

Is there addiction to loud music? Findings in a group of non-professional pop/rock musicians

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Abstract

Listening to loud music may be connected to addictive behavior possibly leading to damaging effects on the cochlea. We hypothesized that members of non-professional pop/rock bands with regular exposure to loud music are more likely to show an addictive-like behavior for loud music than matched control subjects. Fifty non-professional musicians and 50 matched control subjects were asked to complete the Northeastern Music Listening Survey (NEMLS) with two basic components. The first comprises an adaptation of the validated Michigan Alcohol Screening Test (MAST) to study the addictive-like behavior towards loud music. The second comprises the criteria outlined by the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) of the American Psychiatric Society for the diagnosis of substance dependence. The NEMLS was scored using the same point system as used in the MAST.

The DSM-IV criteria for substance dependence were met by nine of the musician group and by one control subject. Seven of these nine musicians also had a positive NEMLS score. Traits of addictive-like behavior to loud music were detected more often in members of non-professional pop/rock bands than in control subjects.

Introduction

The positive effects of music have been well documented and include a strong impact on neuroplasticity, which allows the brain to adapt to environmental factors that cannot be anticipated by genetic programming.¹ Music has also been shown to reduce anxiety and pain, and to improve both the mood and the quality of life of patients, such as those receiving palliative care, by enhancing their sense of comfort and relaxation.² In addition, Lai and Good³ have shown that sleep quality can be improved in older adults by listening to music at bedtime.

Music may also entail negative side effects, such as when it is consumed at intense sound levels for long periods.⁴ The awareness among the general public of the potential dangers of loud music to hearing may have increased over the last decades, yet its consumption is still very common. Cullari and Semanchick⁵ have shown that listeners who demonstrated a greater fondness for a particular type of music preferred to listen to it at a louder level. Additionally, listeners perceive their preferred music to be softer in level when compared to less-preferred music when both are played at the same intensity.⁶ Todd *et al.*⁷ have also demonstrated that vestibular responses may be obtained from exposure to dance music at intensities above 90 dBA. Given that pleasurable sensations of self-motion are widely sought after by more direct means of vestibular stimulation, they suggested that evoking these feelings acoustically could contribute to an individual's compulsion to listen to music at loud levels. Furthermore, given the similarities that have been found between the sound intensities and frequency distributions at rock concerts and in dance clubs, they also suggested that this response might be a physiological basis for the minimum loudness necessary for rock and dance music.

Several studies have demonstrated that music can have an effect in the parts of the brain that are thought to be responsible for reward and emotion. In a positron emission tomography study, individuals who were listening to preferred music tracks showed an increase in blood flow in the same regions of the brain associated with sex, food intake and cocaine consumption.⁸ It has also been found that intense pleasure in response to music can lead to dopamine release in the striatal system.⁸ However, these studies have not addressed the specific effects of volume-driven music.

In studies conducted during aerobics classes, loud music has been

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shown to correlate positively with enjoyment and in pleasure derived from continuing these activities.⁹ Interestingly, the knowledge that exposure to loud sounds can permanently damage hearing did not influence this correlation. This may mean either that people do not take such warnings about the dangers of loud music seriously or that wearing earplugs are subject to many problems as discussed in details somewhere else.^{10,11} Vogel *et al.*¹² has reported that the lack of clear definitions concerning what levels of high-volume music are hazardous is an important barrier to improvement of environmental conditions that reduce the risk for music-induced hearing loss.

Another reason why people may not protect themselves from potential damage from loud music could be its possible addictive effects (and in particular, preferred music tracks). This theory has been addressed by Florentine *et al.*,¹³ who developed the Northeastern Excessive Music Listening Survey (NEMLS), which will be explained in detail in the Methods Section. The purpose of Florentine *et al.* study was to consider if a validated screening instrument for determining alcohol addiction could be adapted to screen for Maladaptive Music Listening (MML), and subjects with a variety of music listening behaviors were sought for a pilot study. The group included 90 subjects: three frequent listeners of loud music, 49 who visited a music store, 18 college students and 20 (non-medical) employees of a hospital. Their findings indicated that 8 of the 90 subjects (9%) scored within a range that would suggest the presence of a maladaptive pattern of music listening behavior similar to that exhibited by substance abusers.

Our study was a follow-up to the Florentine *et al.* study. Starting from the hypothesis that individuals who had been self-exposed to loud music for a significant period of time were more likely to show evidence for MML than subjects without such a behavior, we assessed the listening behaviors of longtime members in non-professional pop/rock groups and in a group of subjects matched in age, gender and education without such exposure. Finding support for this hypothesis would imply that complex and difficult to control behavior may contribute to recreational noise exposure. Such behavior is seldom included as a factor in strategies for controlling noise induced hearing loss.

