Rock 'n' Roll but not Sex or Drugs: Music is negatively correlated to depressive symptoms during the COVID-19 pandemic via reward-related mechanisms

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Abstract (150 words)

The COVID-19 pandemic has deeply affected mental health. We assessed which of many leisure activities had positive psychological effects, with particular attention to music, which has been reported anecdotally to be important. Questionnaire data from over a thousand individuals primarily from Italy, Spain, and the USA during spring 2020 show that people picked music most often as the best activity to cope with psychological distress. Hours of engagement in music and food-related activities during the pandemic were associated with decreased depression symptoms. The benefits of music were mediated by individual differences in sensitivity to reward, whereas the positive effects of food-related activities were related to emotion regulation. Our results demonstrate that music is an important means of improving well-being, and suggest that the underlying mechanism is related to reward, consistent with neuroscience findings. Our data have practical significance in pointing to effective strategies to cope with mental health issues.

33 With more than 60 million cases and nearly 1.5 million deaths confirmed worldwide as of November 2020, the
34 ongoing coronavirus disease 2019 (COVID-19) pandemic has become one of the worst global health crises of
35 modern times¹. Beyond the direct threat to public health, the COVID-19 pandemic has precipitated social and
36 economic crises with significant impacts on mental well-being and daily habits². Indeed, the unprecedented
37 measures taken to slow the spread of the virus (e.g., quarantine and confinement orders), while
38 epidemiologically necessary, have increased mental health burdens by exposing those affected to
39 circumstances associated with negative outcomes for mental well-being (e.g., isolation, financial concerns,
40 etc.)^{2,3}.

41 Recent data clearly suggest that the COVID-19 pandemic has been responsible for a worldwide increase in
42 psychological distress (China^{4,5}; Italy⁶; Spain⁷; United Kingdom⁸; USA⁹); namely depression-, stress- and
43 anxiety-related symptoms (from here on, referred to collectively as ‘pandemic-related psychological distress’).
44 In one large-scale survey in China, for example, more than half of respondents (53.8%) reported moderate-to-
45 severe psychological impacts from the COVID-19 pandemic, with 28.8% and 16.5% of participants also
46 reporting high rates of moderate-to-severe anxiety and depression, respectively⁵. In another recent study (July,
47 2020), 53% of U.S. adults reported that the pandemic has had a negative effect on their mental health¹⁰.

48 Finding activities that help one to cope with depression, stress and anxiety¹¹ is of heightened importance in the
49 context of such a global crisis, and music has emerged as particularly relevant undertaking in this vein. Large-
50 scale survey studies often highlight music as a prevalent and important activity in people’s everyday lives¹².
51 Music is often used to manage or regulate mood (both by attenuating negative and promoting positive affect
52 ^{12,13}), particularly when under perceived stress¹⁴, and is favored for this purpose over other leisure activities
53 such as reading or watching TV¹². Indeed, research consistently shows that music is an effective tool for
54 modulating mood, regulating emotions and reducing stress, anxiety and/or depression in both healthy
55 (including adolescents, adults and the elderly) and clinical populations ^{14–22}. Finally, accumulating evidence
56 shows that music engages vast brain networks involved in emotion ^{23–25}. Of particular relevance—due to its

57 putative role in positive affect regulation ^{17,26–28}—is the evidence that music also engages the brain’s
58 dopaminergic reward system ^{25,29–33}.

59 Taken altogether, these findings suggest a potentially important role for music as a tool for improving mental
60 health outcomes during this time of crisis. Interestingly, media reports from the pandemic’s early international
61 surge often highlighted that many people were turning to music as a way of coping with pandemic-related
62 psychological distress. One particularly well-reported example was the “balcony singing” phenomenon seen in
63 various locations around the globe ^{34,35}. Such media reports on music are, however, entirely anecdotal, and it is
64 not clear whether music plays any *special* role among activities used by the general population to cope with
65 pandemic-related psychological distress. To our knowledge, there exists to date no systematic report of which
66 activities are preferred in this context, nor of how such activities might exert their psychologically beneficial
67 effects, if any.

68 The objective of the research presented here is to assess which of many leisure activities common to everyday
69 life may have had positive effects on mental health during the COVID-19 crisis, and to understand the
70 underlying psychological mechanisms of these effects. Using online crowdsourcing with sampling unbiased
71 towards any one activity, we collected detailed (1h) surveys from over a thousand individuals around the peak
72 of the confinement period during the first wave of the pandemic (May 7th-June 2nd) in three of the countries
73 most severely affected at that time (the USA, Spain and Italy), as well as in other nations in Europe and the
74 Americas in which confinement orders were in place. Individuals provided data regarding their demographics,
75 the impact of the virus on their everyday lives, and their activities while under confinement orders (activities
76 related to music, exercise, cooking, entertainment, socializing, religion, sex, and drugs, among others, totaling
77 43 possible activities; see Table S1); they also completed validated tests (in English, Spanish or Italian,
78 according to the language spoken) measuring depression anxiety and stress, (DASS-21)³⁶, as well as
79 standardized questionnaires assessing personality traits related to individual differences in reward sensitivity
80 and emotional regulation (Physical Anhedonia Scale ³⁷ and Emotional Regulation Questionnaire ³⁸).

81 First, we tested the hypothesis that music would be reported as one of the most popular activities that helped
82 individuals to cope with pandemic-related psychological distress. We also predicted that, the more affected
83 people were by the pandemic (e.g. change in employment status, at-risk populations, etc.), the more they

would engage in activities that are effective in reducing the effects of pandemic-related psychological distress. In the same vein, we expected that there would be a relationship between the amount of time spent on effective coping activities during the pandemic and lower levels of actual emotional distress. Finally, we tested whether the beneficial effects of the coping activities chosen were mediated by individual differences in certain traits, including reward sensitivity and emotional regulation strategies.

Results

First, we aimed to assess the risk factors that contribute to the development of psychological distress and negative emotional symptoms during the pandemic. Participants provided detailed information regarding their personal and professional status and how these had changed during the period of acute lockdowns during the initial spring surge of the COVID-19 pandemic. After applying exploratory factor analysis to these questions (see methods), we calculated a linear mixed-effects model using the DASS-21 total score (a composite measure of depression, anxiety and stress symptoms) as a dependent variable, individuals' situation during the lockdown as explanatory variables (income, change in employment status because of the lockdown, number of people living at home, being part of an at-risk population for COVID-19, being diagnosed or having friends or relatives diagnosed or dying due to the virus, and weeks spent under confinement orders; see methods), and country as a random effect.

