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. Callari andSemanchick5 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
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.\(^{17}\) 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/zieschedownload-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 subsequances 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 and 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 co-author (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 non-alcoholics. 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.

The second set of scores ascribed to each subject was related to the Criteria for Substance Dependence, as delineated in DSM-IV. 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. 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. 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.

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 (Figure1; 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
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

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

<table>
<thead>
<tr>
<th>Age</th>
<th>37</th>
<th>27</th>
<th>27</th>
<th>30</th>
<th>27</th>
<th>27</th>
<th>23</th>
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<td>F</td>
<td>M</td>
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<td>5</td>
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<td>26</td>
<td>18</td>
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<td>17</td>
<td>16</td>
<td>15</td>
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<td>NEMLS subareas</td>
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<tr>
<td>Recognition/admission of problems (questions 1, 3-6, 8, 16)</td>
<td>1, 3, 5, 6, 8</td>
<td>1, 3, 5, 6, 8, 16</td>
<td>5</td>
<td>3, 5</td>
<td>4, 5, 8</td>
<td>3, 5, 6, 8, 16</td>
<td>1, 3, 5, 6, 8, 16</td>
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<td>Legal, work, social problems (questions 10, 13-15, 19, 24)</td>
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<td>Medical symptoms (question 18)</td>
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<td>DSM-IV criteria</td>
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<td>Tolerance (questions 27, 28)</td>
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<td>4</td>
<td>3</td>
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<tr>
<td>Withdrawal (questions 17, 22, 35)</td>
<td>27, 28</td>
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<td>27</td>
<td>28</td>
<td>27</td>
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<td>27</td>
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<tr>
<td>Loss of control (questions 4, 8)</td>
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<tr>
<td>Unsuccessful attempts (question 7)</td>
<td>17, 23, 35</td>
<td>17, 23, 35</td>
<td>17, 23, 35</td>
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<tr>
<td>Time (questions 29, 30, 31)</td>
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<td>29, 30</td>
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<td>29, 30</td>
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<td>Reduced activity (questions 11, 13-16)</td>
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<td>Use despite knowledge (question 18a)</td>
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<td>18a</td>
<td>18a</td>
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<td>18a</td>
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</table>

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. 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. 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. 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.

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. 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.](image)

<table>
<thead>
<tr>
<th>Table 2. Coefficient alpha scores for different combinations of questions.</th>
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<tbody>
<tr>
<td><strong>Present study</strong></td>
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<tr>
<td>Unweighted sum of all answers of the NEMLS (Q. 1-31)</td>
</tr>
<tr>
<td>NEMLS score (Q. 1-6, 8-21, 23, 24)</td>
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<tr>
<td>NEMLS subareas</td>
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<tr>
<td>Recognition and admission of problem (Q. 1, 3, 4-6, 8, 16)</td>
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<tr>
<td>Legal, work, and social problems (Q. 10, 13-15, 19, 24)</td>
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<tr>
<td>Seeking help (Q. 9, 20, 21, 23)</td>
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<td>Marital/family problems (Q. 3, 11, 12)</td>
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<tr>
<td>Q. with very significantly greater numbers of positive answers, in comparison to the controls (P&lt; 0.001)</td>
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<tr>
<td>For the NEMLS (Q. 1, 5, 6, 9, 19, 21, 29, 30)</td>
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<td>Whole questionnaire (Q. 1, 5, 6, 9, 19, 21, 29, 30, 33, 34, 37)</td>
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<tr>
<td>Unweighted sum of all answers (Q. 1-49)</td>
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<tr>
<td>Subareas for Q. 32-49</td>
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<tr>
<td>History of music exposure and hearing problems (Q. 32-33)</td>
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<tr>
<td>Subjective effects of loud music (Q. 34-38)</td>
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<tr>
<td>Drug use and related mental attitudes (Q. 39-49)</td>
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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. One of the seven individuals with indications of MML and with a positive NELMS 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 reported loud music consumption. The DSM-IV criteria for the diagnosis of substance dependence were adopted alongside the transformed questions from the MAST by Florentine et al. The MAST is a well known and validated screening test for alcohol abuse. 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. 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 NELMS 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, 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.

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 NELMS with scores of more than 15 and all fulfilled the DSM-IV criteria. The combination of a positive NELMS score and the fulfillment of the DSM-IV criteria may be more sensitive for addictive behavior towards loud music than just a NELMS threshold of 13 as proposed by Florentine et al. 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 NELMS 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.

Based on our results, we suggest a score of 15 as a threshold in the overall NELMS and the additional fulfillment of the DSM-IV criteria for the presence of a possible MML behavior. Seven musician subjects had a positive overall NELMS score ranging from 15 to 31 points, whereas the fulfillment of the DSM-IV criteria included in NELMS 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 NELMS, 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. Components of the brain’s dopaminergic system, such as dopamine receptors, undergo final maturation in adolescence. 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 development 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. 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.\textsuperscript{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