Materials and Methods

Subject inclusion/exclusion criteria and procedures

Non-professional pop/rock musicians

The musicians examined in this study were mainly recruited by e-mail, either via the homepage of a local club of rock musicians or via their band homepage. In addition, an article describing the purpose for this study, which included contact information, was published in a local newspaper. The inclusion criteria were that the musical activity had to be non-professional in nature (*i.e.*, the main income had to be earned from *nonmusical* activities), and that the musician had to have been a member of a pop/rock band for more than 5 years and have had a weekly exposure to intense sound levels from electro-amplified music for a minimum of 2 h. These criteria made it likely that only individuals were included who had been exposed to loud music for a significant period of time. Informed consent was obtained from the subjects, and the study was approved by the Ethics Committee, University Hospital of Basel.

In addition to a widely used questionnaire to screen for different causes of hearing loss (ISO/TC43/WG1),¹⁴ and the questionnaire listed in the Appendix, the musicians answered a detailed questionnaire concerning their age, gender, education, profession, and the circumstances surrounding their musical activities.

The group of non-professional pop/rock musicians included in our analyses comprised 50 subjects (45 men) with a relatively wide range of age from 21 to 50 years and a mean age of 32 years (SD 8.4 years).

An informal testing of sound levels close to the ear during a rehearsal in 16 of these musicians revealed quite similar results of levels that were approximately 100 to 105 dBA, suggesting that these subjects were exposed to similar intensities of sound. The average weekly exposure to intense sound levels for the entire group was approximately 5 h (SD 3 h, range 2 to 14 h) over a mean period of approximately 13 years (SD 8 years, range 5 to 33 years). A daily noise exposure level of 105 dBA for one hour is equivalent to the permissible exposure level in an occupational setting set by Standard 1910.95 from the Occupational Safety and Health Administration (<http://www.osha.gov>).

Control group

Control subjects were matched by age (± 2 years), gender and level of education. They reported to be neither active musicians nor frequent listeners to loud music or to have hearing problems. They were recruited at random from the general public at public places (*e.g.*, restaurants) located in the city of Basel. They completed the same questionnaires as the musicians. All interviews were carried out carefully by the second author, both in musicians and controls. The respondents had the opportunity to ask for clarification immediately, and the survey was carried out similarly for both groups. Time to complete the questionnaire was about 15 min. Informed consent was obtained, permitting the use of their data for research.

Assessment instrument

The questionnaire that was supplied to the subjects in this study is provided in the Appendix and consisted of 61 items. It included the 32 items of the NEMLS, which has two components. The first comprises 23 items from the Michigan Alcoholism Screening Test (MAST),^{15,16} a widely accepted screening instrument for determining alcohol addiction, which had been adopted by Florentine *et al.*¹³ to examine *loud music* listening. The yes/no items on the MAST fell into five areas: i) recognition and admission of the problem by self and others; ii) legal, work and social problems; iii) seeking involvement with treatment programs; iv) marital-family difficulties and v) medical pathology. Additionally, three demographic items (age, gender, and level of education) were included. The second component of the NEMLS comprised four items assessing three out of seven clinical diagnostic criteria for substance dependence as outlined by the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) of the American Psychiatric Association.¹⁷ The other four criteria were already embedded within the MAST. A validated German translation of the MAST does exist and was used (www.gesis.org/unser-angebot/studien-planen/zis-ehes/download-ehes/downloads). We added 27 questions to the NEMLS that were selected with the help of two mental health professionals with extensive experience in developing screening instruments, one of which is a coauthor (RS). The questions were selected to provide information in four areas: i) history of music exposure and hearing problems (questions 32 and 33); ii) the subjective effects of loud music upon the individual (questions 34 to 38); iii) drug use and related mental attitude (questions 39 to 49) and iv) a personality-profile (questions 50 to 58). One of these additional questions was related to the DSM-IV criteria (question 35). The questions of the subareas iii) and iv) were based on the validated *Basler Drug and Alcohol* Questionnaire,¹⁸ which is well known in the German speaking countries and has been published in German. The English version of these items is provided in the Appendix.

At the end of the procedure, all questions of the questionnaire were carefully checked by coauthor (RS), who is a native German speaker also fluent in English. The German version of this questionnaire is available from the first author (NS). The internal consistency of our questionnaire was examined, and the details of this step are provided later in this section.

A validated version of the MAST exists in both English and German.

A validated version of the NEMLS exists in English, but not in German, which is a limitation of this study. However, the NEMLS in German was developed by modifying the validated German version of the MAST, and compared with the validated English version of the NEMLS by the coauthor (RS) with extensive experience in developing such questionnaires. The subjects were instructed to understand that the references to music listening in the questionnaire included the playing of a musical instrument.

