Short-term Effects of Listening to Music on Breathing and Emotional Affect in People Suffering From Chronic Lung Diseases

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Abstract
Chronic lung diseases (CLD) are often associated with abnormal, ineffective breathing patterns. Some studies already suggest that nonpharmacological interventions can have positive effects on symptoms related to CLD. However, in the current state of research there is a lack of studies investigating the influence of music listening on breathing rate and oxygen saturation in people affected by CLD. In the present study, we conducted two quasi-experiments to investigate the immediate effects of attentive music listening and music listening combined with a breathing instruction on breathing rate, oxygen saturation, and emotional affect in people affected by CLD and healthy controls. In total, we recruited 58 participants affected by CLD and healthy controls. Participants with CLD and healthy controls were either quasi-randomized to a music-oriented instruction (Experiment 1) or to a breathing-related instruction (Experiment 2). In both experiments we measured physiological measures and emotional affect during a baseline measurement (silence) and during one “relaxing” and one “activating” piece of music. We conducted 3 × 2 repeated measures analyses of variances with condition (baseline/relaxing music/activating music) on the first and group (with/without CLD) on the second factor for both experiments. The results of the experiments suggest that there is no immediate effect of music listening on breathing related outcomes irrespective of the instruction of participants. Moreover, we found some indication that the disease severity might influence the processing of the music. Future studies could investigate whether music listening as a long-term intervention can lead to more promising results in relation to improved breathing.

Keywords
Music listening, chronic lung disease, COPD, short-term effects, breathing instruction, asthma

Introduction
Chronic lung diseases (CLD) are among the ten leading causes of death worldwide (Vogelmeier et al., 2007). Specifically, chronic obstructive pulmonary disease (COPD) is a condition that is characterized by a constriction of the respiratory ducts caused by an inflammation of the bronchial parenchyma. The inflammation is mostly determined by the inhalation of noxious substances. The illness is progressive due to exacerbation and the patients experience a range of physical and psychological symptoms, which can severely restrict mobility and quality of life (Franssen et al., 2018). Comorbidities such as heart disease, depression, or bronchial carcinoma also influence the health status. Most of the people affected by COPD suffer from dyspnea (breathlessness or shortness of breath; (Shiber & Santana, 2006), associated with a rapid

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shallow breathing pattern (Loveridge et al., 1984) and reduced oxygen saturation (Vogelmeier et al., 2007). Next to COPD, bronchial asthma is another type of chronic lung disease (Hien, 2012). Asthmatic people frequently show similar symptoms to people with COPD. As COPD, asthma is characterized by a chronic inflammation of the airways. Patients suffer from wheeze, shortness of breath, chest tightness, and cough as well as from a limitation of the expiratory flow (Global Initiative for Asthma (GINA), 2018). According to recommendations of international guidelines, also nonpharmacological interventions are of high relevance in the treatment of CLD. In particular, physical activities for the reduction of dyspnea as well as breathing exercises and strategies to reduce stress are recommended. Beyond that, however, no other treatment specific nonpharmacologic interventions are mentioned (Global Initiative for Asthma (GINA), 2018; Vestbo et al., 2013). Therefore, we wonder if there may also be appropriate musical interventions to alleviate respiratory and emotion-related symptoms.

During the past 10 years, research about music interventions for people suffering from CLD is growing (for a review, e.g., see Panigrahi et al., 2014). Especially, researchers were interested in the benefits of choral singing for people suffering from COPD and found positive effects on physical and psychological symptoms (e.g., Bonilha et al., 2009; Lord et al., 2010; for a review, see Lewis et al., 2016). In this context, the authors found that little attention has been given to the musical content in singing intervention. Thus, we further ask whether listening to music alone can also have an impact on breathing and emotion-related symptoms.

The functional use of music listening has been advanced in many clinical settings with some emphasis on emotion regulation and pain management (Nilsson, 2008; Spintge, 2007) including patient groups who suffer from chronic illness (e.g., Bradt et al., 2013). More specifically, in the context of patients suffering from CLD, earlier work has shown that listening to music can serve as a distraction to increase physical exercise tolerance (e.g., Thornby et al., 1995; for a review, see Lee et al., 2015) and it has been revealed that listening to music can lead to reduced depression and dyspnea (Canga et al., 2015; Singh & Rao, 2009; Sliwka et al., 2012). In particular, music with a tempo between 60 and 80 bpm proved to be suitable (Singh & Rao, 2009). These positive results seem promising. However, the studies leave open which mechanisms lead to the reduction of depression and breathlessness and whether this is an immediate effect of music listening or if it only occurs after several sessions. Is it possible that listening to relaxing music leads to a better, slower breathing pattern and spontaneously improves mood in people suffering from CLD? Research investigating psychophysiological effects of music listening in healthy adults indicated that repetitive listening to sedative music can reduce the respiratory rate (Iwanaga et al., 1996) and that the respiratory rate adapts to the tempo and structure of the music (Bernardi et al., 2006; Bernardi et al., 2009; Gomez & Danuser, 2007). Additionally, some studies suggest that listening to music can reduce stress (Linnemann et al., 2015; for a systematic review, see Finn & Fancourt, 2018) and leads to improved mood, also in older adults (Innes et al., 2016).

