Revue musicale OICRM

revue musicale oicrm

Pilot Study on the Effects of Music-making on Cortisol, Alpha-amylase and Immunoglobulin-a Among Older Amateur Musicians

Audrey-Kristel Barbeau

Volume 11, Number 1, July 2024

URI: https://id.erudit.org/iderudit/1113315ar
DOI: https://doi.org/10.7202/1113315ar

Publisher(s)

Observatoire interdisciplinaire de création et recherche en musique (OICRM)

ISSN

2368-7061 (digital)

Cite this article

Barbeau, A.-K. (2024). Pilot Study on the Effects of Music-making on Cortisol, Alpha-amylase and Immunoglobulin-a Among Older Amateur Musicians. *Revue musicale OICRM*, *11*(1), 118–137. https://doi.org/10.7202/1113315ar

Article abstract

There are many benefits associated with playing music in later life but few studies have looked at biomarkers of stress and immune response among musicians. A pilot study, undertaken to test a research protocol prior to a larger study, was carried out with eight amateur instrumentalists aged 50+ to investigate variations in stress (cortisol and alpha-amylase) and immune response (secretory immunoglobulin A) under two conditions (Music and Rest). In summary, cortisol levels tend to decline following both conditions, but results were more pronounced for the Rest condition. While sIgA increased in the Rest condition, it showed a larger variability in the Music condition. These results are promising and demonstrate that music can influence some biological markers. This study contributes to raising awareness that music can be a creative strategy to promote healthy aging.

Pilot Study on the Effects of Music-making on Cortisol, Alpha-amylase and Immunoglobulin-a Among Older Amateur Musicians

Audrey-Kristel Barbeau

Abstract

There are many benefits associated with playing music in later life but few studies have looked at biomarkers of stress and immune response among musicians. A pilot study, undertaken to test a research protocol prior to a larger study, was carried out with eight amateur instrumentalists aged 50+ to investigate variations in stress (cortisol and alpha-amylase) and immune response (secretory immunoglobulin A) under two conditions (Music and Rest). In summary, cortisol levels tend to decline following both conditions, but results were more pronounced for the Rest condition. While sIgA increased in the Rest condition, it showed a larger variability in the Music condition. These results are promising and demonstrate that music can influence some biological markers. This study contributes to raising awareness that music can be a creative strategy to promote healthy aging.

Keywords: immune response; music-making; older amateur musicians; salutogenesis; stress.

Résumé

Il existe de nombreux avantages associés à la pratique de la musique plus tard dans la vie, mais peu d'études se sont penchées sur les biomarqueurs du stress et de la réponse immunitaire chez les musicien·ne·s. Une étude pilote, entreprise pour tester un protocole de recherche avant sa mise en place dans contexte plus large, a été réalisée auprès de huit instrumentistes amateur·rice·s âgé·e·s de 50 ans et plus pour étudier les variations du stress (cortisol et alpha-amylase) et de la réponse immunitaire (immunoglobuline-a sécrétoire, ou IgA) sous deux conditions (Musique et Repos). En résumé, les niveaux de cortisol ont eu tendance à diminuer après les deux conditions, mais le changement était plus marqué pour la condition Repos. Pour l'IgA, les niveaux ont augmenté dans la condition Repos et ont montré une plus grande variabilité dans la condition Musique. Ces résultats sont prometteurs et démontrent que la musique peut exercer une influence sur certains marqueurs biologiques.

Mots clés : musicien·ne·s amateur·rice·s âgé·e·s ; pratique musicale ; réponse immunitaire ; salutogenèse ; stress.

Introduction

In Canada, as in the rest of the world, the population is growing and the proportion of aging people is steadily increasing (Statistics Canada 2020; United Nations 2019). Research suggests that playing music can have positive effects on seniors, especially on psychophysiological levels (Cohen *et al.* 2006; Creech *et al.* 2014; Skingley and Bungay 2010). Music-making improves the ability to manage stress (Chafin *et al.* 2004; Eyre 2011; Hanser 1985), which is significant because prolonged exposure to stress can have a negative effect on memory (Lupien *et al.* 1998), contribute to the development of diseases (Gassen *et al.* 2017), and even reduce life expectancy (Epel and Lithgow 2014).

Salutogenesis is a theory developed by Aaron Antonovsky in 1979 that seeks to explain the factors that positively influence health and the ability to cope with stress. One of the key elements of salutogenesis is the sense of coherence, which comes in three dimensions:

- Comprehensibility: the ability to interpret internal and external stimuli as structured, predictable, and explainable elements;
- Manageability: the ability to cope with these stimuli or obtain the resources necessary to cope with them;
- Meaningfulness: the ability to assign meaning to the challenges encountered and to decide whether the efforts required to meet them merit investment and commitment (Antonovsky 1987; Lindström and Eriksson 2011).

Kari Batt-Rawden (2012) reports that music helps participants transcend pain and suffering, acting as an alternative to medication, and allows them to better adapt thanks to the sense of coherence that this brings. This aligns with previous studies which demonstrated that among some older amateur musicians, playing an instrument contributes to pain management (Barbeau and Mantie 2019) and improved quality of life (Barbeau and Cossette 2019). That said, the salutogenesis could be used to study the physiological effects of music-making, particularly on stress and immune responses.

Techniques to evaluate stress and immune responses have evolved over time. Today, multiple biomarkers can be measured through saliva, including cortisol, alpha-amylase and immunoglobuline-a. Cortisol is a glucocorticoid whose secretion results from stress, causing activation of the hypothalamic-pituitary axis (Ulrich-Lai and Herman 2009). Alpha-amylase (or sAA) is an enzyme indicative of noradrenergic activity. Both are recognized as being effective biomarkers of physiological stress (Lupien 2013; Ali and Nater 2020). Secretory immunoglobulin A (or sIgA) can serve as a biomarker to determine the functional state of the immune system because it is known to protect against viral and bacterial infections of the mucous membranes (Chanda and Levitin 2013).

In recent decades, some researchers have sought to shed light on the relationship between music and health using cortisol, sAA, and sIgA. A review of the literature revealed that several of these studies were conducted with singing interventions (Beck *et al.* 2000; Eyerly 2007; Fancourt, Aufegger and Williamon 2015; Good and Russo 2022; Grebosz-Haring and Thun-Hohenstein 2018; Khun 2002; Kreutz *et al.* 2004; Wulff *et al.* 2021), and frequently in a hospital context (e.g., Burns *et al.* 2001; Fancourt *et al.* 2016). Very few studies investigating instrumental music have been found, and most have mainly been carried out in the context of music therapy intervention including non-melodic instruments, namely percussion (Bittman *et al.* 2001; Burns *et al.* 2001). Only one study using another instrument (the piano) was identified, and the results demonstrated a drastic drop in cortisol levels of post-secondary students after 30 minutes of intervention (Toyoshima, Fukui and Kuda 2011). It is impossible to know whether these results would be transferable to other instruments and to older musicians. More recently, Melanie Mitsui Wong and colleagues (2021) conducted a systematic review in which four studies reported significant stress reduction following a music intervention. However, the authors urge caution in generalizing the results, due to the fact that a variety of stress biomarkers were used and research protocols differed between studies.