Analysis

Scoring

The NEMLS assessments were initially scored in the same manner as the MAST point system, in which each question is differentially weighted, according to its effectiveness in discriminating between alcoholics and nonalcoholics.¹⁵ Most scored items received either 1 point (questions 3,5,10 and 17) or 2 points (questions 1, 2, 4, 6, 8, 11-16, 18, 19, 23 and 24). Questions that identified subjects who sought help received 5 points each (questions 9, 20, and 21). Question 7 received 0 points, as it does also in the MAST. The threshold for the diagnostic significance of the NEMLS results was defined as a total score of 13 or greater, in accordance with the definition for the MAST assessment.¹⁹

The second set of scores ascribed to each subject was related to the Criteria for Substance Dependence, as delineated in DSM-IV.¹⁷ This consisted of manifesting at least three of the following seven criteria (the specific questions that determined these criteria are indicated in parentheses): i) Tolerance: a need for markedly increased amounts of the substance or markedly diminished effects with continued use of the same amount of the substance (questions 27 or 28 positive); ii) Withdrawal: characteristic withdrawal syndrome for the substance or that taking the same substance relieves or avoids the withdrawal symptoms (questions 22 or 17 and 35 positive); iii) Loss of control: the substance is often taken in larger amounts or over a longer period than was intended (question 4 or 8 positive); iv) Unsuccessful attempts: persistent desire or unsuccessful efforts to cut down or control substance use (question 7 positive in addition to question 8); v) Time: a great deal of time is spent in activities necessary to either obtain the substance, use the substance or recover from its effects (questions 29-31, with at least two positive); vi) Reduced activity: important social, occupational or recreational activities are given up or reduced because of substance use (questions 13 or 15 positive; or at least two positives out of 11, 14, 16); vii) Use despite knowledge: the substance use is continued despite the knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance (question 18a positive).

The musicians and the control subjects self-assessed their personality profile (questions 50 to 58) using a Visual Analogue Scale (VAS). The VAS consists of a line of typically 10 cm in length on a page with clearly defined end points (0 cm and 10 cm), and a clearly identified scale between the two end points. The specific endpoints are illustrated in the Appendix.

Internal consistency of the questionnaire

Coefficient alpha values were calculated to examine the internal consistency of our questionnaire. One principal goal of our analysis was to examine our data from the NEMLS and to compare these with the results obtained by Florentine *et al.*¹³ The findings from the NEMLS were tested with two calculations. First, the unweighted sum of all answers for questions 1 to 31 was used. Any answer indicating a tendency towards MML was given a score of 1. Second, the NEMLS score, which was the weighted score for a subset of questions as described, was used (weighted questions 1-6, 8-21, 23, and 24). The coefficients alpha were calculated for four of the five subareas of the NEMLS, in accordance

with the previous analyses of Florentine *et al.*¹³ The subarea for medical symptoms was not used because it contains only one question. Moreover, the questions with significantly greater numbers of positive answers for the musician subjects than for the control subjects (McNemar's Test, always $P < 0.001$) were also analyzed for their internal consistency, which included items from the NEMLS (questions 1 to 31) and also questions 32 to 49. Finally, the coefficients alpha were calculated for the three subareas of the additional questions from 32 to 49.

Statistics

Statistical procedures were performed using SPSS software (version 13) to calculate the coefficients alpha and with SigmaStat software (version 3.0) for the remaining analyses. The McNemar's Test was used to compare the number of positive answers for items 1-49 of the questionnaire to the results for the matched controls. For paired and nonparametric data, the Wilcoxon signed rank test was performed. For unpaired and nonparametric data, the Mann-Whitney Rank Sum Test was used. Spearman rank order correlation analysis was used to measure the strength of a potential association between the NEMLS score and the number of fulfilled DSM-IV criteria.

Results

Northeastern Music Listening Survey score and Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria

The NEMLS score was significantly higher in the group of 50 rock musicians with a median of 13 points, in comparison with the control group with a median of 3 points (Figure 1; Wilcoxon signed rank test, $P < 0.001$).

Twenty-six rock musicians and two control subjects had scores that were equal to or above the proposed diagnostic threshold of 13. The highest scores of the control subjects were 13 and 14 points. By setting the threshold of the NEMLS score to 15, and thus above the highest score obtained for the control subjects, 21 of the musician subjects still had a positive NEMLS score.