Our results indicate that higher DASS-21 total scores were more evident in individuals who had lower income [$\beta = -2.69$, $SE = 0.88$, $\chi^2(1) = 9.33$, $p = 0.002$], who lost their job or had to close their business [slope computed using no change in employment as a baseline, $\beta = 10.48$, $SE = 3.16$, $\chi^2(4) = 14.04$, $p = 0.007$], who were part of an at-risk population for COVID-19 [$\beta = 2.92$, $SE = 1.38$, $\chi^2(1) = 4.50$, $p = 0.034$], or who were diagnosed or had friends or relatives diagnosed or dying due to the virus [$\beta = 3.44$, $SE = 1.07$, $\chi^2(1) = 10.28$, $p = 0.001$]. The number of weeks under confinement orders [$\beta = -0.34$, $SE = 0.43$, $\chi^2(1) = 0.64$, $p = 0.42$], number of elderly people [$\beta = 0.69$, $SE = 0.93$, $\chi^2(1) = 0.55$, $p = 0.46$] and total number of people living at home [$\beta = 1.56$, $SE = 1.02$, $\chi^2(1) = 2.33$, $p = 0.13$] did not influence the level of psychological distress. All the variables that significantly correlated with the DASS-21 total score were standardized, and the resulting values were summed to give a composite measure of COVID-19 impact on mental well-being (from now on, 'COVID-19 Factor'). No differences in age [$\beta = 0.003$, $SE = 0.005$, $\chi^2(1) = 0.47$, $p = 0.49$], gender [male vs female: $\beta = -0.03$, $SE =$

0.12, $\chi^2(1) = 1.81$, $p = 0.40$], or level of education [$\beta = 0.56$, $SE = 1.79$, $\chi^2(1) = 4.95$, $p = 0.29$] were found for the COVID-19 Factor scores. Furthermore, and in order to provide an independent validation of the COVID-19 Factor as an index that captures the pandemic's impact of psychological distress levels, we computed a sentiment analysis (i.e., an analysis determining whether a particular text has positive or negative connotations) of free text responses to a question that asked participants if they could think of any 'silver linings' to the ongoing pandemic. Notably, participants who provided negative comments, even when prompted in this way to express something positive related to the COVID-19 pandemic, had higher COVID-19 Factor scores than those who provided positive comments (i.e., individuals who were more severely impacted by COVID-19 tended to report seeing no silver linings to the pandemic at all; see Figure S1).

Figure 1. Most helpful activity for coping with pandemic-related psychological distress as reported during the period of acute lockdowns in the initial spring surge of the COVID-19 pandemic. Word cloud (A) and summary percentages (B) for the activities that helped participants the most in coping with the pandemic. Music-related activities were reported to be the most useful for 19% of our sample. *Music*, involves all music related activities including composing, playing an instrument or singing; *Food*, includes all activities related to cooking, baking or eating; *Videocalls*, refers to talking with family and friends; *Social Media*, includes all items related to the use and discovery of social media applications; *Exercise* covers all activities related to sport, indoors or outdoors; *Entertainment* includes watching series, documentaries and movies, reading books and listening to the radio; *Spiritual* comprises any religious (e.g., prayer) activity, yoga and meditation; *Sex*, includes any sexual or erotic activity.

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Once the COVID-19 Factor was calculated and validated, we turned to assess participants' strategies for coping with pandemic-related psychological distress. To this end, we devised a list of 43 items that account for a large range of everyday activities that people might have used (see Table S1). When participants were asked

to select from among this pool of 43 items the activities that had helped them the most in coping with pandemic-related psychological distress, “Listening to music” was selected as the #1 most helpful by the largest share of participants (14.48%; **see Figure 1A**), followed by “Talking with friends, family and colleagues” (14.07%) and “Exercising indoors” (12.95%; see Table S1). Two-sample binomial tests show that these three activities were chosen as the #1 activity significantly more often than the fourth one, “Cooking”, which was selected by 10.79% of participants (Music: $p < 0.001$, $CI = 0.12-0.17$; Talking: $p < 0.002$, $CI = 0.12-0.16$; Exercising indoors: $p < 0.05$, $CI = 0.10-0.15$). When pooling together the 43 items by topic (e.g., adding together the share of participants who selected music-related items: listening to music, listening to sad music, playing music, etc.), *music-related* activities emerge as the top choice for the #1 most helpful coping group of activities, selected by 19.37% of participants. Importantly, two-sample binomial tests show that music-related activities were selected significantly more often than the second and third most frequently selected categories (in both cases, $p < 0.05$, $CI = 0.17-0.21$), which were *Entertainment* (16.62%; this category included watching series, documentaries and movies, reading books and listening to the radio; **see Figure 1B**) and *Exercising* (16.00%).

In addition to selecting the most effective activity for coping with pandemic-related psychological distress from among the list of 43, participants were also asked to indicate how much they pursued these activities during the pandemic by rating the subjective perceived change in their active engagement using a Likert scale (i.e., if they were engaging in these activities more or less than before the pandemic). Using factor analysis, the initial set of 43 items was reduced to the following 6 dimensions: Music, Food, Reading and/or Watching Series/Movies, Drugs, Social, and Exercise-related activities. On average, participants reported higher engagement with all the activities across these six dimensions than compared to before the pandemic (all $ps < .001$; *Cohen’s d*: Music=0.49; Reading and/or Watching Series/Movies=0.93; Exercise=0.51; Social=0.99; Food=0.80) with the exception of activities relating to drug use, which were less pursued during the spring 2020 surge of COVID-19 [$t(950) = -13.07$, $p < .001$, $d = 0.42$]. Interestingly, linear mixed-effects model analysis revealed that the COVID-19 Factor (higher for those individuals that were more critically impacted by the pandemic) was associated with participants’ active engagement in music-related activities [$\beta = 0.16$, $SE = 0.08$, $\chi^2(1) = 4.40$, $p = 0.036$], but not with changes in any of the other dimensions. Thus, the participants who were more severely impacted by the COVID-19 pandemic, reported higher levels of subjective engagement in

151 music-related activities during the spring 2020 phase of acute lockdowns (**Figure 2**). This relationship further
 152 indicates that, among the many activities explored, music was particularly pursued as a means for coping with
 153 pandemic-related psychological distress.

Figure 2. Music engagement and impact of COVID-19. Participants who pursued more music-related activities were more severely impacted by the pandemic. Main result (with 95% confidence interval) of the linear mixed-effects model estimating the impact of COVID-19 as a function of the subjective change in engagement in music activities (Likert scale going from 1-*Much Less* to 7-*Much More*, with 4 corresponding to *About the Same*). Each dot represents the response by one participant (a small jitter has been applied for visualization purposes; final N=981).

154
 155 To further elucidate the potential of music-related activities specifically, and of top-rated coping activities
 156 generally, to mitigate feelings of anxiety, stress or depression during the pandemic, participants indicated,
 157 separately from the Likert scale questions, the number of days per week and hours per day that they engaged
 158 in five broad types of activities (music, food, sex, drugs, and physical exercise; activities selected *a priori*, see
 159 methods) before and during the COVID-19 pandemic. We computed the number of hours per week dedicated
 160 to each activity before and during the COVID-19 lockdown, and examined *dose-response* relationships
 161 between the actual time spent on these activities and the levels of depression, anxiety and stress evinced by
 162 answers to the DASS-21. Linear mixed-effects models (using DASS-21 subscale scores as dependent
 163 variables, hours per week *before* and *during* the pandemic for each of the 5 activities as well as age,
 164 education, and gender as fixed-factors, and country as random effect) first revealed that hours of engagement

165 before the pandemic in food-related [e.g., cooking, baking; $\beta = 0.12$, $SE = 0.05$, $\chi^2(1) = 5.76$, $p = 0.016$] and in
 166 sex-related activities [$\beta = 0.20$, $SE = 0.09$, $\chi^2(1) = 4.70$, $p = 0.030$] were positively associated with higher
 167 subsequent levels of anxiety and of stress, respectively, during the spring surge of COVID-19. In addition, age
 168 was negatively associated with levels of depression [$\beta = -0.16$, $SE = 0.04$, $\chi^2(1) = 18.38$, $p < 0.001$], anxiety [$\beta =$
 169 -0.12 , $SE = 0.03$, $\chi^2(1) = 15.84$, $p < 0.001$] and stress [$\beta = -0.17$, $SE = 0.04$, $\chi^2(1) = 21.92$, $p < 0.001$] (i.e.,
 170 younger individuals presented worse mental health during the pandemic generally), and gender showed a
 171 significant relation with stress [women experienced more stress than men; $\beta = -1.72$, $SE = 0.78$, $\chi^2(1) = 6.84$, p
 172 $= 0.032$].