To our knowledge, there was no study that evaluated the effect of instrumental practice on the salivary cortisol, secretory alpha-amylase (or sAA), and secretory immunoglobulin-A (or sIgA) levels of older amateur musicians when we began this research project. There were also no studies who looked at these effects through the lens of salutogenic theory.

Aim of the Study

The aim of this pilot study was to undertake an exploratory investigation of the effects of music-making on the stress levels and variations of the immune system for a small sample of amateur musicians aged 50 and over, in preparation for a larger study. The objectives of the larger study were

a) to determine the extent to which music-making is associated with a sense of coherence as identified by the salutogenic theory (i.e. using music as part of a healthy orientation to life);
b) to provide a current picture of the psychological stress levels of senior amateur musicians by assessing their anxiety levels under two conditions (Music and Rest);
c) to physiologically measure the effects of music-making on stress and immune response by collecting samples of cortisol, sAA, and sIgA pre- and post-test, under both conditions.

In the context of this pilot study, an added objective was to test the research protocol to ensure that it could be applied effectively to a larger cohort of 80 musicians (40 singers and 40 instrumentalists).

Methods

Recruitment

This study was approved by the Ethics committee of the Université du Québec à Montréal. The recruitment was done in the Montréal New Horizons Band (Quebec, Canada). The researcher explained the project at the beginning of a regular rehearsal of the ensemble. People interested were asked to provide their name and email so that they could be sent the Information and Consent form. Following this process, eight musicians (five females, three males) agreed to participate in the pilot study.

Research Protocol

This study took place in July 2019. Participants completed an introductory survey online in which they provided demographic data and information about their musical background, in addition to filling out questionnaires about anxiety (i.e. STAI-T; Spielberger 1983) and quality of life (WHOQOL-Bref; The WHOQOL Group 1998). The WHOQOL-Bref and STAI-T were used to control for various parameters in participants' lives that could potentially influence physiological results.

Using a quasi-experimental design, participants had to meet two conditions (Music and Rest). The Music condition consisted of participating in a concert band rehearsal for 90 min. This rehearsal was a summer gathering occurring once, at the request of band members who wished to meet to make music. It was not associated with any formal performance. For the Rest condition, participants were invited to the Université du Québec à Montréal to watch a 90-minute documentary about classical music. For both conditions, participants did pre- and post-completion of the STAI-S (Spielberger 1983). In addition, they also filled out the Orientation to Life questionnaire (Antonovsky 1987) once during the Rest condition (SOC-13 original), and an adapted version during the Music condition (SOC-13 music). To avoid potential biases associated with uncontrollable events, an open question was also included pre- and post-intervention: "In your own words, briefly report how you are feeling now." For each condition, all questionnaires were administered in hard copy. Pre- and post-saliva samples were collected within 15 minutes of the interventions.

The order of conditions was assigned randomly for each participant, which served to alleviate the effect of stress due to novelty (i.e. the presence of researchers during a music rehearsal) and the transfer effect (i.e. the influence of a test on the other). It is important to note that saliva samples were collected using a passive drool method at the same hours of each day to account for the normal variations in the diurnal cycle of cortisol secretion (Lupien 2013). The laboratory of the Centre for Studies on Human Stress conducted the analysis of the saliva samples. Each sample was tested twice and the mean and standard deviation was provided for each type of analysis (cortisol, sAA, and sIgA).

Data Analysis

Descriptive statistics were used to report means and standard deviations associated with the participants' demographic information (age, years of playing, hours of practice per week, etc.), as well as scores on the questionnaires. Results were calculated from raw data and by percentages of change. Pre- and post-test results were compared for each condition independently, then between the Music and Rest conditions, on each of the three physiological variables (cortisol, sAA, sIgA) as well as on the psychological variable State anxiety. The sense of coherence was also compared (SOC-13 original versus SOC-13 music).

Statistical analyzes were conducted using parametric statistics (two-tailed Student *t* test) for cortisol and soc-13 where assumptions of normality and homogeneity of variance were met, which were verified with Kolmogorov-Smirnov tests and Levene's tests respectively (Field 2009). Effect sizes and Bayes factors were also reported. To estimate the effect size, Pearson product-moment correlation coefficients were used to measure the strength of the association between variables. Values range from -1 (negative correlation) to 1 (positive correlation) and provide an indication of the direction of correlations. While Cohen's guidelines to interpret the size of effects have typically been $r = .10$, .30 and .50 for small, medium, and large effect, a recent study (Brydges 2019) conducted in gerontology suggested using the following guidelines: $r = .10$ (small effect), .20 (medium effect), and .30 (large effect). The Bayes factor was also calculated to explore the strength of the evidence for one theory over the other, with strong evidence for the null hypothesis being close to 0, strong evidence for the alternative hypothesis being much greater than 1, and no evidence for one theory or the other being around 1 (Dienes 2014).

For sIgA, sAA, and stai-s analyses, non-parametric tests were used (i.e. Wilcoxon signed-rank tests). It is worth noting that, given the small sample size, statistical analyses were used as an exploratory process to test the full research protocol and to complement the analysis presented in this paper. As explained by Charity J. Morgan (2017, p. L873), "A study's statistical power (i.e., the probability that a significant effect will be detected, if it exists) is directly tied to its sample size. As sample size decreases, the ability of a study to detect small or even moderate effects vanishes." As such, because our sample was small, we foresaw that only large effects would potentially be detected.

Results

Five female and three male musicians participated in the study. We asked participants to provide their age, sex, and instruments played (see Table 1). Mean age for the sample was 67.5 ($SD = 5$). Five out of eight played more than one musical instrument. Participants had various musical backgrounds: years of playing ranged from 2 to 60 ($M = 22.38$, $SD = 21.73$). Years of participation in the Montréal New Horizons Band, which was founded six years prior, ranged from six months to 5 years ($M = 3.06$, $SD = 1.57$). On average, participants practiced approximately five hours per week at home ($M = 4.94$, $SD = 2.48$) and a little over two hours per week with their ensemble ($M = 2.11$, $SD = 0.54$).

Baseline Questionnaires

Two questionnaires (whoqol-bref, stai-t) were completed online as a baseline prior to the interventions.

1. Quality of Life

The whoqol-bref questionnaire was used to assess participants' quality of life under four domains. As part of the score computation, results for each domain were converted into a 0-100 scale. Score analysis showed a general tendency toward a positive perception of quality of life among participants, with mean scores ranging from 64% (*SD* = 22.03) for Social Relationship to 87% (*SD* = 12.59) for Environment (Table 2). It is worth noting that for social relationships, five out of eight participants (I01, I02, I04, I05, I07) had their lowest scores compared to the other domains.

Participants	Age	Sex	Instruments played
I01	64	Female	Piano, djembe, percussion, handbells
I02	70	Female	Clarinet
I03	77	Male	Clarinet, bass clarinet, (piano)
I04	67	Male	Upright bass, guitar
I05	65	Female	Saxophone
I06	71	Male	Tenor saxophone, piano
I07	62	Female	Flute
I08	64	Female	Piano, alto saxophone

Table 1: Demographic data.