The DSM-IV criteria for substance dependence were met by nine of the musicians and by only one control subject. Of the nine musicians who fulfilled the DSM-IV, seven also had a positive NEMLS score. The

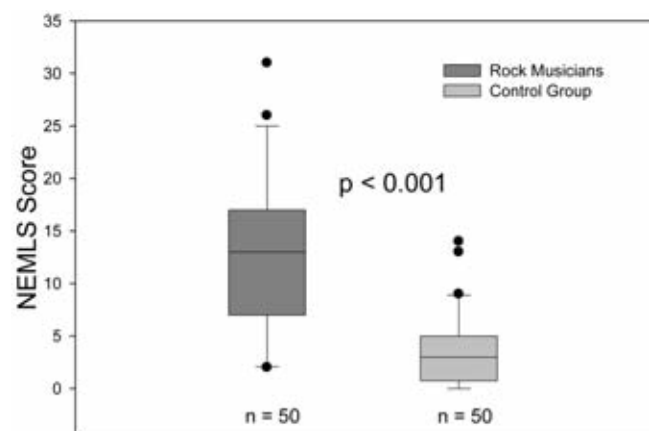


Figure 1. The results of the Northeastern Music Listening Survey (NEMLS) scored for the pop/rock musician subjects in comparison to the control group.

distribution of positive questions for these seven subjects, forming the NEMLS score and the DSM-IV criteria, is shown in Table 1.

Positive answers relating to questions 1-49 of the questionnaire

Positive answers for 19 of the questions were obtained significantly more often from individuals in the musician group than from the control subjects (McNemar's Test, $P < 0.001$ for 11 answers and $P < 0.05$ for 8 answers) (Figure 2).

Combination of criteria

Six musicians scored above the threshold of 15 on the NEMLS, fulfilled the DSM-IV criteria and described themselves as being *addicted to loud music* (question 38). None of the control subjects fulfilled this combination of criteria or answered positively to question 38.

Personality profile

Our results of the personality profiles are depicted in Figure 3. The musician subjects assessed their creativity potential at a significantly higher level than the control subjects (Wilcoxon signed rank test, $P < 0.001$). The other personality characteristics gave similar results for both groups (Wilcoxon signed rank test, $P > 0.05$).

Internal consistency of the questionnaire

To examine the internal consistency of the questionnaire, the coefficient alpha was calculated. This coefficient evaluates the extent to

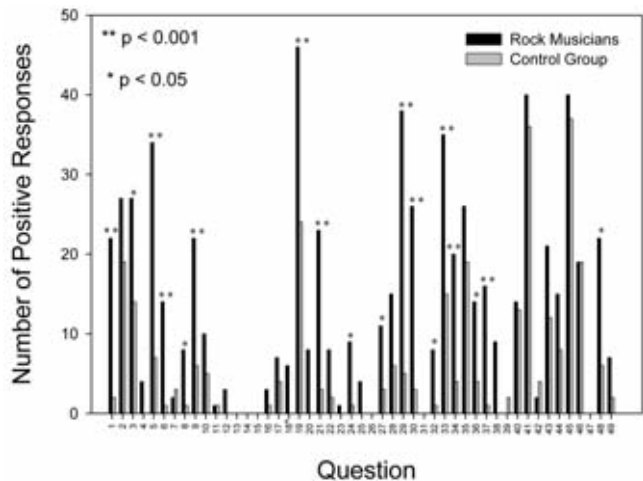


Figure 2. The percentage of positive responses to each question for both the group of musicians and the control group. Questions 1 to 31 are covered by the Northeastern Music Listening Survey. Questions 32 to 49 represent subareas i) history of music exposure and hearing problems (questions 32 and 33), ii) the subjective effects of loud music on the individual (questions 34 to 38) and iii) drug use and related mental attitude (questions 39 to 49). All six musicians who gave a positive answer for question 18 also provided a positive answer for question 18a.

Table 1. Profile of individual subjects with an Northeastern Music Listening Survey score ≥ 13 that fulfilled the Diagnostic and Statistical Manual of Mental Disorders criteria. Positive responses by question number are shown.

Age	37	27	27	30	27	27	23
Gender	M	M	M	F	M	M	M
Education	3	1	4	3	5	4	4
NEMLS score	31	26	18	17	17	16	15
NEMLS subareas							
Recognition/admission of problems (questions 1, 3-6, 8, 16)	1, 3, 5, 6, 8	1, 3, 5, 6, 8, 16	5	3, 5	4, 5, 8	3, 5, 6, 8	1, 3, 5, 8
Legal, work, social problems (questions 10, 13-15, 19, 24)	19, 24	10, 19	19, 24	19	19, 24	19	19, 24
Help seeking (questions 9, 20, 21, 23)	9, 20, 21	9, 23	9	9	9		
Problems in family relationships (questions 3, 11, 12)	3	3, 12		3		3	3
Medical symptoms (question 18)	18	18					
DSM-IV criteria							
Tolerance (questions 27, 28)	3	4	3	3	4	4	3
Withdrawal (questions 17, 22, 35)		<i>27, 28</i>	<i>28</i>	<i>27</i>	<i>28</i>	<i>27</i>	<i>27</i>
Loss of control (questions 4, 8)		<i>35</i>	<i>17, 35</i>	<i>17, 22, 35</i>	<i>17, 35</i>	<i>17, 22, 35</i>	<i>22, 35</i>
Unsuccessful attempts (question 7)	8	8			4, 8	8	8
Time (questions 29, 30, 31)	<i>29, 30</i>	<i>29, 30</i>	<i>29, 30</i>	<i>29, 30</i>	<i>29, 30</i>	<i>29, 30</i>	<i>29, 30</i>
Reduced activity (questions 11, 13-16)		<i>16</i>					
Use despite knowledge (question 18a)	<i>18a</i>	<i>18a</i>					