173

174 **Figure 3. Music- and food-related activities are negatively associated with depressive symptoms.** Main result
 (with 95% confidence interval) of the linear mixed-effects model estimating depressive symptoms as a function of the
 number of hours per week engaged in music- (left) or food- (right) related activities. Each dot represents the response
 of one participant (a small jitter has been applied for visualization purposes).

175 Perhaps most relevantly: time spent on food- and music-related activities *during* the crisis (but not before) was
 176 *negatively* associated with levels of pandemic-related psychological distress. Specifically, the time spent in
 177 lockdown on music-related activities was negatively associated with levels of depression [$\beta = -0.08$, $SE = 0.04$,
 178 $\chi^2(1) = 5.01$, $p = 0.025$; **Figure 3, left**]. That is, the more time spent on music-related activities *during* the
 179 COVID-19 crisis (but not *before*), the lower the concurrent levels of depression. Time spent in lockdown on

180 food-related activities was negatively associated with levels of anxiety [$\beta = -0.14$, $SE = 0.04$, $\chi^2(1) = 13.35$, $p <$
181 0.001] and depression [$\beta = -0.15$, $SE = 0.05$, $\chi^2(1) = 10.50$, $p = 0.0012$; **Figure 3, right**]. Thus, the more time
182 spent on food-related activities such as cooking *during* the COVID-19 pandemic (but not *before*), the lower the
183 concurrent levels of anxiety and depression.

184 These findings indicate the potential of engaging in food- and music-related activities during the pandemic to
185 mitigate the appearance of psychological distress symptoms. But what mechanisms might mediate these
186 effects? Is it that these activities are rewarding and pleasurable, and thus make people feel good? Or do they
187 act as distractions from worries, or help to express/suppress frustrations and emotions? In other words, is
188 psychological distress mitigated by music- and food-related activities due to their intrinsic effects as rewarding
189 activities, due to their role in emotion regulation, or both? To address this point, we administered personality
190 questionnaires designed to measure individuals' sensitivity to reward (that is, to experiencing pleasure;
191 measured using the *Physical Anhedonia Scale*, PAS ³⁷) and individuals' habitual strategies for regulating their
192 emotions (as measured by the *Emotion Regulation Questionnaire*, ERQ ³⁸). We performed a mediation
193 analysis to assess whether the direct effects of music- and food-related activities on pandemic-related
194 psychological distress were mediated by inter-individual variation in sensitivity to reward or in emotion-
195 regulation strategies. This analysis revealed that the negative association between the time spent on music-
196 related activities and levels of depression was fully mediated by the participant's ability to experience pleasure
197 (as measured by the PAS; scores are inverted so that greater values imply more sensitivity to reward for the
198 sake of clarity, $b = -0.02$, 95% CI = $-.040 - -.01$; $p < .001$, see **Figure 4a**). In order to rule out any effect of
199 musical training, we also performed the same mediation analysis while including musical training (as measured
200 by the *Goldsmith Musical Sophistication Index*, Gold-MSI ³⁹) as a mediator. No mediation of musical training
201 was found ($b = .005$, 95% CI = $-.004 - 0.02$; $p = .25$), suggesting that the effect that music had on participants'
202 mental health was mediated by their ability to experience pleasure in general, and not by their musical training
203 in particular.

204 In contrast, associations of food-related activities with depression ($b = -.02$, 95% CI = $-.04 - -.01$; $p = 0.02$) and
205 with anxiety ($b = -.14$, 95% CI = $-.28 - -0.03$; $p = .036$) were partially mediated by individual differences in
206 emotional *expressive suppression* (as measured with the ERQ-expressive suppression scale, with a *negative*

relationship; see **Figure 4b**). In other words, the positive effect that engagement in food-related activities during the pandemic had on mental health was partially mediated by the participant's ability *to avoid inhibiting* the expression of emotions.

Fig 4. Mediation analysis. The attenuation of depressive symptoms is mediated by individual differences in sensitivity to reward **(A)** in the case of music-related activities, and by individuals' ability to avoid suppressing their emotions in the case of food-related activities **(B)**. Numerical values represent the regression coefficients between different pairs of scores. The coefficients between music and depression and food and depression represent the correlation coefficient with the mediator taken into account. Sensitivity to reward was measured with the PAS. Emotional suppression was measured with the ERQ. For the sake of clarity, scores for the PAS have been inverted so that higher values imply greater sensitivity to reward. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ Bonferroni corrected for the three correlations calculated per mediation analysis.

Thus, although both music- and food-related activities were associated with lower levels of psychological distress, their benefits may rely on participants' predispositions to enjoy rewards and to avoid suppressing their emotions, respectively.

Discussion

The primary aim of this study was to identify which of many everyday leisure activities could have had positive effects on mental health during the COVID-19 crisis in highly affected countries, as well as the candidate psychological mechanisms responsible. Out of the more than forty everyday activities in nine broad categories probed, we found that music-related activities were rated as being the most helpful for coping with the pandemic by the greatest share of our sample, followed by activities relating to other types of entertainment (e.g., reading books, watching movies, etc.), to exercise, to social interactions (e.g., talking with family), and to

220 food (e.g., cooking, baking). Moreover, using an index of the degree to which each individual was impacted by
221 the pandemic (in terms of health, employment, income, etc.), we show that the more people were affected by
222 COVID-19, the more frequently they engaged in music-related activities during the spring surge of the
223 pandemic. Remarkably, no group of activities other than music correlated with the impact of COVID-19. In this
224 vein, the hours of engagement in music-related and food-related activities *during*, but *not before*, the pandemic
225 were associated with decreased mental health symptoms, and these were the only two activities that showed
226 this positive effect. Different psychological mechanisms underlie these relationships, however: while the
227 positive effects of food-related activities were mediated by participants' ability to avoid suppressing their
228 emotions, the benefits of musical engagement were mediated by their capacity to experience pleasure and
229 reward. These findings indicate that the impacts of music- and food-related activities on mood are driven via
230 different psychological mechanisms (reward/pleasure and emotional expressive suppression, respectively),
231 and thus, that the potential benefit of these activities for coping with pandemic-related psychological distress
232 may depend on the personality profile of each individual.

233 Notably, our sample was not biased towards people with any particular affinity for music; neither the invitation
234 to participate nor the questionnaire included "music" in the title, nor was it distributed specifically amongst
235 people with musical interests. Indeed, our sample in fact is somewhat skewed towards limited musical training
236 (see supplemental Figure 20), yet music-related activities were most frequently indicated as the top choice for
237 coping with the pandemic-related psychological distress. Recent studies have highlighted the role of physical
238 exercise^{40–42} and other leisure activities such as reading, making handcrafts, talking with friends and watching
239 TV or film^{7,43,44} as protective factors against developing psychological distress symptoms associated with the
240 COVID-19 pandemic. To the best of our knowledge, however, none of these studies investigated the role of
241 music in coping with COVID-19-related adversities and mitigating their effects within the context of other
242 activities or across multiple countries (see ⁴⁵ for an exception, limited however to a highly educated sample of
243 400 individuals). The former point is particularly important since individual differences in engagement with
244 distinct reward-related activities share a common variance (e.g. individuals that are more sensitive to reward
245 are more likely to engage in reward-related activities in general), and it is therefore crucial to explore a large
246 and heterogeneous sample of activities in order to rule out potential nonspecific effects. In addition, testing

across multiple countries allows more generalizable conclusions to be drawn about how music and other activities modulated mental health outcomes during the COVID-19 crisis. Thus, our results point to the potential efficacy of music as a coping tool with which to mitigate the adverse effects of stressful situations, and do so (1) in an unbiased group of participants sampled from different countries, and (2) when controlling for participants' engagement in many other activities, as well as for other confounding factors such as age, gender, and level of education.