Participants	Domain 1: Physical health	Domain 2: Psychological	Domain 3: Social relationships	Domain 4: Environment	Total Mean
I01	69	69	56	88	71
I02	63	56	31	63	53
I03	75	69	94	88	82
I04	88	100	56	94	85
I05	56	69	56	88	67
I06	81	94	94	100	92
I07	75	56	50	75	64
I08	100	69	75	100	86
Mean	75.88	72.75	64.00	87.00	74.91
SD	13.96	16.09	22.03	12.59	13.23

Table 2: WHOQOL.

Besides the questions related to each domain, two general questions were part of the WHOQOL-BREF questionnaire. To the question "how would you rate your quality of life?" all participants answered 4 ("good") or 5 ("very good"), except participant I02, who answered 3 ("neither good nor poor"). To the question "how satisfied are you with your health?” the same tendency occurred, with participants I02 and I07 being the only ones with a response under 4 (“satisfied”). Both answered 2 (“dissatisfied”).

2. Trait Anxiety

Participants also filled out the STAI-T to help us determine the extent to which they tend to be anxious in their general lives. Mean trait anxiety scores were 39 (*SD* = 8.57). Four participants (I01, I02, I05, and I07) reported higher anxiety scores (43 and above), which may be indicative of more anxious personalities. All four of these participants were female.

3. SOC

After both interventions, participants filled out the SOC-13 questionnaires (Table 3). The original version was used during the Rest condition, to assess participants’ sense of coherence in their daily lives, whereas an adapted version was used for the Music condition, in order to assess participants’ perception about their SOC during a rehearsal.

When we compared the original version of the SOC-13 ($M = 66.63$, $SD = 5.95$) to the adapted version specifically made for music rehearsals ($M = 79.63$, $SD = 9.56$), results were found to be significantly higher in music, $t(7) = 4.10$, $p = .005$, $r = .84$, $BF_{10} = 77.21$. Table 3 shows the score variation between the original and music versions of the questionnaire.

Participants	SOC-13 original Total score	SOC-13 Music Total score	Score variation * (%)
I01	61	81	20 (32.79%)
I02	52	77	25 (48.08%)
I03	73	80	7 (9.59%)
I04	76	77	1 (1.32%)
I05	54	72	18 (33.33%)
I06	73	74	1 (1.37%)
I07	74	89	15 (20.27%)
I08	70	87	17 (24.29%)
Mean score	66.63	79.63	
SD	9.56	5.95	

***Corresponds to the total score of SOC-13 music subtracted by the total score of SOC-13**

Table 3: Comparison of SOC-13 original and SOC-13 music.

In the SOC-13 original, the three participants (I01, I02, I05) with the lowest total scores had a noticeably higher score for the SOC-13 music. These changes represent a percentage of variation ranging from 32.8% to 48.1%.

Items' means for each of the three dimensions of the SOC-13 original and SOC-13 music were calculated and are shown in Table 4. The tendency toward a greater sense of coherence in music-making appeared in all three dimensions of the questionnaire, but was most prevalent in the Comprehensibility dimension, followed by Manageability.

	Comprehensibility	Manageability	Meaningfulness
Condition	Mean (SD)	Mean (SD)	Mean (SD)
SOC-13 original	4.80 (0.44)	5.19 (0.63)	5.47 (0.73)
SOC-13 music	6.13 (0.81)	6.34 (0.96)	5.91 (0.75)

Table 4: Dimensions of the SOC-13.

Pre and Post Tests

1. State Anxiety

Regarding the STAI-S (Table 5), the mean score pre-intervention in the Rest condition was 27.38 (*SD* = 10.01), and post-intervention 24.88 (*SD* = 5.11), indicating that participants reported fewer symptoms of situational anxiety after watching a documentary about music. While one participant (I07) had a noticeable decrease of 16 points post-intervention, most participants had a stable anxiety score before and after watching the documentary (we define as stable all results with a variation of 1 point).

	Rest Condition			Music Condition		
Participants	Pre	Post	Variation* (%)	Pre	Post	Variation* (%)
I01	30	29	-1 (-3.33%)	27	27	0 (0%)
I02	21	20	-1 (-4.76%)	55	33	-22 (-40%)
I03	24	21	-3 (-12.50%)	31	23	-8 (-25.81%)
I04	23	25	2 (8,70%)	42	26	-16 (-38.10%)
I05	25	25	0 (0%)	39**	33	-6 (-15.38%)
I06	20	20	0 (0%)	20	21	1 (5%)
I07	51	35	-16 (-31.37%)	41**	43	2 (4.88%)
I08	25	24	-1 (-4%)	21	21	0 (0%)
Mean	27.38	24.88	-2.5 (-9.13%)	34.50	28.38	-6.12 (-17.74%)
SD	10.01	5.11		11.95	7.58	

****Results indicate post-test data subtracted by pre-test data. The percentage of change appears in parentheses.***

*****Missing question. Score adjusted with STAI protocol.***

Table 5: STAI-S: comparison between Rest condition and Music condition.

In the Music condition, the mean score pre-intervention was 34.50 (*SD* = 11.95), and after the intervention, 28.38 (*SD* = 7.58). Three participants (I01, I06, I08) had a stable anxiety score before and after the intervention while five (I02, I03, I04, I05, I07) showed variations. Out of those five, two (I02, I04) had a decrease of over 15 points. That said, no statistical difference was found between anxiety scores pre- and post-intervention for each condition, nor between conditions.

Comparison was made between men and women. Female participants had higher mean scores overall for state anxiety. Mean score for males was found to remain stable pre- and post-intervention in the Rest condition, but showed a larger decrease following the music condition compared to the women (Table 6). Nevertheless, results must be interpreted with caution because of score adjustments that had to be made in the women's groups (due to missing values) and because there were only three men in the study.

	Rest Condition			Music Condition		
Participants	Pre	Post	Variation* (%)	Pre	Post	Variation* (%)
Mean score for males	22.33	22	-0.33	31	23.33	-7.67
(SD)	(11.30)	(11.21)	(-1.49%)	(17.91)	(11.85)	(-24.73%)
Mean score for females	30.4	26.6	-3.80	36.6	31.4	-5.2
(SD)	(16.38)	(11.99)	(-12.5%)	(19.06)	(14.76)	(-14.21%)

Results indicate post-test data subtracted by pre-test data. The percentage of change appears in parentheses.

Table 6: STAI-S: comparison by sex between Rest condition and Music condition.

2. Cortisol, sAA, and sIgA

In the Rest condition, the cortisol mean went from 0.060 (*SD* = 0.022) pre-intervention to 0.042 (*SD* = 0.018) post-intervention (see Table 7). Levels decreased among all participants following viewing of a classical music documentary, making them on average 28.35% (*SD* = 19.79%) less stressed post-intervention. These changes were found to be significant $t(7) = 3.44$, $p < .05$, $r = 0.79$, $BF_{10} = 22.91$. In the Music condition, cortisol also decreased but less noticeably, going from 0.068 (*SD* = 0.032) pre-intervention to 0.063 (*SD* = 0.039) post-intervention. In fact, cortisol was found to be lower in six out of eight participants (I02, I04, I05, I06, I07, I08) after rehearsing music together. It is worth noting that participant I01 had a major increase in cortisol in the music condition, which affects the mean and standard deviation reported at the bottom of the table (*M* = -5.70%, *SD* = 52.60%). The result of the dependent sample *t* test was not significant.