Education: 1, High school or less; 2, current apprenticeship, 3, finished apprenticeship; 4, some college courses; 5, college graduate. Data in italics: fulfilled DSM-IV criteria as defined in the Methods. NEMLS, Northeastern Music Listening Survey; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders.

which the different items on a test measure the same construct or aspect. The coefficients alpha for combinations of questions described in the Analysis section are shown in Table 2.

Comparable results were found to be similar to the findings of Florentine *et al.*¹³ A coefficient alpha of about 0.7 is considered as acceptable and thus the alpha scores for the subareas of the NEMLS, and for questions 32-33 and 39-49, did not meet this standard. These results are assessed in further detail in the Discussion.

Discussion

The results of our study support the hypothesis that individuals who have been self-exposed to loud music for a significant period of time are more likely to show evidence for Maladaptive Music Listening behavior than matched subjects without such exposure. Longtime members in non-professional pop/rock bands showed clearly more often positive findings in questionnaires testing MML, including the NEMLS as developed by Florentine *et al.*¹³ We did not explore the reasons why these subjects with repeated exposure to high-sound levels of electro-amplified music may be more likely to show traits of maladaptive behavior to loud music than the control subjects, and whether they develop such behavior before or after joining a pop/rock band.

It has been hypothesized that music is an indirect agonist of the D2 receptor within the dopamine system of the ventral tegmental area (VTA), that it could be of therapeutic value in addictive behavior, and that the effect may be associated with certain specific gene polymorphism.²⁰ The VTA is often referred to as the main nucleus of the reward system. If this hypothesis is correct, then it would follow that music could conversely also induce addictive behavior with the development of tolerance. Music can be conceptualized as having commonalities with acknowledged addictive substances, such as alcohol or heroin, even though the consequences of MML cannot be considered as serious as those from substance abuse. Indeed, maladaptive pattern of music-listening behavior have been proposed to include an addictive element to loud music.¹³

Our finding of MML evidence in seven of the 50 musicians self-exposed to loud music but in none of the 50 matched control subjects can be interpreted either as a selection of individuals susceptible to MML by joining pop/rock-bands, or as an induction of such behavior

through the regular exposure to loud music. This study was not designed to distinguish between these two possibilities. However, we had no indication within our results that a general addictive behavior was more common in the pop/rock musicians than in the control subjects, with the noteworthy exception of nicotine consumption, which was more frequently answered positively by the musicians. Questions concerning drug use and related mental attitudes (questions 39 to 49) were answered similarly by both the musicians and the control subjects. The personality self-assessment of nine characteristics revealed similar results for both the musician and control group with the exception of *creativity*. An additional general caveat is the fact that self-reported data are less reliable than psychometric measures. They tend to involve underestimation of true levels of drug use, though the possibility of exaggeration should also not be ignored.^{7,8} Even if the results

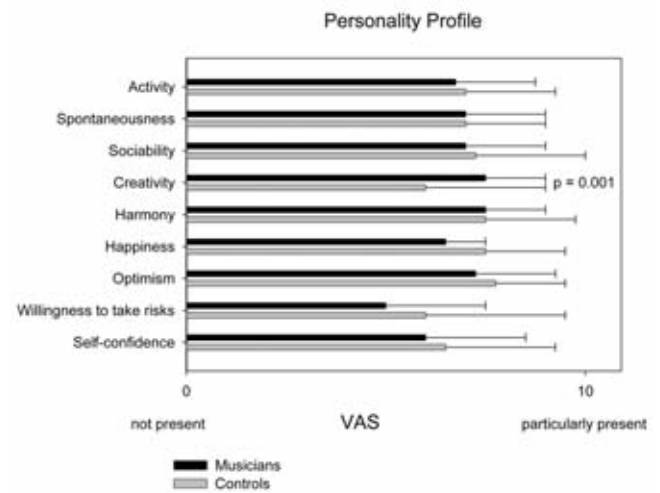


Figure 3. Personality self-assessment characteristics using a visual analogue scale (VAS) ranging from 0 (not present) to 10 (particularly present) for the group of musicians, in comparison to the control group.