Music constitutes a fundamental human activity, considered to be among the most enjoyable and satisfying⁴⁶, which is created and consumed in all societies and across all age groups⁴⁷. An important aspect of music listening is its ability to modulate the emotional state of the listener⁴⁸, which in turn can promote well-being⁴⁹. Indeed, several studies have highlighted the crucial role of music in mood regulation and management, enabled by driving positive feelings and reducing stress^{18,50–52}. It is therefore reasonable to hypothesize that participants identified in music-related activities (such as listening or singing) positive, accessible and reliable strategies to help them face the critical COVID-19 period. In support of this conclusion, we found a negative relationship between music-related activities and depression symptoms during the COVID-19 crisis: the higher the engagement in music-related activities, the lower the depressive symptoms reported by participants in our sample. Although the correlational approach alone does not allow clear identification of the directional causality of such an association, several studies in both healthy and in clinical populations indicate that music activities are effective at increasing positive affect^{53,54} and reducing, specifically, depression symptoms^{55–60}. Engaging in music-related activities, ranging from music listening to singing songs, has been shown to improve levels of depression, as well as anxiety and functioning in people with mild, moderate or severe depressive episodes⁵⁸. The finding that engagement in music-related activities correlated positively with the impact of COVID-19 and negatively with depressive symptoms counters the interpretation that more depressed people were simply less motivated to engage in musical activities (i.e., the people most affected by the pandemic are the ones engaging the most in music related activities). This notion is also supported by the finding, depicted in supplementary Figure S21, that people who selected music as their top #1 coping activity had worse mental health overall than the other participants.

273 It is noteworthy that not only music but also food-related activities were associated with decreased depression
274 symptoms, as well as decreased anxiety. Food-related activities such as cooking represent a pleasant leisure
275 activity likely to improve socialization among people ⁶¹. Several studies, especially in aging research, suggest
276 that cooking may promote mental health and decrease depressive symptoms ^{62–64}. Research shows that
277 music- and cooking-based interventions can lead to similar positive changes in Alzheimer’s disease patients’
278 emotional state while decreasing the severity of their behavioral disorders ^{61,65}. Importantly, our mediation
279 analyses highlighted that distinct psychological mechanisms underpin the respective relationships of music-
280 related and food-related activities with mental health. While the benefits of food-related activities were
281 mediated by our participants’ ability to avoid suppressing their emotions, the positive effects of musical
282 engagement were mediated by people’s ability to experience pleasure and reward. The ability to experience
283 pleasure and the ability to suppress emotions are distinct psychological traits. On the one hand, expressive
284 suppression reflects the behavioral response to an emotional state and involves inhibiting its expression.
285 While inhibiting the *behavioral expression*—but not the *internal experience*—of a negative emotion can be
286 beneficial, this is also related to many detrimental side-effects, such as the decrease in expression of not only
287 negative, but also positive affect, as well as the creation of a feeling of dishonesty stemming from the
288 difference between the experienced and expressed emotion ^{38,66}. Thus, emotional suppression does not
289 necessarily reflect a positive psychological trait. and has been considered as “unhealthy”/detrimental, being
290 linked to more negative consequences in terms of well-being and mental health ^{cf., 67,68}. This is in agreement
291 with our results, which show that the positive effects of food-related activities on mood depend on people’s
292 abilities to avoid engaging in emotional suppression strategies. Thereby, cooking-related activities may
293 represent an effective way to reduce emotional suppression and thus promote healthier emotional coping
294 strategies.

295 On the other hand, decreased sensitivity to pleasure (i.e., anhedonia) has been consistently related to
296 depression, with individuals who experience less pleasure from typically rewarding stimuli being at greater risk
297 of developing more severe depressive symptoms ⁶⁹. Importantly, the neurobiological mechanisms supporting
298 responses to pleasurable stimuli are thought to play a crucial role in the regulation of well-being, life
299 satisfaction and ultimately the expression of depression ^{70,71}. In this vein, music—one of the most rewarding

abstract stimuli for human beings⁴⁶—is strongly related to increases in psychophysiological arousal and to enhanced brain activity in core reward-related circuitry within the mesolimbic dopaminergic system^{23–25,30–33,72}, especially, in more hedonic subjects^{73,74}. Interestingly, the mesolimbic reward circuitry appears altered in individuals with depression, who suffer from anhedonia, reduced motivation and decreased energy level^{75–77}. It is therefore plausible to hypothesize that the relationship between music engagement, hedonia and depressive symptoms observed in the current study is related to music's influence on the brain's reward system.

It should be recognized that although our sample was not biased towards music per se, we cannot conclude that music would necessarily be equally effective among people who indicate preference for other activities. Furthermore, as previous studies indicate that some types of musical activities are more beneficial to well-being than others^{78,79}, future research should focus on highlighting the particular musical activities that are associated with better mental health. Nevertheless, since we did not find consistent relationships with reduction in anxiety or depression associated with other activities besides food-related ones, we infer that perhaps music should be encouraged as a potential coping strategy, particularly given its relative accessibility and low cost.

In conclusion, our results are timely and provide the scientific community with important information about how different activities that people turn to as means for coping relate to their mental health during times of crisis, and suggest possible underlying mechanisms. Our results regarding music are quite specific as: i) music was the only activity that correlated with the impact of COVID-19, so that more affected individuals pursued music-related activities more; and ii) depression was negatively correlated with the hours of engagement in music-related activities *not before but during* the pandemic, with this effect being mediated by reward-related mechanisms. These data suggest that perhaps music should be encouraged as a potential strategy to cope with pandemic-related psychological distress, particularly given its relative accessibility and low cost. Moreover, our results have practical significance in that they will encourage people to follow effective, affordable and easy to implement strategies to cope with depression, stress or anxiety, mental health disorders that are likely to keep increasing. Indeed, the pandemic continues to run its course at this moment (December 2020), with several countries facing new social restrictions and lockdowns.

Methods

Participants

One thousand and thirty one participants completed the survey. Participants were recruited via two modalities: i) as unpaid volunteers using online postings, social media and mailing lists; or ii) as paid participants recruited from Amazon Mechanical Turk (AMT; a total of 477 were recruited in this way), which further ensured that no specific predilections in terms of interests or psychological factors influenced participants' recruitment. Participants read and accepted an online version of a written informed consent. All protocols were approved by the local institutional review board (New York University's Committee on Activities Involving Human Subjects). From the original sample, fifty participants were discarded for failing to successfully complete several attentional checks placed within the survey (all questionnaires had a "Please select X" item: e.g., "Please select Yes" for the PAS) and/or giving consistently conflicting answers to other questions. The final sample was composed of 981 participants distributed across Italy (N=286), Spain (N=295), the United States (N=306), South America (N=43), rest of Europe (N=26), and the rest of the world (N=25). The characteristics of our participants were quite representative of the demographics and socioeconomic distribution of the general population in each of the main countries sampled (see Supplementary Figures S2 to S20; gender in Italy and rest of the world is skewed towards women). The sample target size of around 1000 subjects was based on a COVID-19 related study also using the DASS-21⁵. In addition, we run a post-hoc power analysis for our main results (the main effect of hours/week of music related activities on depression) using the *simr* R package⁸⁰. Using the *powerSim* function with 1000 simulations, we computed an analysis that showed that there is a 99.40% (95% confidence intervals: 98.26%, 99.88%) power to find a significant main effect of music in our main model as compared to the same model without music as a fixed factor.