Participants	Rest Condition (µg/dl)			Music Condition (µg/dl)		
	Pre	Post	Variation* (%)	Pre	Post	Variation* (%)
I01	0.073	0.056	-0.017 (-23.29)	0.044	0.093	0.049 (111.36)
I02	0.057	0.038	-0.019 (-33.33)	0.067	0.031	-0.036 (-53.73)
I03	0.08	0.072	-0.008 (-10.00)	0.092	0.113	0.021 (22.83)
I04	0.043	0.015	-0.028 (-65.12)	0.061	0.047	-0.014 (-22.95)
I05	0.05	0.046	-0.004 (-8.00)	0.048	0.041	-0.007 (-14.58)
I06	0.095	0.049	-0.046 (-48.42)	0.137	0.119	-0.018 (-13.14)
I07	0.025	0.021	-0.004 (-16.00)	0.047	0.032	-0.015 (-31.91)
I08	0.053	0.041	-0.012 (-22.64)	0.046	0.026	-0.02 (-43.48)
Mean	0.060	0.042	-0.017 (-28.35)	0.068	0.063	-0.005 (-5.70)
SD	0.022	0.018	0.014 (19.79)	0.032	0.039	0.025 (52.60)

Results indicate post-test data subtracted by pre-test data. The percentage of change appears in parentheses.

Table 7: Cortisol levels and variations under two conditions.

Participants	Rest Condition (U/ml)			Music Condition (U/ml)		
	Pre	Post	Variation* (%)	Pre	Post	Variation* (%)
I01	175.808	106.272	-69.54 (-39.55)	85.444	188.6	103.16 (120.73)
I02	94.972	295.692	200.72 (211.35)	114.144	103.484	-10.66 (-9.34)
I03	331.444	324.72	-6.72 (-2.03)	153.012	862.312	709.30 (463.56)
I04	213.692	208.116	-5.58 (-2.61)	236.488	353.748	117.26 (49.58)
I05	97.416	221.236	123.82 (127.10)	140.22	145.796	5.58 (3.98)
I06	423.94	779	355.06 (83.75)	895.112	1074.85	179.74 (20.08)
I07	146.78	63.96	-82.82 (-56.42)	232.552	157.112	-75.44 (-32.44)
I08	93.152	115.128	21.98 (23.59)	139.4	66.256	-73.14 (-52.47)
Mean	197.151	264.266	67.12 (43.15)	249.547	369.020	119.47 (70.46)
SD	121.853	227.384	150.19 (91.23)	266.158	383.820	242.25 (167.55)

Results indicate post-test data subtracted by pre-test data. The percentage of change appears in parentheses.

Table 8: sAA levels and variations under two conditions.

Regarding sAA levels (see Table 8), the mean increased in the Rest condition from 197.15 (*SD* = 121.85) pre-intervention to 264.27 (*SD* = 227.38) post-intervention. Standard deviations varied greatly, because sAA levels increased in four participants (I02, I05, I06, I08) and decreased in the four others (I01, I03, I04, I07). While a small decrease was observed in participants I03 (-2.03%) and I04 (-2.61%), a marked increase was noted for participants I02 (211.35%) and I05 (127.10%). In the Music condition, the mean rose from 249.55 (*SD* = 266.16) pre-intervention to 369.02 (*SD* = 383.82) post-intervention. The sAA levels increased in five participants (I01, I03, I04, I05, I06) and decreased in the three others (I02, I07, I08). The mean percentage change was highly affected by participant I03 (who had a 464.56% increase). Overall, the sAA level increased on average 43.15% (*SD* = 91.23%) after the Rest condition compared to 70.46% (*SD* = 167.55%) in the Music condition. No significant difference was observed within nor between conditions using Wilcoxon signed-rank tests.

Participants	Rest Condition (µg/ml)			Music Condition (µg/ml)		
	Pre	Post	Variation* (%)	Pre	Post	Variation* (%)
I01	21.88	18.42	-3.46 (-15.81)	25.24	22.53	-2.71 (-10.74)
I02	38.25	33.84	-4.41 (-11.53)	30.59	37.92	7.33 (23.96)
I03	35.61	62.18	26.57 (74.61)	38.86	82.44	43.58 (112.15)
I04	58.62	45.56	-13.06 (-22.28)	42.63	72.68	30.05 (70.49)
I05	17.51	19.46	1.95 (11.14)	31.34	23.93	-7.41 (-23.64)
I06	74.39	135.9	61.54 (82.73)	78.92	110.7	31.78 (40.27)
I07	36.95	48.76	11.81 (31.96)	44.97	31.41	-13.56 (-30.15)
I08	49.69	56.83	7.14 (14.37)	53.43	30.23	-23.20 (-43.42)
Mean	41.613	52.619	11.01 (20.65)	43.248	51.480	8.23 (17.36)
SD	18.778	37.285	23.66 (40.06)	17.009	32.842	22.83 (54.51)

Results indicate post-test data subtracted by pre-test data. The percentage of change appears in parentheses.

Table 9: sIgA levels and variations under two conditions.

As for the immune response (Table 9), the sIgA mean increased in the Rest condition from 41.63 (*SD* = 18.78) pre-intervention to 52.62 (*SD* = 37.30) post-intervention. This increase specifically affected five participants (I03, I05, I06, I07, I08) out of eight after the viewing (see Table 7), indicating that their immune systems were more active, and therefore stronger. For participants I03 and I06, the response heightened noticeably, with a 74.61% and 82.73% increase respectively. In the Music condition, the sIgA mean also increased, going from 43.25 (*SD* = 17.01) pre-intervention to 51.48 (*SD* = 32.84) post-intervention. Three participants (I03, I04, I06) had an increased immune response, one remained stable (I02), and four (I01, I05, I07, I08) had a decrease. The mean percentage of change is still associated with an increase in sIgA after the band rehearsal, but this can mainly be explained by the marked increase observed in participant I03 (112.15%) and, to some extent, in participant I04 (70.49%). Overall, the sIgA level increased on average 20.65% (*SD* = 40.06%) after the Rest condition compared to 17.36% (*SD* = 54.51%) in the Music condition. No significant difference was observed within nor between conditions using Wilcoxon signed-rank tests.

To be able to interpret our results more accurately, we asked the participants during both conditions: "Did you experience a situation that caused stress during the intervention?" For the Rest condition, elements that were mentioned included being "tired of sitting" (I01) or having to move legs often due to restless legs syndrome (I07). One participant (I05) wrote: "I was cold and a toothache started because of the cold in the room." The elements reported here did not appear to have had a marked impact on their results. It is worth noting that several comments made mention of being moved or inspired by the documentary. These positive emotions may have contributed to the lowering of cortisol levels in the Rest condition.