Table 2. Coefficient alpha scores for different combinations of questions.

	Present study	Florentine <i>et al.</i> ¹³
Unweighted sum of all answers of the NEMLS (Q. 1-31)	0.71	0.81
NEMLS score (Q. 1-6, 8-21, 23, 24)	0.66	0.65
NEMLS subareas		
Recognition and admission of problem (Q. 1, 3, 4-6, 8, 16)	0.55	0.56
Legal, work, and social problems (Q. 10, 13-15, 19, 24)	-0.4	0.33
Seeking help (Q. 9, 20, 21, 23)	0.43	-0.06
Marital/family problems (Q. 3, 11, 12)	0.56	0.56
Q. with very significantly greater numbers of positive answers, in comparison to the controls (P< 0.001)		
For the NEMLS (Q. 1, 5, 6, 9, 19, 21, 29, 30)	0.64	-
Whole questionnaire (Q. 1, 5, 6, 9, 19, 21, 29, 30, 33, 34, 37)	0.69	-
Unweighted sum of all answers (Q. 1-49)	0.77	-
Subareas for q. 32-49		
History of music exposure and hearing problems (Q. 32-33)	0.28	-
Subjective effects of loud music (Q. 34-38)	0.77	-
Drug use and related mental attitudes (Q. 39-49)	0.47	-

Q., questions; NEMLS, Northeastern Music Listening Survey.

obtained by self-assessment are not as reliable as psychometric measures, it can be generally stated that the personality profile was similar for both groups. These results suggest further that the two groups of subjects were well matched.

This study provides evidence that a few subjects may exhibit a MML. The results of the questionnaires make it unlikely that MML or addiction to loud music leads to serious social or work-related problems, but from an audiological point of view, the main damage of MML will be permanent noise induced hearing loss. Our study did not evaluate systematically the connection between MML and permanent damage of hearing. Audiometric data obtained in another context from 42 of the 50 musicians revealed a small, but significant mean hearing loss of 6 dB in the noise-susceptible range from 3 to 8 kHz.²¹ One of the seven individuals with indications of MML and with a positive NEMLS score of 31 and fulfilling the DSM-IV criteria had a significant age and gender appropriate hearing loss in the noise susceptible frequency range from 3 to 8 kHz of 8 dB in the right and 6 dB in the left ear. This subject also reported *Medical Symptoms* (question 18, *Have you ever been told you have a noise-induced hearing loss in which loud music played a part?*), along with another subject with a NEMLS score of 26. Neither of the two subjects reported tinnitus or hypersensitivity to sound. These results underscore again that MML is not as serious as some other addictions. This study cannot assess the connection between MML and damage to hearing, and it was not designed to do so. Nevertheless, it must be assumed that addiction to loud music can lead to noise-induced auditory symptoms such as tinnitus or hypersensitivity to sounds with their serious impact on the lives of individuals.

Since physiological dependence is not expected to develop in MML, the main tools to examine MML clinically are behavioral examinations through questionnaires. The DSM-IV criteria for the diagnosis of substance dependence were adopted alongside the transformed questions from the MAST by Florentine *et al.*¹³ The MAST is a well known and validated screening test for alcohol abuse.¹⁶ Alcohol can clearly induce physiological dependence. Therefore, the transformation and application of an alcohol misuse-screening tool to a presumed behavioral addiction such as MML may constrain its reliability and effectiveness. The additional inclusion of questions to assess the DSM-IV criteria for substance dependence does not change such limitations. Florentine *et al.*¹³ performed the translation of the questions with extraordinary diligence employing a three-tiered translation strategy, but *translation littering* from the MAST was obvious for some questions, suggesting that a direct comparison of loud music behavior to the abuse of substances such as alcohol may be partially inadequate.

The finding that no positive response from all our subjects was obtained for five items of the NEMLS questionnaire (questions 13-15, 26, and 31) may be related to these inadequacies. Neither the performance nor the playing of loud music caused any problems in the work place (covered by items 14 and 15), and none of our subjects reported that they had lost either friends or girlfriends/boyfriends, that they had been excluded from a household because of loud music activities, or that they had ever needed to spend large periods of their time in dealing with the consequences of their loud music activities. Hence, serious work-related or social problems, which have been well documented in people with addictions to alcohol or drugs,²²⁻²⁷ have not occurred among our study subjects as a result of loud music consumption. The effects of addictive substances such as alcohol and loud music on both the individual and the surroundings are obviously different. Whereas excessive alcohol consumption makes individuals lose their inhibitions and become more likely to start a fight, loud music is more likely to provoke an aggressive response from people in the vicinity who are unwillingly exposed to it. The use of MAST derived questions such as *Have you gotten into arguments or fights when listening to loud music?* (question 10) may be inappropriate to search for MML behavior. In fact, the question did not discriminate well between musicians with ten positive

answers and control subjects with five, whereas the equivalent question from the MAST distinguishes between alcoholics and nonalcoholics quite well.¹⁶