To summarize, previous studies suggest an influence of music listening on breathing rate as well as positive effects on mood. However, none of the studies reported above investigated breathing-related responses to music listening in older adults with CLD although this issue is extremely interesting due to the abnormal breathing patterns and reduced oxygen saturation found in people suffering from CLD (Loveridge et al., 1984; Vogelmeier et al., 2007). Moreover, the psychological effect of music listening in this group is unclear. Other nonpharmacological interventions such as yogic breathing seem already promising regarding breathing related symptoms and quality of life (for a review, see Jayawardena et al., 2020). However, also in this context, the influence of one single session remains unclear, since interventions in most studies included in the review had daily frequencies with a duration of 3 months (e.g., Prem et al., 2013). Additionally, these studies leave open in how far the breathing instruction led to a change in breathing rate.

Therefore, the aim of the current study was to investigate the effect of music listening on breathing rate and SpO₂-saturation as breathing-related outcomes as well as on positive and negative affect. Since it is known that people suffering from chronic lung disease show generally abnormal breathing patterns, we compared this group with a group of healthy older adults. As it was shown that especially music with a tempo between 60 and 80 bpm seem beneficial for people suffering from a chronic lung disease, we compared the responses of a slow and more “relaxing” piece of music to a faster and more “activating” piece of music to investigate whether music in general influences breathing and positive affect or whether different pieces of music can lead to different responses. Additionally, we were interested whether music listening alone was suitable to reduce breathing rate or whether participants need an explicitly instruction to manage their breathing. As yoga breathing techniques seem to be helpful for people suffering from CLD, we chose to use an instruction based on yogic breathing. Thus, we designed two studies using a quasi-experimental design, which were identical in their protocols except of the instruction of participants. In Experiment 1, participants received a “music oriented” instruction whereas participants of Experiment 2 received a “breathing oriented” instruction. Since it was shown that a respiratory rate of approximately 6 respiratory cycles/minute had a positive effect on oxygen saturation (Bernardi et al., 1998), participants in Experiment 2 were instructed to breathe slowly with 4–6 breathing cycles per minute while listening to the music.

**Research Questions and Hypotheses**

To investigate the effect of music listening in older adults with and without CLD, we address the following research
questions: (a) How does music listening affect breathing-related outcomes and psychological responses in older adults with CLD and without chronic lung disease (N-CLD)? (b) Specifically, is relaxing music with a slow tempo more suitable than activating and faster music? Our hypothesis holds that the respiratory rate significantly decreases during listening to relaxing music compared to activating music; simultaneously, oxygen saturation is expected to significantly increase in response to relaxing music. These changes should be more pronounced for the participants who are not affected by a chronic lung disease, because due to normal breathing abilities it might be easier for them to adapt breathing to the music spontaneously. Furthermore, our second hypothesis states that music listening is associated with significant increases in positive affect and with decreases in negative affect accordingly.

Methods

Prior to its initiation, this study received approval from the medical ethics committee of the University of Oldenburg. Each participant was required to give informed consent before testing. Participants were informed verbally and in writing about the procedure and objectives of the study.

We conducted two experiments that were identical in their procedure except for the instruction of participants. While in Experiment 1 we were interested in the effect of music listening itself and spontaneous reactions regarding the breathing rate, in Experiment 2 we wanted to know whether a breathing instruction could even enhance the desired effects.

Participants Experiment 1

Twenty-eight participants (mean age = 70.61 years, SD = 6.99 years, range from 52 to 84 years; CLD: n = 14 (10 female); N-CLD: n = 14 (12 female); see Table 1, for details) were recruited from a recreational singing group, which gathers on a regular basis at the cafeteria of a local hospital. Hence, it was ensured that all participants showed some affinity to music and that they were sufficiently mobile to follow the invitation to our lab to conduct the listening experiment. Participants with CLD suffered either from COPD (n = 8), asthma (n = 7), or another chronic lung disease which was similar in symptoms (e.g., chronic bronchitis; n = 2). For participants with CLD the total scores of the SGRQ ranged between 13 and 65 (M = 37.04, SD = 17.93).