Regarding the Music condition, two participants mentioned the high temperature in the room (I01 and I08). Participant I01 also indicated getting lost in the score while playing and being only a little stressed. That said, we observed a 111.36% increase in cortisol and a 120.73% increase in sAA at the end of the rehearsal for that musician (see Table 8). Another participant (I03) had to play short solos during rehearsal and had a 22.83 % increase in cortisol, combined with a 463.56% increase in sAA and a 112.15% increase in sIgA. One "felt bad not being able to keep up with the group but immersed [him]self [in the task] to feel better" (I02). This strategy seemed to have helped as we noticed a decrease of 53.73% in cortisol post-rehearsal. Finally, I07 indicated: "I was the only flute and I'm not very good at sight reading". However, this element does not seem to have prevented this musician from experiencing a decrease of over 30% in cortisol and sAA.

Discussion

The aim of this pilot study was to test a research protocol that could eventually be applied to a larger sample of musicians. Given the objectives of the study, we were expecting that (1) the sense of coherence would be stronger in the Music condition than in the Rest condition; (2) anxiety levels would decrease in the Music condition and remain stable in the Rest condition; and (3) biomarkers of stress (cortisol, sAA) and immune response (sIgA) would be more influenced by the Music condition than the Rest condition.

soc

The sense of coherence was found to be significantly higher in the context of a music rehearsal than in participants' daily lives. This is not surprising, as music is recognized in the literature to provide multiple benefits that may affect wellbeing and quality of life (Creech *et al.* 2014). In fact, because collective music-making is a structured activity that happens at a specific moment in time, it may be easier to orient oneself in terms of comprehensibility, manageability, and meaningfulness. Indeed, because participants are actively engaged during band rehearsal, they may focus more on the music and being in the moment than on other elements of life. For instance, while participants sometimes felt "like sad sacks (losers) in certain situations" of everyday life (item 10, Antonovsky 1987), they reported far fewer of these feelings during rehearsals. When something happened, they tended to see things in the right proportion more easily in a musical context than in everyday life (item 11). It was also easier to find that things had meaning during rehearsals (item 12). Music-making was reported to be a "source of deep pleasure and satisfaction" (item 7) in comparison with everyday things. During rehearsals, participants reported few instances of being surprised by the behaviour of the people they thought they knew (item 2) and felt less often disappointed by them (item 3) as well. Participants tended to have fewer "mixed-up feelings and ideas" (item 8) or feelings that they would "rather not feel" (item 9) while playing music in comparison with everyday life events.

Comprehensibility was the dimension that stood out a little more in the Music condition, which means that stimuli (both internal and external) are perceived more easily as being structured, predictable and explainable in a musical environment than in everyday life. Challenges during music rehearsals were also perceived to be more manageable, which means that participants felt that they had the ability to deal with difficulties (or at least have access to resources to help them cope with difficulties). Furthermore, they found meaning in their music-making experience, which indicates that their efforts were worthy of the commitment they made.

Anxiety

State anxiety decreased in both conditions, though results were not statistically significant. The decrease in state anxiety post-intervention was more substential in the Music condition (-17.74% versus -9.13%), which contributes to supporting our expectation that music-making would tend to alleviate anxiety more than a Rest condition. This finding is aligned with that of Kumiko Toyoshima and colleagues (2011), who found that one 30-minute session of piano playing reduced anxiety significantly more than other creative activities (i.e. clay molding and calligraphy) or a control activity (remaining silent).

Participants reported higher state anxiety pre-intervention in the Music condition (M = 34.5, SD = 11.95) than in the Rest condition (M = 27.38, SD = 10.01). This suggests that music rehearsals may generate a certain level of anxiety, which could be associated with music performance anxiety (Esplen and Hodnett 1999; Kenny 2011; Papageorgi, Hallam and Welch 2007). In fact, while it is acknowledged that music performance anxiety is usually more intense in contexts of public or solo performances (Cox and Kenardy 1993; Miller and Chesky 2004; Nicholson, Cody and Beck 2015), Kim E. Robson and Dianna T. Kenny (2017) have shown that it can also be experienced in rehearsal contexts. Thus, it is possible that some participants started the Music condition with a level of state anxiety that was somewhat higher than under normal circumstances.

It is acknowledged that self-perceived anxiety varies between men and women (Leach *et al.* 2008; Pigott 1999). We thus wanted to compare if this was the case in our sample. In terms of trait anxiety, four out of five women reported high STAI-T scores, indicating that they had a propensity to be more anxious in life. In terms of state anxiety, it was also found that overall, women in our sample reported higher state anxiety scores than men. As mentioned above, the percentage of variation in state anxiety post- versus pre-intervention was larger in the Music condition than in the Rest condition, and this applied to both females' and males' results. That said, the decrease in state anxiety was greater for men in the Music condition post-intervention than for women. Due to the small sample size, these results must be interpreted with caution, because they may be influenced by individual variability.

Cortisol, sAA, and sIgA

Regarding cortisol levels, our original expectation that the Music condition would generate a greater decrease in cortisol than the Rest condition could not be confirmed. While we were able to observe a decrease in cortisol in both conditions, it was only significant in the Rest condition. Just like for anxiety, it is possible that music performance anxiety may have influenced cortisol levels for some participants. In fact, a study conducted with preschoolers (Boucher and Ryan 2011) has shown that anxiety and cortisol levels can be influenced by the performance location (participants familiar with their performance environment were less anxious than those who were not) and the recurrence of performances (a second performance within days of the first one was less stressful). Therefore, because the rehearsal that was used for the Music condition was a special event organized only once during the summer, it may have been perceived as more special than a regular rehearsal (and thus more stressful), even if it was conducted in the same location.

Regarding the Rest condition, we posit that the significance of our results was the consequence of listening to relaxing music, as the documentary selected for the intervention included multiple excerpts of classical music. In fact, music listening has been known to alleviate stress and affect cortisol levels and other biomarkers (Burns *et al.* 2001; Staricoff 2004; Thoma *et al.* 2013). As such, we concluded that our Rest condition was more a condition of *passive music* than a control condition, and that this would have to be addressed in the protocol for the larger study.

As for sAA, we first hypothesized that results would be lower in the Music condition than the Rest condition post-intervention. Instead, our mean values increased. None of these increases were found to be statistically significant, due to there being a lot of variability in the results. In fact, the standard deviations of sAA results were especially large compared to the means, a consequence of extreme values observed in specific individuals. A larger sample size would be needed to reach sufficient statistical power to be able to detect a change. In a study on active and passive rhythmic music, Trevor McPherson and colleagues (2019) also investigated cortisol and sAA levels in 16 participants in a music therapy session and did not find a statistical difference between conditions either. Their small sample size may explain the lack of significance in their results. In addition, it is also worth considering that sAA may not be the most appropriate biomarker to study physiological stress in a music context. Because this enzyme is indicative of noradrenergic activity, which is associated with the activation of the sympathetic branch of the autonomic nervous system (Petrakova *et al.* 2017), it is known to have a faster reactivity than cortisol (Maruyama *et al.* 2012; Rohleder and Nater 2009). As such, one may wonder whether spontaneous feelings that can arise during a rehearsal, whether positive such as excitement or negative such as anger or anxiety, could have influenced levels of sAA. Emma K. Adam, Lindsay Till Hoyt, and Douglas A. Granger (2011) seem to be confirming this in their study with adolescents, where they indicate that "acute sAA increases may reflect levels of emotional arousal, including high arousal positive emotions, rather than being specific to stress or emotions of negative valence" (p. 171). Consequently, this led us to consider whether, in relation with our research protocol, the cost-benefit of using this biomarker was justified in the next phase of our research.