We added one question of self-assessment for addiction to loud music (question 38) examining a simple and direct criterion. This question showed good agreement with parts of the other screening tools. Six musicians described themselves as being *addicted to loud music*. All six were screened as positive by the NEMLS with scores of more than 15 and all fulfilled the DSM-IV criteria. The combination of a positive NEMLS score and the fulfillment of the DSM-IV criteria may be more sensitive for addictive behavior towards loud music than just a NEMLS threshold of 13 as proposed by Florentine *et al.*¹³ Twenty-six of the musician subjects in this study were screened as positive using only the threshold of 13, but only seven of them fulfilled the DSM-IV criteria. No correlation between the overall NEMLS scores and DSM-IV criteria was found in our study (Spearman rank order correlation, $Rho=0.3$, $P=0.4$), in contrast to the study of Florentine *et al.*¹³

Based on our results, we suggest a score of 15 as a threshold in the overall NEMLS and the additional fulfillment of the DSM-IV criteria for the presence of a possible MML behavior. Seven musician subjects had a positive overall NEMLS score ranging from 15 to 31 points, whereas the fulfillment of the DSM-IV criteria included in NEMLS ranged from 3 to 4 in these individuals (Table 1). However, the questions of how to diagnose MML reliably and if such a diagnosis is appropriate remain open. Addictive aspects of loud music remain a concept that has not been widely explored, and quite limited evidence and knowledge exist.

It will be necessary to improve both the understanding of the concept of MML and the diagnostic tools with future research. A low coefficient alpha result for some subareas of the NEMLS, and for some subareas of our additional questions, indicated that either some questions need to be refined or, more probably, that they are not appropriate for the proper assessment of target populations with an addictive potential to loud music. At this time, it does not seem appropriate to use the individual results from the subareas, and we do not recommend using our methods for other populations without further evaluation.

Neurocognitive development of risk aversion from early childhood to adulthood was recently investigated by Paulsen *et al.*, using functional magnetic resonance imaging.²⁸ Components of the brain's dopaminergic system, such as dopamine receptors, undergo final maturation in adolescence.²⁹ In this study, the age range of participating musicians was wide. Ranging from 21 to 50 years it did not include the typical age of behavioral development implying that stages of brain development³⁰ were not sufficiently considered leading possibly to unacknowledged influence on our results.

Consistent evidence shows that high alcohol consumption in late adolescence can lead to continuation into adulthood and later association with alcohol problems, including dependence.³¹ Our study could not assess whether similar developments might take place in the consumption of loud music.

In spite of these possible biases, the comparison between our two different populations should be valid because it rests on the same age range and methodological inaccuracies, which may have been present. It will be important for future research to develop simple and reliable tools to assess MML and to explore the use of them in audiological practice.

Conclusions

A minority of our current study subjects demonstrated loud music listening behaviors that share some characteristics with other addictive behaviors. Such traits were found only in subjects with regular self-exposure to loud music, but not in a group of matched control subjects.

We used tools for assessment that were developed previously, making our results comparable to those of Florentine *et al.*¹³ Even so, it was obvious that the development of simpler and more reliable tools for use in audiological practice is desirable.

It must be assumed that self-inflicted damage to the inner ear will occur more likely in subjects with MML, but our study was not designed to address this question. Given the real possibility of MML in pop/rock bands, continuing education about the risk to hearing and the need for the persistent use of ear protection for musicians is warranted. However, loud music listening is certainly not as harmful as alcohol, opioids, or nicotine, and it is important to recognize the many positive aspects of music.

