	.00
After listening to the music, i.e., T2 and T3	% change in NA score	EPQ-RSC score	−.02	.01	−.29*	.08
	% change in heart rate	EPQ-RSC score	−.01	.00	−.19	.06

Note. EPQ-RSC – Eysenck Personality Questionnaire-Revised Short Scale; NA – negative affect; *p < .05.

groups, participants' rates of change of both NA score and heart rate between T1 and T2 were calculated. The current results showed that participants with HNT showed a significantly lower rate of increase in NA score (M = 13.97%) than the participants with LNT (M = 28.29%) after being exposed to the stressor (F(1, 77) = 4.21, p = .045, η_p^2 = 0.08, power = 0.52), even though there was no significant difference in their heart rate changes (F(1, 77) = 0.00, p = .998).

Furthermore, a linear regression analysis was also conducted to examine how the variation of participants' neurotic tendency, as indicated by their scores in the section of neuroticism in EPQ-RSC, predicted the variance in the rate of change of NA score and heart rate between T1 and T2 in this study. Participants' neurotic tendency significantly predicted the variance of the rate of change of their NA scores (F(1, 78) = 6.61, p = .012, adjusted R^2 = .05) but not the changes in their heart rate (F(1, 78) = 1.24, p = .268, adjusted R^2 = .00); see Table 3. Results of the regression analysis were consistent with the findings in the ANOVA analysis that the variation of participants' neurotic tendency only significantly predicted the variance in the rate of change of their NA score but not heart rate after experiencing the stressor.

DIFFERENCE IN THE EFFECTIVENESS OF MUSIC LISTENING (T2 AND T3) BETWEEN GROUPS

Participants with HNT again showed a significantly lower degree of reduction in the NA score (HNT: M = 17.52%; LNT: M = 32.18%) than their counterparts (F(1, 77) = 6.91, p = .011, η_p^2 = 0.12, power = 0.73), though there was no significant difference in their rate of reduction in heart rate (F(1, 77) = 2.50, p = .118), after listening to the music. These observations also aligned with the results from the regression analyses, which showed that participants' score in the scale of neuroticism significantly predicted the variance in the rate of change of their NA score (F(1, 78) = 9.18, p < .001, adjusted R^2 = .08) but not heart rate (F(1, 78) = 3.78, p = .055, adjusted R^2 = .02).

DISCUSSION

Both SSST and music listening were found to be effective in serving their functions in this study. Both groups of participants were found to be stressed after the SSST and felt less stressful after listening to comforting music, as reflected by the variations in the NA score and heart rate. Participants in the LNT group showed a larger percentage change in the NA score after the SSST (i.e., a higher rate of increase) and music listening (i.e., a higher rate of decrease) than participants in the HNT group, though there was no significant difference in the percentage change of heart rate between the groups. In other words, participants with HNT were less expressive in reporting the stress (i.e., after the SSST) and the relief (after listening to the music) that they experienced, in terms of the rate of change of their NA score, when compared with their counterparts.

UNDER-REPORTED CHANGE OF INCREASING STRESS

Both groups of participants were found to be effectively induced with stress by the SSSI. Yet participants with HNT showed a lower level of increase in the negative affect score (M = 13.97%), as a self-reported indicator of feeling stress, when compared with their counterparts with LNT (M = 28.29%). Given that the rate of change of heart rate in both participants groups was similar, the smaller change of the NA score suggested that participants with HNT might not be as expressive as those with LNT in showing how much stress they experienced. These findings are compatible with the negative relationship between neuroticism and emotion expressiveness (Gross & John, 1995). Participants with a high level of neuroticism are commonly found to adopt maladaptive emotion regulation strategies by suppressing their expressions of negative emotions (Yang et al., 2020). Fear of judgement (Allan et al., 2017) and avoidance tendencies (Mohammadkhani et al., 2016) could be the possible reasons why people with high levels of neuroticism tend to under-express their feelings towards negative events. The low tendency of expressing negative emotions may therefore also explain why the rate of change of the NA score observed in the HNT group was smaller than the change in the LNT group in this study.

In addition, the present findings showed that there was no significant difference in the bodily receptiveness, in terms of heart rate, to the feeling of stress between the participant groups. In other words, participants with HNT, after being stressed, shared a similar increase of the heart rate as the participants with LNT. This asymmetrical relationship between the self-reported responses and bodily responses in the HNT group was also observed in the relieving effect of music listening in this study.

RELIEF IN HNT GROUP

Music listening could generally lower the stressful feeling of the participants in both HNT and LNT groups as indicated by the rate of decrease in their NA score and heart rate. The change of heart rate partially represented how the body reacted to the manipulation of music listening as a relaxation process. It was therefore expected that participants in both groups would show a level of change in their NA score which corresponded to the change of their heart rate. The current results showed no significant difference in the rate of change of the heart rate between the participant groups after listening to the music, but participants with HNT had a significantly lesser degree of reduction (M = 17.52%) in the NA score than those in the LNT group (M = 32.18%). This nonparallel relationship probably implies skewed psychological beliefs about stress with a loose awareness of the connection between the subjective feeling and the physiological responses. It could be further explained by the dispositional characteristics of neuroticism in the HNT group which generated an experiential bias in processing emotional feelings. Previous studies have shown that people with high neurotic tendency were more likely to exhibit negative affect, which is probably due to different cognitive biases (e.g., Norris et al., 2019; Pang & Wu, 2023). Such biased processing might also impose an impact on handling information related to positive information. For example, as compared to the low neurotic group, the high neurotic group was highly sensitive in processing a negative stimulus, while under-performing in the processing of a positive stimulus (Chan et al., 2007). Participants with a higher neurotic score were also found to be less likely to accept positive compliments or feedback, which were wrongly regarded as insincere or mistaken (Sawyer et al., 2002).

The current findings are consistent with the past studies in showing that participants with HNT generally under-report the change of their stress level, no matter whether they are exposed to stressors or calming situations. In addition, their bodily responses to the change of stress, which were not different from their counterparts, further illustrate a potential difficulty of the HNT participants in expressing their emotional feelings.

FEATURES OF MUSIC

The music stimuli Pachelbel's Canon in D major, which was adopted in the current study, has been widely used as a music piece to reduce stress in different studies (e.g., Chafin et al., 2004; Parada-Cabaleiro et al., 2021). All participants in this study were told to adjust the music volume to their comfortable level before listening to the music. Nevertheless, there was no standardized control of any music parameter, e.g., intensity, when the music was played. It is therefore unknown whether these music features could alter the effectiveness of music listening for stress reduction. Based on the positive relationship between music tempo and heart rate (Bretherton et al., 2019; Sugunna & Deepika, 2017), it is speculated that the effect of music listening could be further enhanced, in terms of verbal and bodily responses, in people with LNT when a slow tempo music is played. Based on the present findings, it is also uncertain whether a similar degree of facilitation effect on stress reduction can be observed in people with HNT whose dispositional neurotic characteristics may dampen their experiences of the relief. All these speculations relating to the variations of the music parameters and their effects on stress reduction in people with different levels of neuroticism await verification in future research.

Disclosure

The authors declare no conflict of interest.

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