In terms of sIgA, we observed an increase in mean values post-intervention in both conditions, but none of these changes were statistically significant. In their study on the relationship between cortisol and sIgA, Frank Huckelbridge and colleagues (1998) found that these two biomarkers were negatively correlated, which means that when one rose, the other lowered. Among the participants in our study, results were mixed. For instance, in the Rest condition, while five participants showed a similar trend post-intervention (decrease in cortisol and increase in sIgA), three participants (I01, I02, I03) were found to have a decrease in cortisol accompanied by a decrease in sIgA. In the Music condition, I03 had higher levels of both cortisol and sIgA post-intervention. Three other participants (I05, I07, I08) showed a decrease in cortisol levels combined with lower sIgA results post-intervention. These results seem to suggest that some parameters may affect cortisol and sIgA independently. One way to explain these results is provided by Jos A. Bosch and colleagues (2002), who specify that acute and chronic stress influence sIgA differently: while acute stress tends to increase sIgA, chronic stress tends to decrease it. That said, more research is needed to better understand the relationship between these biomarkers and determine the real impact of active music-making on immune response.

Strengths and Limitations

The aim of this pilot study was to test a research protocol that could eventually be applied to a sample of 80 musicians (40 singers and 40 instrumentalists). To our knowledge, this was the first study analyzing the effect of music-making on cortisol, sAA, and sIgA of amateur instrumentalists aged 50 and over. It was also one of the few research projects using salutogenic theory in a music context.

This pilot study allowed us to identify certain aspects to correct. The most predominant element was associated with the research protocol and the selection of the documentary that was used for the Rest condition. In wanting to offer a documentary that would interest musicians, we selected a film about classical music. Participants were thus exposed to many musical excerpts over a period of 90 minutes. As indicated previously, multiple studies have shown that listening to music can lower cortisol levels (e.g., Kreutz *et al.* 2004; Linnemann *et al.* 2015; Thoma *et al.* 2013), and after interpreting our data, it became evident that our choice of documentary had influenced our Rest condition. This led us to adapting the current protocol by selecting another documentary for the next steps of our study.

Another element to consider was the use of sAA as a biomarker of stress. As indicated in the discussion, the large variability between participants made the interpretation of results challenging and made us question its inclusion in the next phase of our project. This reflection was based on multiple considerations: (1) the lack of evidence in the literature to prove the reliability of this biomarker to measure sympathetic activation (Petrakova *et al.* 2017); (2) the difficulty in interpreting results due to the lack of research about music-making and sAA; and (3) the necessity or not of using two biomarkers of stress (especially considering the financial cost associated with sample analysis) when cortisol seemed to have provided more consistent results than sAA.

In terms of data, our results were affected by the small sample size and the large variability observed between participants. Some factors such as music performance anxiety or self-efficacy (which has been linked to the former; Dempsey and Comeau 2019; Orejudo *et al.* 2017; Zelenack 2015) may have influenced participants' outcomes in ways that are difficult to assess, because we did not use validated questionnaires to account for these potential effects. Inter-individual variability in circadian rhythms may have also played a role in the data variability. Consequently, results must be interpreted with caution. That said, the next phase of our project, which will aim to recruit 80 musicians, should address these issues.

Conclusion

This pilot study sought to explore the effects of music-making on the stress levels and variations in immune response of older amateur musicians, through the lens of salutogenic theory and its concept of sense of coherence (soc). The results showed that the soc was higher during a music rehearsal than in participants' daily lives. State anxiety decreased to a larger extent in the Music condition than in the Rest condition, although results were not statistically significant. The cortisol levels declined significantly after watching a documentary, whereas this decline was observed only in six participants after a rehearsal of ensemble music. No significant change was found for sAA, due to the large variability between participants. As for sIgA, though no significant change was noted, levels increased for 5 participants in the Rest condition after viewing the documentary. The Music condition was marked with greater variability.

Even if these results are preliminary, they are still promising and demonstrate that music can have an effect on certain biological markers. The outcome of this study is significant for academia, organizations dedicated to seniors, music educators, and the general public because it may contribute to raise awareness that music can be a creative strategy to promote healthy aging. The next phase of this research project is to apply the modified protocol of this pilot study to a larger sample of instrumentalists and singers of 50 years old and over, to determine whether results can be generalized to a larger population.

Acknowledgements

This research is funded by the Social Sciences and Humanities Research Council of Canada (SSHRC). This work was presented at a poster session of the International Symposium of Performance Science 2023. The poster and following article were done with the contribution of Hubert Charland, undergraduate research assistant at UQAM.

Bibliography

Adam, Emma K., Lindsay Till Hoyt, and Douglas A. Granger (2011), "Diurnal Alpha Amylase Patterns in Adolescents. Associations with Puberty and Momentary Mood States," *Biological Psychology*, vol. 88, nos 2-3, pp. 170–173, https://doi.org/10.1016/j.biopsycho.2011.07.007.

Ali, Nida, and Urs M. Nater (2020), "Salivary Alpha-Amylase as a Biomarker of Stress In Behavioral Medicine," *International Journal of Behavioral Medicine. Official Journal of the International Society of Behavioral Medicine*, vol. 27, no 3, pp. 337–342, https://doi.org/10.1007/s12529-019-09843-x.

Antonovsky, Aaron (1979), *Health, Stress, and Coping. New Perspectives on Mental and Physical Well Being*, San Francisco, Jossey-Bass Publishers.

Antonovsky, Aaron (1987), *Sense of Coherence Scale* [Database record], APA PsycTests, https://doi.org/10.1037/t12396-000.

Barbeau, Audrey-Kristel, and Isabelle Cossette (2019), "The Effects of Participating in Community Concert Band on Senior Citizens' Quality of Life, Health aAnd Performance Anxiety," *International Journal of Community Music*, vol. 12, no 2, pp. 269–288, http://dx.doi.org/10.1386/ijcm.12.2.269_1.

Barbeau, Audrey-Kristel, and Roger Mantie (2019), "Music Performance Anxiety and Perceived Benefits of Musical Participation Among Older Adults in Community Bands," *Journal of Research in Music Education*, vol. 66, no 4, pp. 408–427, http://dx.doi.org/10.1177/0022429418799362.

Batt-Rawden, Kari (2012), "The Role of Music in a Salutogenic Approach to Health," *International Journal of Mental Health Promotion*, vol. 12, no 2, pp. 11–18, https://doi.org/10.1080/14623730.2010.9721809.

Beck, Robert J., *et al.* (2000), "Choral Singing, Performance Perception, and Immune System Changes in Salivary Immunoglobulin A and Cortisol," *Music Perception. An Interdisciplinary Journal*, vol. 18, no 1, pp. 87–106, https://doi.org/10.2307/40285902.