Survey

The survey was created using oTree, a Python-based framework for the development of controlled experiments on online platforms⁸¹. Tasks developed with oTree can be deployed into AMT, a crowdsourcing platform that allows for acquisition of large datasets in a rapid, affordable, anonymous and easily replicable manner. Research using AMT has replicated the results of classical tasks from experimental psychology (e.g., Flanker⁸²) and of even more complex designs⁸³. In addition to allowing for AMT deployment, oTree also allows non-AMT participants (volunteers) to participate in an experiment simply by following a hyperlink. We used this functionality to recruit volunteers from all over the world. On beginning the experiment, participants

first saw an informed consent form, and then a second form focused on the European General Data Protection Regulation (GDPR) when needed. General instructions were then presented, just before participants started the task. Participants first provided demographic data, and then information detailing how COVID-19 had affected them (see appendix) ². They then completed the DASS-21 ³⁶, a quick-to-fill test (of only 21 questions) that has been validated in multiple languages and is ideal for the tracking of sub-clinical mental health status ^{5,84,85}. Subjects subsequently provided information regarding the top activities among the suggested list of 43 that helped them the most to cope with the pandemic, accompanied by a subjective evaluation of whether they were engaging more or less in each of the 43 activities during the pandemic (Likert scale 1-7 with 4 corresponding to “The same amount”). Before completing several personality questionnaires (PAS ^{37,86,87}, ERQ ^{38,88,89}, Gold-MSI ³⁹ among others), participants provided quantitative data regarding the number of days per week and hours per day that they spent, before and during the pandemic, engaged in five types of activities related to: music, exercise, drugs and alcohol, sex and food. We selected these five broad categories, from which more detailed data was collected, *a priori*, and based on the documented potential of these activities to induce reward and pleasure ^{25,32,90}. The presentation of the 5 categories was randomized for each participant so that neither activity was shown systematically before other. The median total time for completing the survey was 39 minutes.

Data analysis

Factorial Analysis. In order to investigate the relationship between participants’ psychological distress during the spring 2020 wave of the pandemic and their personal situation, we asked subjects to answer several questions regarding their personal circumstances (number of people living at home, health status, diagnostic status for COVID-19, etc.; see appendix in supplementary materials). We applied exploratory factor analysis (EFA) to identify groups of items sharing common variance and reduced the number of dimensions by grouping these. Concretely, we conducted an EFA using principal axis factoring and orthogonal varimax rotation on 11 items relating to participants’ current situation during the pandemic (income, changes in employment status, weeks of confinement, current health status, heightened risk for COVID-19, number of children/elders/total persons living at home, if they were diagnosed with the disease and/or had friends or

380 relatives diagnosed with or who had died due to the disease). All analyses were performed using IBM SPSS
 381 version 22.0. Current health status (from poor to excellent) and being part of an at-risk population for COVID-
 382 19 were grouped into one factor (COVID-19 Risk). Being diagnosed with COVID-19, having a relative/friend
 383 diagnosed with COVID-19, and experiencing the loss of a loved one because of COVID-19 were grouped into
 384 another factor (COVID-19 Diagnosis). Finally, the total number of people and children living at home were
 385 grouped together (COVID-19 NHousehold). The rest of the items did not group (weeks of confinement, income,
 386 number of elderly people living at home, change of employment status). Using regression (as implemented in
 387 SPSS), scores were calculated for each factor and, together with those items that did not group, were used in
 388 follow-up analyses testing the relationships between these factors and stress, anxiety and depression.

389 We also examined the leisure activities in which participants engaged during the spring surge of the COVID-19
 390 pandemic in 2020 (May-June). With that purpose in mind, we first created a pool of 43 items covering a large
 391 range of activities and situations. Participants had to indicate whether they actively engaged in each activity
 392 more or less than before the COVID-19 crisis using a 1-7 Likert scale (1-Much Less, 7-Much More; 4-The
 393 same amount). We conducted an EFA using principal axis factoring and orthogonal varimax rotation (IBM
 394 Corp., 2013). The initial rotated solution revealed an 11-factor solution that explained 58.5% of the variance.
 395 Those items with loadings lower than 0.30 (4 items), and those that represented one factor by itself (2 items)
 396 were removed. A second selection of items was performed based on the content and adequacy of the items,
 397 removing those with ambiguous meanings and loadings (15 items). The remaining 22 items were submitted to
 398 an EFA using the same procedure, yielding a 6-factor solution that accounted for 60.22% of the variance. The
 399 resulting factors represented different types of experiences: music-, food-, entertainment-, drugs-, social-, and
 400 exercise-related activities. For each factor, participants' ratings were averaged across items in order to
 401 compute average ratings for the subjective perceived change in those activities. A one-sample t-test was
 402 performed to assess whether the sample-average ratings were statistically different from 4 (representing "No
 403 change at all"; that is, we tested whether there had been a significant change due to the pandemic).

404 *Linear Mixed-effects Models.* We performed generalized linear mixed modelling in R (version 4.0.2) and
 405 RStudio (version 1.3.959) using the *lme4* package ⁹¹. All models included random intercepts for each region
 406 (Spain, Italy, USA, South America, rest of Europe, and rest of the World; in the supplementary figures we

report summary demographic measures for Spain, Italy, USA and rest of the world for ease of interpretation). It should be noted that our objective was not to compare results between regions and that we did not, therefore, choose these nations for specific features for which we would like to control. Our objective was to study how people's everyday activities and well-being change due to the pandemic, regardless of their country of origin. For that reason, participants' region was included in all models as a random factor. The effects of the different predictors were assessed by means of likelihood ratio tests (LRT) using the *afex* package ⁹² in R. These tests were based on Type 3 sums of squares.

Mediation analysis. We conducted causal mediation analyses to investigate the roles of sensitivity to reward (as measured by PAS) and emotion regulation strategies (using the ERQ facets) as mediators of the associations between hours spent on music- or food-related activities on the one hand, and DASS-21 scores for anxiety and depression on the other. For each association, three different mediation analyses were performed including either the PAS, the ERQ cognitive reappraisal facet or the ERQ emotional suppression facet scores. To allow for a comparable analysis, all variables were standardized by subtracting the mean and dividing by the standard deviation ⁹³. We used the existing R *mediation* package to estimate the mediated effect and calculate confidence intervals by means of a quasi-Bayesian Monte Carlo method with 1000 simulations based on normal approximation ⁹⁴. The resulting p values were corrected for multiple comparisons (3 correlations per mediation analysis).

Sentiment analysis. Participants were asked if they perceived any silver linings in the ongoing COVID-19 crisis, and the sentiment of each free text response (positive or negative) was classified. First, silver linings were manually rated as positive or negative by the same person (P.R.) who speaks Spanish, English and Italian. For the English silver linings, a sentiment analysis using machine learning was performed using a Naïve Bayes classifier ⁹⁵. To train the classifier in English, we used more than 1.6 million tweets from the *Sentiment140* corpus, which contains tweets that do not focus on any particular topic (see ⁹⁶). To prepare this corpus for classifier training, we ran the text of each tweet through a pre-processing pipeline: hyperlinks and twitter handles were removed; contractions were expanded (e.g. "did not" was substituted for "didn't"); the text was tokenized (i.e., segmented using spaces and punctuation) to form ordered lists of words; pronouns, articles, and other 'stop words' were removed; any remaining punctuation was removed, and other non-Latin alphabet

characters were either removed or replaced with their Latin alphabet counterparts ('e' was substituted for 'é', and so on; this was necessary to account for participants' inconsistent use of grave characters); word forms were normalized by lemmatization, such that inflectional variants across case, tense, number, etc. were replaced with the base form for each word (e.g. 'goes', 'going', 'gone' and 'went' were each replaced by *go*); finally, bigrams (conjoined pairs of adjacent words) were constructed for the full processed text of each tweet⁹⁷. Participants' answers to the silver linings question were prepared for classification using this same pipeline. The classifier was then trained on the processed corpus and applied to the processed participant answers in English. The classifier output (i.e. a label of positive or negative) for each answer was then compared to the assessment of the human judge. Participants were then divided into two groups, according to whether they gave a positive or negative answer to the silver lining question. An independent sample t-test was used to assess whether there were differences between the groups in terms of COVID-19 Factor.