References

- Munte TF, Altenmuller E, Jancke L. The musician's brain as a model of neuroplasticity. *Nat Rev Neurosci* 2002;3:473-8.
- Kemper KJ, Danhauer SC. Music as therapy. *South Med J* 2005;98:282-8.
- Lai HL, Good M. Music improves sleep quality in older adults. *J Adv Nurs* 2005;49:234-44.
- Zhao F, Manchaiah VK, French D, Price SM. Music exposure and hearing disorders: an overview. *Int J Audiol* 2010;49:54-64.
- Cullari S, Semanchick O. Music preferences and perception of loudness. *Percept Mot Skills* 1989;68:186.
- Fucci D, Harris D, Petrosino L, Banks M. Effect of preference for rock music on magnitude-production scaling behavior in young adults: a validation. *Percept Mot Skills* 1993;77:811-5.
- Todd NP, Cody FW, Banks JR. A saccular origin of frequency tuning in myogenic vestibular evoked potentials?: implications for human responses to loud sounds. *Hear Res* 2000;141:180-8.
- Blood AJ, Zatorre RJ. Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proc Natl Acad Sci U S A* 2001;98:11818-23.
- Wilsont WJ, Herbstein N. The role of music intensity in aerobics: implications for hearing conservation. *J Am Acad Audiol* 2003;14:29-38.
- Chesky K, Pair M, Yoshimura E, Landford S. An evaluation of musician earplugs with college music students. *Int J Audiol* 2009;48:661-70.
- Zander MF, Spahn C, Richter B. Employment and acceptance of hearing protectors in classical symphony and opera orchestras. *Noise Health* 2008;10:14-26.
- Vogel I, Van Der Ploeg CP, Brug J, Raat H. Music venues and hearing loss: Opportunities for and barriers to improving environmental conditions. *Int J Audiol* 2009;48:531-6.
- Florentine M, Hunter W, Robinson M, Ballou M, Buus S. On the behavioral characteristics of loud-music listening. *Ear Hear* 1998;19:420-8.
- Preferred test conditions for determining hearing thresholds for standardization. ISO/TC 43/WG 1 Threshold of hearing. International Organization for Standardization Technical Committee 43. *Scand Audiol* 1996;25:45-52.
- Selzer ML. The Michigan alcoholism screening test: the quest for a new diagnostic instrument. *Am J Psychiatry* 1971;127:1653-8.
- Storgaard H, Nielsen SD, Gluud C. The validity of the Michigan Alcoholism Screening Test (MAST). *Alcohol Alcohol* 1994;29:493-502.
- American Psychiatric Association: Diagnostic and statistical manual of mental disorders. 4 ed. Washington, DC; 1994.
- Graw P, Ladewig D, Hobi V. [Different steps in construct validation of the Basel Drug and Alcohol Questionnaire (BDA)]. *Pharmacopsychiatry* 1984;17:84-93.
- Ross HE, Gavin DR, Skinner HA. Diagnostic validity of the MAST and the alcohol dependence scale in the assessment of DSM-III alcohol disorders. *J Stud Alcohol* 1990;51:506-13.
- Blum K, Chen TJ, Chen AL, Madigan M, Downs BW, Waite RL, et al. Do dopaminergic gene polymorphisms affect mesolimbic reward activation of music listening response? Therapeutic impact on Reward Deficiency Syndrome (RDS). *Med Hypotheses* 2010;74:513-20.
- Schmuziger N, Patscheke J, Probst R. Hearing in nonprofessional pop/rock musicians. *Ear Hear* 2006;27:321-30.
- Allamani A, Voller F, Decarli A, Casotto V, Pantzer K, Anderson P, et al. Contextual determinants of alcohol consumption changes and preventive alcohol policies: a 12-country European study in progress. *Subst Use Misuse* 2011;46:1288-303.
- Amato L, Davoli M, Vecchi S, Ali R, Farrell M, Faggiano F, et al. Cochrane systematic reviews in the field of addiction: what's there and what should be. *Drug Alcohol Depend* 2011;113:96-103.
- Bagnardi V, Sorini E, Disalvatore D, Assi V, Corrao G, De Stefani R, et al. 'Alcohol, less is better' project: outcomes of an Italian community-based prevention programme on reducing per-capita alcohol consumption. *Addiction* 2011;106:102-10.
- Buscemi L, Turchi C. An overview of the genetic susceptibility to alcoholism. *Med Sci Law* 2011;51 Suppl 1:S2-6.
- Magnavita N, Bergamaschi A, Chiarotti M, Colombi A, Deidda B, De Lorenzo G, et al. [Workers with alcohol and drug addiction problems. Consensus Document of the Study Group on Hazardous Workers]. *Med Lav* 2008;99 Suppl 2:3-58.
- Webb G, Shakeshaft A, Sanson-Fisher R, Havard A. A systematic review of work-place interventions for alcohol-related problems. *Addiction* 2009;104:365-77.
- Paulsen DJ, Carter RM, Platt ML, Huettel SA, Brannon EM. Neurocognitive development of risk aversion from early childhood to adulthood. *Front Hum Neurosci* 2011;5:178.
- Burke AR, Watt MJ, Forster GL. Adolescent social defeat increases adult amphetamine conditioned place preference and alters D2 dopamine receptor expression. *Neuroscience* 2011;197:269-79.
- Bava S, Tapert SF. Adolescent brain development and the risk for alcohol and other drug problems. *Neuropsychol Rev* 2010;20:398-413.
- Mccambridge J, Mcalaney J, Rowe R. Adult consequences of late adolescent alcohol consumption: a systematic review of cohort studies. *PLoS Med* 2011;8:e1000413.