Bittman, Barry B., *et al.* (2001), "Composite Effects of Group Drumming Music Therapy on Modulation of Neuroendocrine-Immune Parameters in Normal Subjects," *Alternative Therapies in Health and Medicine*, vol. 7, no 1, pp. 38–47, https://www.rhythmresearchresources.net/uploads/1/1/2/9/112916705/bittman_article._neuroendocrine_effects.pdf, accessed April 25, 2024.

Bosch, Jos A., *et al.* (2002), "Stress and Secretory Immunity," *International Review of Neurobiology*, vol. 52, pp. 213–253, https://doi.org/10.1016/S0074-7742(02)52011-0.

Boucher, Hélène, and Charlene A. Ryan (2011), "Performance Stress and the Very Young Musician," *Journal of Research in Music Education*, vol. 58, no 2, pp. 329–345, https://doi.org/10.1177/0022429410386965.

Brydges, Christopher R. (2019), "Effect Size Guidelines, Sample Size Calculations, and Statistical Power in Gerontology," *Innovation in Aging*, vol. 3, no 4, pp. 1–8, https://doi.org/10.1093/geroni/igz036.

Burns, Sarah, *et al.* (2001), "A Pilot Study into the Therapeutic Effects of Music Therapy at a Cancer Help Center," *Alternative Therapies in Health and Medicine*, vol. 7, no 1, pp. 48–56.

Chafin, Sky, *et al.* (2004), "Music Can Facilitate Blood Pressure Recovery from Stress," *British Journal of Health Psychology*, vol. 9, nº 3, pp. 393–403, https://doi.org/10.1348/1359107041557020.

Chanda, Mona Lisa, and Daniel J. Levitin (2013), "The Neurochemistry of Music," *Trends in Cognitive Sciences*, vol. 17, nº 4, pp. 179–193, https://doi.org/10.1016/j.tics.2013.02.007.

Cohen, Gene D., *et al.* (2006), "The Impact of Professionally Conducted Cultural Programs on The Physical Health, Mental Health, and Social Functioning of Older Adults," *Gerontologist*, vol. 46, nº 6, pp. 726–734, https://doi.org/10.1093/geront/46.6.726.

Cox, Wendy J., and Justin Kenardy (1993), "Performance Anxiety, Social Phobia and Setting Effects in Instrumental Music Students," *Journal of Anxiety Disorders*, vol. 7, nº 1, pp. 49–60, https://doi.org/10.1016/0887-6185(93)90020-L.

Creech, Andrea, *et al.* (2014), *Active Ageing with Music. Supporting Wellbeing in the Third and Fourth Ages*, London, Institute of Education Press.

Dempsey, Erin, and Gilles Comeau (2019), "Music Performance Anxiety and Self-efficacy in Young Musicians. Effects of Gender and Age," *Music Performance Research*, vol. 9, pp. 60–79.

Dienes, Zoltan (2014), "Using Bayes to Get the Most out of Non-significant Results," *Frontiers in Psychology*, vol. 5, article 781, https://doi.org/10.3389/fpsyg.2014.00781.

Epel, Elissa S., and Gordon J. Lithgrow (2014), "Stress Biology and Aging Mechanisms. Toward Understanding the Deep Connection Between Adaptation to Stress and Longevity," *The Journals of Gerontology. Series A*, vol. 69, Issue Suppl_1, pp. S10–S16, https://doi.org/10.1093/gerona/glu055.

Esplen, Mary Jane, and Ellen Hodnett (1999), "A Pilot Study Investigating Student Musicians' Experiences of Guided Imagery as a Technique to Manage Performance Anxiety," *Medical Problems of Performing Artists*, vol. 14, pp. 127–132.

Eyerly, Heather Erin (2007), *Choral Singing and Health. The Impact of Circle of Sound Voice Education (C) and Choral Singing on Salivary Immunoglobulin A of Children and Youth*, doctoral dissertation, University of Toronto, https://tspace.library.utoronto.ca/handle/1807/117086, accessed April 25, 2024.

Eyre, Lillian (2011), "Therapeutic Chorale for Persons with Chronic Mental Illness. A Descriptive Survey of Participant Experiences," *Journal of Music Therapy*, vol. 48, nº 2, pp. 149–168, https://doi.org/10.1093/jmt/48.2.149.

Fancourt, Daisy, Lisa Aufegger, and Aaron Williamon (2015), "Low-Stress and High-Stress Singing Have Contrasting Effects on Glucocorticoid Response," *Frontiers in Psychology*, vol. 6, pp. 1242–1242, https://doi.org/10.3389/fpsyg.2015.01242.

Fancourt, Daisy, *et al.* (2016), "Singing Modulates Mood, Stress, Cortisol, Cytokine and Neuropeptide Activity in Cancer Patients and Carers," *ecancermedicalscience*, vol. 10, nº 631, https://doi.org/10.3332/ecancer.2016.631.

Field, Andy (2009), *Discovering Statistics Using spss*, 3rd edition, London, Sage Publications.

Gassen, Nils C., *et al.* (2017), "Life Stress, Glucocorticoid Signaling, and the Aging Epigenome. Implications for Aging-Related Diseases," *Neuroscience and Biobehavioral Reviews*, vol. 74, part B, pp. 356–365, https://doi.org/10.1016/j.neubiorev.2016.06.003.

Grebosz-Haring, Katarzyna, and Leonhard Thun-Hohenstein (2018), "Effects of Group Singing Versus Group Music Listening on Hospitalized Children and Adolescents with Mental Disorders. A Pilot Study," *Heliyon*, vol. 4, nº 12, https://doi.org/10.1016/j.heliyon.2018.e01014.

Good, Arla, and Frank A. Russo (2022), "Changes in Mood, Oxytocin, and Cortisol Following Group and Individual Singing. A Pilot Study," *Psychology of Music*, vol. 50, nº 4, pp. 1340–1347, https://doi.org/10.1177/03057356211042668.

Hanser, Suzanne B. (1985), "Music Therapy and Stress Reduction Research," *Journal of Music Therapy*, vol. 22, nº 4, pp. 193–206, https://doi.org/10.1093/jmt/22.4.193.

Hucklebridge, Frank, Angela Clow, and Phil Evans (1998), "The Relationship Between Salivary Secretory Immunoglobulin A and Cortisol. Neuroendocrine Response to Awakening and the Diurnal Cycle," *International Journal of Psychophysiology*, vol. 31, nº 1, pp. 69–76.

Kenny, Dianna T. (2011), *The Psychology of Music Performance Anxiety*, Oxford, Oxford University Press.

Kreutz, Gunter, *et al.* (2004), "Effects of Choir Singing or Listening on Secretory Immunoglobulin A, Cortisol, and Emotional State," *Journal of Behavioral Medicine*, vol. 27, pp. 623–635, https://doi.org/10.1007/s10865-004-0006-9.

Kuhn, Dawn (2002), "The Effects of Active and Passive Participation in Musical Activity on the Immune System as Measured by Salivary Immunoglobulin A (SlgA)," *Journal of Music Therapy*, vol. 39, nº 1, pp. 30–39.

Leach, Liana S., *et al.* (2008), "Gender Differences in Depression and Anxiety Across the Adult Lifespan. The Role of Psychosocial Mediators," *Social Psychiatry and Psychiatric Epidemiology*, vol. 43, nº 12, pp. 983–998, https://doi.org/10.1007/s00127-008-0388-z.