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Author contributions

EMH, NS, LF, MM, RZ and PR, designed the research and wrote the paper; EMH, MM and PR analyzed the data. PR acquired the data.

Competing Interests statement

The authors declare no competing interests

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Supplemental Material

Table S1

Figures S1 to S21

Appendix A includes the survey questions regarding demographics and impact of COVID-19

Activity	Percentage
Listening to music	14.48%
Talking with friends/family/colleagues (by phone or by video call)	14.07%
Exercising indoors	12.95%
Cooking	10.81%
Watching series, movies or documentaries	8.05%
Reading (books, magazines, articles, etc.)	4.89%
Playing games (table/video games, in person/online)	4.49%
Engaging in social media	3.26%
Learning a new skill or hobby	2.45%
Playing music	2.34%
Exercising outdoors	2.34%
Sexual activities (alone or with others)	1.94%
Working	1.83%
Watching movies/series/documentaries I already watched	1.43%
Religious activities (for example, praying)	1.43%
Baking (bread, cakes, cookies, etc.)	1.33%
Meditating	1.02%
Practicing yoga	0.82%
Writing / journaling	0.71%
Looking for new ways to interact through social media	0.71%
Looking for new ways to exercise	0.71%
Discovering new meals/tastes/recipes	0.71%
Listening to radio or podcasts	0.71%
Consuming alcohol	0.61%
Composing/creating new music	0.61%
Singing	0.61%
Eating food with high sugar/caloric content	0.61%
Photography/ Video recordings/ Media creation	0.51%
Cooking my favorite/old meals	0.51%
Watching live or recorded concerts	0.41%
Listening to music I used to listen to when I was younger	0.41%
Looking for new movies/series/documentaries	0.31%
Looking for new books to read	0.31%
Dancing	0.31%
Listening to sad music	0.20%
Reading books I already read	0.20%
Listening to happy music	0.20%
Going to a therapist (in person or remote)	0.20%
Watching pornographic or erotic films/pictures	0.20%
Consuming drugs	0.20%
Discovering/searching for new music	0.10%
Consuming pills/sedatives	0%
Attending virtual museums or art galleries	0%

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Table S1. Activity options and percentage of selection as top choice for coping with pandemic psychological distress. The 43 options from which participants could select the activities that they had found most helpful in coping with the pandemic, with the percentage of the sample that selected each as their first choice.

Figure S1. Sentiment analysis. Silver linings were rated as positive or negative by the same person (P.R.) who speaks Spanish, English and Italian. The COVID-19 factor was higher for those participants reporting negative comments as compared as to those reporting positive ones [$t(893)=2.87$, $p=0.004$, $d=0.233$]. For the English silver linings, a sentiment analysis using machine learning was calculated. The output of this analysis was then compared with the judgments provided by P.R, achieving an agreement of 69%. Here we show the result for those silver linings in which the human rater and the sentiment analysis agreed, once again showing that participants who provided negative comments tended to be more severely impacted by COVID-19 [$t(215)=2.04$, $p=0.042$, $d=0.278$]. The boxplots represent the median (horizontal black line), the minimum and maximum quartiles (whiskers), and the first and third quartiles (box), with dots representing each subject and black dots as outliers.

Figure S2. Age by geographic location. Histograms show the distributions of participant age in **(A)** all locations (Mean, $M = 34.66$, Standard Deviation, $SD = 11.71$), **(B)** Italy ($M = 31.36$, $SD = 11.47$), **(C)** Spain ($M = 35.13$, $SD = 11.95$), **(D)** the United States ($M = 35.89$, $SD = 10.61$), and **(E)** other countries ($M = 39.26$, $SD = 12.68$). Red lines represent mean age values in Italy (45.2 years of age in 2018 as reported by the Istituto Nazionale di Statistica <istat.it>) and Spain (43 years of age in 2019 as reported by the Instituto Nacional de Estadística <ine.es>). Mean age data was not available for the United States from an official source; the orange line represents median age in the US (38.2 years of age in 2018 as reported by U.S. Census Bureau <census.gov>). The box-and-whisker plot **(F)** shows the age distributions across countries in a more compact way. Each box extends from the end of the first to the end of the third quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; in the latter case, any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S3. Gender distribution of participants by geographic location. Red lines represent the percentage of males in each country: Italy, 49% in 2018 as reported by Istituto Nazionale di Statistica <istat.it>; Spain, 49% in 2019 as reported by Instituto Nacional de Estadística <ine.es>; USA, 49% in 2019 as reported by U.S. Census Bureau <census.gov>. Not shown: “Non-Binary” option, selected by 1 participant each in Italy, Spain, and the United States, and 0 times by participants in other countries.

Figure S4. Educational attainment by geographic location. Histograms show the distributions of participant educational attainment (the highest level of schooling completed) in **(A)** Italy (median bracket = secondary school, SD = 0.96 brackets), **(B)** Spain (median bracket = post-secondary degree, SD = 0.77), and **(C)** the United States (median bracket = post-secondary degree, SD = 0.67). The distribution patterns in our sample agree broadly with the educational statistics for each country as reported by the Organization for Economic Co-operation and Development <stats.oecd.org>, which show: in Italy, graduate degree-holders outnumber those whose highest degree is the three-year Bachelor's equivalent (*Laurea Breve*), as many who complete the latter go on to complete a two-year Master's equivalent (*Laurea Magistrale*); the reverse is true in Spain and in the United States, where Bachelor's or equivalent is favored as the highest degree earned (especially in the U.S.). The largest deviation from the reported statistics is the underrepresentation of non-college high school graduates in the sample.

Figure S5. Pre-pandemic household income by geographic location. Histograms show the distributions of participant annual household income brackets prior to the novel coronavirus (COVID-19) pandemic in **(A)** Italy (median bracket = €20,000-€50,000, SD = 1.13 brackets), **(B)** Spain (median bracket = €20,000-€50,000, SD = 1.08 brackets), and **(C)** the United States (median bracket = \$50,000-\$75,000, SD = 1.21 brackets). Red lines represent mean income values for each country: Italy, €31,393 in 2017 as reported by Istituto Nazionale di Statistica <istat.it>; Spain, €23,000 in 2017 as reported by Instituto Nacional de Estadística <ine.es>; USA, \$98,088 in 2019 as reported by U.S. Census Bureau <census.gov>. As income brackets vary in size, each red line is positioned relative to the ends of the bracket in which it falls.

Figure S6. Racial and ethnic distribution of participants in the United States. Solid bars represent the proportion of US participants that identified as White, Black / African American, Asian, American Indian / Alaskan Native, or Native Hawaiian / Other Pacific Islander; dashed bar represents the proportion of US participants of any race that identified as Hispanic / Latino. Red lines represent the proportion of each racial or ethnic group in the US in 2019 (76.3%, 13.4%, 5.9%, 1.3%, 0.2%, and 18.5%, respectively) as reported by the U.S. Census Bureau <[census.gov](https://www.census.gov)>.