Lindström, Bengt, and Monica Eriksson (2011), "From Health Education to Healthy Learning. Implementing Salutogenesis in Educational Science," *Scandinavian Journal of Public Health*, vol. 39, nº 6_suppl, pp. 85–92, https://doi.org/10.1177/1403494810393560.

Lindström, Bengt, and Monica Eriksson (2012), *La salutogenèse. Petit guide pour promouvoir la santé*, French adaptation by Mathieu Roy and Michel O'Neill, Québec, Presses de l'Université Laval.

Linnemann, Alexandra, *et al.* (2015), "Music Listening as a Means of Stress Reduction in Daily Life," *Psychoneuroendocrinology*, vol. 60, pp. 82–90, https://doi.org/10.1016/j.psyneuen.2015.06.008.

Lupien, Sonia J., *et al.* (1998), "Cortisol Levels during Human Aging Predict Hippocampal Atrophy and Memory Deficits," *Nature Neuroscience*, vol. 1, nº 1, pp. 69–73, https://doi.org/10.1038/271.

Lupien, Sonia J. (2013), *How to Measure Stress in Humans*, 2nd edition, Centre for Studies in Human Stress, Fernand Seguin Research Centre of Louis-H. Lafontaine Hospital, Quebec, Canada.

Maruyama, Yoshihiro, *et al.* (2012), "Differences in Salivary Alpha-Amylase and Cortisol Responsiveness following Exposure to Electrical Stimulation versus the Trier Social Stress Tests," *Plos One*, vol. 7, nº 7, article e39375, https://doi.org/10.1371/journal.pone.0039375.

McPherson, Trevor, *et al.* (2019), "Active and Passive Rhythmic Music Therapy Interventions Differentially Modulate Sympathetic Autonomic Nervous System Activity," *Journal of Music Therapy*, vol. 56, nº 3, pp. 240–264, https://doi.org/10.1093/jmt/thz007.

Miller, Staci Renee, and Kris Chesky (2004), "The Multidimensional Anxiety Theory. An Assessment of and Relationships Between Intensity and Direction of Cognitive Anxiety, Somatic Anxiety, and Self-Confidence over Multiple Performance Requirements among College Music Majors," *Medical Problems of Performing Artists*, vol. 19, nº 1, pp. 12–20.

Morgan, Charity J. (2017), "Use of Proper Statistical Techniques for Research Studies with Small Samples," *American Journal of Physiology*, vol. 313, nº 5, pp. L873–L877, https://doi.org/10.1152/ajplung.00238.2017.

Nicholson, D. Riley, Meghan W. Cody, and J. Gayle Beck (2015), "Anxiety in Musicians. On and off Stage," *Psychology of Music*, vol. 43, nº 3, p. 438–449.

Orejudo, Santos, *et al.* (2017), "The Relation of Music Performance Anxiety (MPA) to Optimism, Self-efficacy, and Sensitivity to Reward and Punishment. Testing Barlow's Theory of Vulnerability on a Sample of Spanish Music Students," *Psychology of Music*, vol. 45, nº 4, pp. 570–583.

Papageorgi, Loulia, Susan Hallam, and Graham F. Welch (2007), "A Conceptual Framework for Understanding Musical Performance Anxiety," *Research Studies in Music Education*, vol. 28, pp. 83–107.

Petrakova, Liubov, *et al.* (2017), "Salivary Alpha-Amylase and Noradrenaline Responses to Corticotropin-releasing Hormone Administration in Humans," *Biological Psychology*, vol. 127, pp. 34–39, https://doi.org/10.1016/j.biopsycho.2017.04.016.

Pigott, Teresa A. (1999), "Gender Differences in the Epidemiology and Treatment of Anxiety Disorders," *Journal of Clinical Psychiatry*, vol. 60, pp. 4–15.

Robson, Kim E., and Dianna T. Kenny (2017), "Music Performance Anxiety in Ensemble Rehearsals and Concerts. A Comparison of Music and Non-music Major Undergraduate Musicians," *Psychology of Music*, vol. 45, nº 6, pp. 868–885, https://doi.org/10.1177/0305735617693472.

Rohleder, Nicolas, and Urs M. Nater (2009), "Determinants of Salivary a-Amylase in Humans and Methodological Considerations," *Psychoneuroendocrinology*, vol. 34, nº 4, pp. 469–485, https://doi.org/10.1016/j.psyneuen.2008.12.004.

Skingley, Ann, and Hilary Bungay (2010), "The Silver Song Club Project. Singing to Promote the Health of Older People," *British Journal of Community Nursing*, vol. 15, nº 3, pp. 135–140, https://doi.org/10.12968/bjcn.2010.15.3.46902.

Spielberger, Charles D. (1983), *Manual for the State-trait Anxiety Inventory*, Palo Alto, CA, Consulting Psychologists.

Statistics Canada (2020), "Estimations de la population du Canada. Âge et sexe, 1er juillet 2020,", *Le Quotidien*, September 29, https://www150.statcan.gc.ca/n1/daily-quotidien/200929/dq200929b-fra.htm, accessed May 2, 2024.

Staricoff, Rosalia Lelchuck (2004), *Arts in Health. A Review of The Medical Literature*, Research Report 36, London, Arts Council England.

The WHOQOL Group (1998), "Development of the World Health Organization WHOQOL-BREF Quality of Life Assessment," *Psychological medicine*, vol. 28, nº 3, pp. 551–558, https://doi.org/10.1017/S0033291798006667.

Thoma, Myriam V., *et al.* (2013), "The Effect of Music on the Human Stress Response," *Plos One*, vol. 8, nº 8, article e70156, https://doi.org/10.1371/journal.pone.0070156.

Toyoshima, Kumiko, Hakime Fukui, and Kiyoto Kuda (2011), "Piano Playing Reduces Stress more than Other Creative Art Activities," *International Journal of Music Education*, vol. 29, nº 3, pp. 257–263, https://doi.org/10.1177/0255761411408505.

Ulrich-Lai, Yvonne M., and James P. Herman (2009), "Neural Regulation of Endocrine and Autonomic Stress Responses," *Nature Reviews. Neuroscience*, vol. 10, nº 6, pp. 397–409, https://doi.org/10.1038/nrn2647.

United Nations (2019), *World Population Prospects 2019. Highlights*, ST/ESA/SER.A/423, New York, United Nations, https://doi.org/10.18356/13bf5476-en.

Wong, Melanie Mitsui, *et al.* (2021), "Biomarkers of Stress in Music Interventions. A Systematic Review," *Journal of Music Therapy*, vol. 58, nº 3, pp. 241–277, https://doi.org/10.1093/jmt/thab003.

Wulff, Verena, *et al.* (2021), "The Effects of a Music and Singing Intervention during Pregnancy on Maternal Well-being and Mother-infant Bonding. A Randomised, Controlled Study," *Archives of Gynecology and Obstetrics*, vol. 303, pp. 69–83.

Zelenak, Michael S. (2015), "Measuring Sources of Self-efficacy among Secondary School Music Students," *Journal of Research in Music Education*, vol. 62, nº 4, pp. 389–404.