Figure S7. Positive COVID-19 diagnosis by geographic location. Bars represent the proportion of participants who reported receiving a positive diagnosis for the novel coronavirus (COVID-19) in Italy, Spain, the United States, and other countries.

Figure S8. Positive COVID-19 diagnosis in “someone close” by geographic location. Bars represent the proportion of participants who reported knowing someone well who had received a positive diagnosis for the novel coronavirus (COVID-19) in Italy, Spain, the United States, and other countries.

Figure S9. COVID-19 death in “someone close” by geographic location. Bars represent the proportion of participants who reported a death in someone they knew well that was caused by the novel coronavirus (COVID-19) in Italy, Spain, the United States, and other countries.

Figure S10. COVID-19-related changes to lifestyle by geographic location. Bars represent the proportion of participants who reported making changes to their lifestyle or daily activities because of the novel coronavirus (COVID-19) in Italy, Spain, the United States, and other countries.

Figure S11. COVID-19 risk group status by geographic location. Bars represent the proportion of participants who reported belonging to a COVID-19 risk group in Italy, Spain, the United States, and other countries.

Figure S12. COVID-19-related confinement orders by geographic location. Bars represent the proportion of participants who reported being under or having been under local confinement orders related to COVID-19 in Italy, Spain, the United States, and other countries.

Figure S13. Weeks under confinement orders by geographic location. Histograms show the distributions of duration in local COVID-19-related confinement orders in **(A)** all locations ($M = 8.08$, $SD = 2.44$), **(B)** Italy ($M = 8.36$, $SD = 2.65$), **(C)** Spain ($M = 8.85$, $SD = 1.98$), **(D)** the United States ($M = 7.13$, $SD = 2.34$), and **(E)** other countries ($M = 7.68$, $SD = 2.56$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S14. Distributions of participant DASS21 Depression Scale scores by geographic location. Histograms show the score distributions in **(A)** all locations ($M = 10.88$, $SD = 10.49$), **(B)** Italy ($M = 12.87$, $SD = 10.12$), **(C)** Spain ($M = 8.31$, $SD = 9.15$), **(D)** the United States ($M = 11.53$, $SD = 11.82$), and **(E)** other countries ($M = 10.74$, $SD = 9.39$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles. Severity interpretation of the DASS-21 depression scores: Normal (0-9), Mild (10-13), Moderate (14-20), Severe (21-27), Extremely Severe (more than 28).

Figure S15. Distributions of participant DASS-21 Anxiety Scale scores by geographic location. Histograms show the score distributions in **(A)** all locations ($M = 6.57$, $SD = 8.45$), **(B)** Italy ($M = 6.48$, $SD = 7.73$), **(C)** Spain ($M = 5.21$, $SD = 7.39$), **(D)** the United States ($M = 7.99$, $SD = 9.89$), and **(E)** other countries ($M = 6.51$, $SD = 7.89$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles. Severity interpretation of the DASS-21 anxiety scores: Normal (0-7), Mild (8-9), Moderate (10-14), Severe (15-19), Extremely Severe (more than 20).

Figure S16. Distributions of participant DASS-21 Stress Scale scores by geographic location. Histograms show the score distributions in (A) all locations ($M = 13.31$, $SD = 10.23$), (B) Italy ($M = 16.01$, $SD = 9.68$), (C) Spain ($M = 11.62$, $SD = 9.90$), (D) the United States ($M = 12.32$, $SD = 10.95$), and (E) other countries ($M = 13.60$, $SD = 8.87$). The box-and-whisker plot (F) compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles. Severity interpretation of the DASS-21 depression scores: Normal (0-14), Mild (15-18), Moderate (19-25), Severe (26-33), Extremely Severe (more than 34).

Figure S17. Distributions of participant ERQ Reappraisal Scale scores by geographic location. Histograms show the score distributions in **(A)** all locations ($M = 29.32$, $SD = 5.80$), **(B)** Italy ($M = 30.65$, $SD = 5.87$), **(C)** Spain ($M = 27.80$, $SD = 4.88$), **(D)** the United States ($M = 30.08$, $SD = 6.21$), and **(E)** other countries ($M = 27.58$, $SD = 5.37$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S18. Distributions of participant ERQ Suppression Scale scores by geographic location. Histograms show the score distributions in **(A)** all locations ($M = 15.73$, $SD = 5.11$), **(B)** Italy ($M = 15.82$, $SD = 5.15$), **(C)** Spain ($M = 15.87$, $SD = 4.59$), **(D)** the United States ($M = 16.25$, $SD = 5.58$), and **(E)** other countries ($M = 13.29$, $SD = 4.28$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S19. Distributions of Physical Anhedonia Scale scores by geographic location. Histograms show the score distributions in (A) all locations ($M = 10.81$, $SD = 7.39$), (B) Italy ($M = 11.31$, $SD = 6.82$), (C) Spain ($M = 9.62$, $SD = 5.83$), (D) the United States ($M = 10.73$, $SD = 8.59$), and (E) other countries ($M = 13.27$, $SD = 8.45$). The box-and-whisker plot (F) compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S20. Distributions of normalized Goldsmith's Musical Training Index scale by geographic location. Histograms show the distributions of participant Musical Training scale, with score expressed as a percentage of the maximum possible score, in **(A)** all locations ($M = 40.60\%$, $SD = 20.91$), **(B)** Italy ($M = 42.16\%$, $SD = 20.36$), **(C)** Spain ($M = 38.18\%$, $SD = 21.91$), **(D)** the United States ($M = 40.68\%$, $SD = 19.73$), and **(E)** other countries ($M = 44.48\%$, $SD = 23.25$). The box-and-whisker plot **(F)** compares the distributions across countries. Each box extends from the lower to the upper quartile of the data, with a solid orange line at the median and dashed green line at the mean. The whiskers extend in both directions either to the limit (min or max) of the data or to 150% of the interquartile distance, whichever is less; any data points beyond the whiskers are classified as outliers and are represented by hollow circles.

Figure S21. Selection of a music-related activity as the #1 most helpful for coping with pandemic-related psychological distress was associated with worse mental health status. Participants who ranked a music-related activity as their top choice for coping with pandemic-related psychological distress had, on average, higher total DASS-21 scores than participants who made any other selection [$\beta = -5.87$, $SE = 2.12$, $\chi^2(1) = 7.62$, $p = 0.0057$]. Main result (with 95% confidence interval) of the linear mixed-effects model estimating depressive symptoms as a function of the top #1 activity (Music or any other activity). Each dot represents the response by one participant (a small jitter has been applied for visualization purposes).

727 **Appendix A: Survey Items**

728 **Instructions**

729 You will be asked to complete several questionnaires designed to assess your demographic, linguistic,
730 economic, and educational background, your personality, your attitude toward typically rewarding
731 stimuli and your attitude toward and ways of coping with a moment of crisis such as the one provoked
732 by the new coronavirus (COVID-19) emergency. There are no right or wrong responses. Please
733 provide honest answers.

734 It takes a maximum of 30-45 minutes to complete the entire survey. If you do not have enough time
735 right now, no worries - you will be able return to the last page you left unfilled as long as you are
736 using the same device (computer, tablet, or smartphone) and browser. Leave the page open and
737 come back to it later or click again on the link that you originally followed to get to this page. Your
738 input is highly valuable, and we appreciate your time and cooperation in filling this out!

739 (VOLUNTEERS SEE THIS)

740 Please input an ID code. Your ID code is:

741 The first 2 letters of the first name of the person who raised you.

742 The first 2 letters of the city in which you lived when you were 10 years old.

743 Your age.

744 For example, if I was raised by my mother, who is named Mary, if I lived in New York City when I
745 was 10 years old, and if I am now 34 years old, my ID would be 'MANE34'.

746 ID: _____

747 (MTURK PAID WORKERS SEE THIS)

748 For the ID field, please use your MTURK worker ID:

749
750 ID: _____

751 **Demographics**

752
753 1. Gender: _____

754 2. Age: _____

755 (ONLY FOR USA PARTICIPANTS)

756 3. Are you of Hispanic, Latino, or of Spanish origin? Yes or No
757

758 (ONLY FOR USA PARTICIPANTS)

- 759 4. How would you describe yourself?
- 760 ☐ American Indian or Alaska Native
- 761 ☐ Asian
- 762 ☐ Black or African American
- 763 ☐ Native Hawaiian or Other Pacific Islander
- 764 ☐ White
- 765 5. Location of residence during the new coronavirus (COVID-19) emergency; include country and
766 region (for example: USA/San Diego, California or France/Marseille):
- 767 _____
- 768 6. Highest level of education completed:
- 769 ☐ Did not complete elementary school
- 770 ☐ Elementary school
- 771 ☐ High School
- 772 ☐ Bachelor's degree (e.g. B.A., B.Sc.)
- 773 ☐ Graduate studies (e.g. M.A., M.Sc., Ph.D., M.D.)
- 774 7. Employment status **before** the new coronavirus (COVID-19) emergency started (select all
775 that apply):
- 776 ☐ Unemployed
- 777 ☐ Student
- 778 ☐ Employed, part time
- 779 ☐ Employed, full time
- 780 ☐ Employed, multiple jobs
- 781 ☐ Underemployed (I was having trouble finding as much work as I would like)
- 782 ☐ On an unpaid leave of absence
- 783 ☐ On a paid leave of absence
- 784 ☐ Working from home
- 785 ☐ Working more than usual
- 786 ☐ Working less than usual
- 787 ☐ Working as a healthcare professional
- 788 ☐ Retired
- 789 ☐ Self-employed

8. Annual household income **before** the new coronavirus (COVID-19) emergency started in USD/EURO:

☐ Less than \$10,000

☐ \$10,001 - \$20,000

☐ \$20,001 - \$50,000

☐ \$50,001 - \$75,000

☐ \$75,001 - \$150,000

☐ \$150,001 - \$200,000

☐ More than \$200,001

(ONLY FOR PARTICIPANTS OUTSIDE OF USA)

If you do not know the US Dollar or Euro equivalent of your annual household income, please write in your approximate annual household income in your own currency here. For example, between 100,000 and 200,000 Argentine pesos":_____

9. Marital status:

☐ Married

☐ Engaged

☐ In a domestic partnership, cohabitation, or de facto marriage

☐ Separated

☐ Widowed

☐ Divorced

☐ Never married

10. Parental status (select all that apply):

☐ Parent to one or more children under 18 years old

☐ Parent to one or more children 18 years or older

☐ No children

11. Number of individuals currently living in your household, including yourself: _____

12. Number of children under 18 years old currently living in your household: _____

13. Number of adults at least 65 years old currently living in your household: _____

Please answer the following questions regarding how the new coronavirus (COVID-19) emergency has affected your lifestyle.

1. Have you even been diagnosed with the new coronavirus (COVID-19)?

☐ No

☐ Yes

2. Even if you were not diagnosed (with a test), do you think you have had the new coronavirus (COVID-19)?

- 826 ☐ No
- 827 ☐ Yes
- 828 3. Has someone close to you been diagnosed with the new coronavirus (COVID-19)?
- 829 ☐ No
- 830 ☐ Yes
- 831 4. Did someone close to you pass away from the new coronavirus (COVID-19)
- 832 complications?
- 833 ☐ No
- 834 ☐ Yes
- 835 5. Have you made any changes to your lifestyle or daily activities because of the new coronavirus
- 836 (COVID-19) emergency?
- 837 ☐ No
- 838 ☐ Yes
- 839 5b. Which of the following have you done due to the COVID-19 crisis? (Select all that apply)
- 840 ☐ Washing hands more
- 841 ☐ Avoiding social gatherings
- 842 ☐ Stocking up on food and supplies
- 843 ☐ Avoiding or canceling domestic travel
- 844 ☐ Working from home
- 845 ☐ Avoiding gym and exercise classes
- 846 ☐ Avoiding or canceling international travel
- 847 ☐ Avoiding routine health care appointments
- 848 ☐ Not attending classes
- 849 ☐ I am making no changes to my lifestyle
- 850
- 851 6. Has your employment status changed because of the new coronavirus (COVID-19) emergency?
- 852 (Select all that apply)
- 853 ☐ No
- 854 ☐ Yes, I have a reduced income
- 855 ☐ Yes, I have lost my job
- 856 ☐ Yes, my workplace went out of business
- 857 ☐ Yes, my working hours have been reduced
- 858 ☐ Yes, my working hours have been increased
- 859 ☐ Yes, my working conditions have become stressful

860 ☐ Yes, my job responsibilities have changed

861 ☐ Yes, I work from home

862

863 7. Do you belong to a new coronavirus (COVID-19) risk group?

864 ☐ Yes

865 ☐ No

866 ☐ I don't know

867 8. How would you rate your current overall health?

868 ☐ Excellent

869 ☐ Very good

870 ☐ Good

871 ☐ Fair

872 ☐ Poor

873 ☐ I am not sure

874 9. Are you a healthcare professional?

875 ☐ Yes

876 ☐ No

877 10. Do you live with a healthcare professional?

878 ☐ Yes

879 ☐ No

880 11. Do you currently hold any form of health insurance?

881 ☐ No

882 ☐ Yes, I have a private health insurance

883 ☐ Yes, my country has a public health coverage

884 ☐ I don't know

885 12. Was your area of residence under confinement orders during the new coronavirus (COVID-19)

886 emergency?

887 ☐ No

888 ☐ Yes

889 ☐ I don't know

890 12b. How long have you been confined (or were you confined, if confinement orders have been lifted)

891 during the new coronavirus (COVID-19) emergency? Input the number of weeks.

12c. Have confinement orders in your area of residence been lifted or partially lifted at this point in time? If so and you are no longer completely confined, indicate for how many days (input 0 if the confinement orders are still in place or you have chosen to remain in confinement).

13. Did/have you encountered any of the following difficulties during the new coronavirus (COVID-19) emergency? Please indicated all that apply):

☐ Getting food

☐ Getting medications

☐ Getting sanitizing and/or cleaning supplies

☐ Using public transportation

☐ Accessing healthcare

☐ Increased childcare duties

☐ Increased household duties (i.e., cleaning, etc.)

☐ Social isolation and loneliness

☐ Moved out of my home

☐ I did not encounter any difficulties at all

☐ Other (Write 'No' if you did not encounter any additional difficulties listed above):

14. To what extent are you self-isolating?

☐ All of the time - I am staying at home nearly all the time

☐ Most of the time - I only leave my home to buy food and other essentials.

☐ Some of the time. I have reduced the amount of times I am in public spaces, social gatherings, or at work.

☐ None of the time. I am doing everything I normally do.

15. How worried do you feel that you or your loved ones will contract the new coronavirus (COVID-19)?

☐ Not at all worried

☐ Slightly worried

☐ Moderately worried

☐ Very worried

☐ Extremely worried

16. How worried are you about the implications of the new coronavirus (COVID-19) emergency?

☐ Not at all worried

☐ Slightly worried

926

☐ Moderately worried

927

☐ Very worried

928

☐ Extremely worried

929

17. Have you experienced or perceived any silver linings/positive aspects of the new coronavirus (COVID-19) emergency?

930

931

☐ _____