A power analysis using G*Power (Faul et al., 2007) suggested that a sample size of 28 participants per experiment was sufficient to ascertain small to medium effects (f = 0.25) in a mixed within-/between-subject design (α: 0.05, power (1−β): 0.80, correlations between repeated measures: r = .50). Therefore, we assume that our sample sizes are sufficient.

Stimulus Selection

We chose to use experimenter selected music for the experiments because different music stimuli might be differentially effective in supporting breathing. To be able to check which music might be particularly suitable for regulating breathing, we conducted a pretest. For this purpose, we selected six classical music pieces (three with a slow tempo, found as “relaxing” and three with a fast tempo, found as “activating”) in part from the previous research literature (Modesti et al., 2010). The three activating pieces had a tempo between 104 and 144 beats per minute (bpm), whereas the relaxing pieces were slower with a tempo from 50 to 76 bpm. Eight students (mean age = 25.50 years, SD = 0.5 years; 4 female) rated in individual sessions each piece for “activation” and “relaxation” on five-point Likert scales that ranged from “totally disagree” (1) to “totally agree” (5). The pieces were presented via a sequencing software (Cubase LE 7® by Steinberg). The students marked the time points at which they inhaled by using a separate track while the music was played. The results showed that the “Hungarian March” from “The Damnation of Faust” by Hector Berlioz received the highest “activating” ratings (M = 4.63, SD = 0.52). The average respiratory rate for this piece was 8.76 years; see Table 1 for further details). Participants with CLD suffered either from COPD (n = 8), asthma (n = 7), or another chronic lung disease which was similar in symptoms (e.g., chronic bronchitis; n = 2).

Participants Experiment 2

Seventeen participants with CLD (12 females) and 13 controls (9 females) without CLD participated in Experiment 2 (age: M = 68.13 years, SD = 8.49 years, range: 41-80 years; see Table 1 for further details). Participants with CLD suffered either from COPD (n = 8), asthma (n = 7), or another chronic lung disease which was similar in symptoms (e.g., chronic bronchitis; n = 2). For participants with CLD the total scores of the SGRQ ranged between 13 and 65 (M = 37.04, SD = 17.93).

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| Table 1. Means (and standard deviations) of the demographic and health variables for the participants of Experiments 1 and 2. |
|-----------------|-----------------|-----------------|
| Experiment 1    | M (SD)          | Experiment 2    | M (SD)          |
| Age             |                 |                 |
| CLD             | 68.79 (5.83)    | 68.24 (5.80)    |
| N-CLD           | 72.43 (7.76)    | 68.00 (11.37)   |
| Physical health |                 |                 |
| CLD             | 34.27 (9.66)    | 43.99 (7.33)    |
| N-CLD           | 50.26 (6.98)    | 44.97 (9.10)    |
| Mental health   |                 |                 |
| CLD             | 51.43 (9.85)    | 50.89 (9.92)    |
| N-CLD           | 51.58 (11.49)   | 49.86 (9.91)    |
| Disease-related health |        |                 |
| CLD             | 48.29 (15.42)   | 34.01 (18.97)   |
| N-CLD           | -               | -               |
breaths per minute. The “Adagio” from the “Clarinet Concerto in A-Major” (KV 622) by Wolfgang Amadeus Mozart was perceived as the most “relaxing” ($M = 4.5, SD = 0.54$) and was associated with an average respiratory rate of 5.99 breaths per minute. This piece of music was also chosen for relaxing music in a former study that addressed music-guided slow breathing for patients with hypertension (Modesti et al., 2010). Consequently, these two pieces were selected for the main experiment.

To assess the subjective responses to the music pieces, the participants rated emotional expression (“happy” and “sad”), the perceived level of arousal (“activating” and “calming”) and liking on 5-point Likert-type rating scales that ranged from “totally disagree” (1) to “totally agree” (5). Furthermore, the participants indicated their familiarity with the music pieces in terms of whether they had heard the specific piece before and if they remembered the title of the piece.

### Measurement Instruments

#### Questionnaires

A brief questionnaire was developed by the authors to collect the demographic variables, previous musical experiences, and medication. The items included, for example (German translation in brackets), “What is your marital status?” (Wie ist Ihr Familienstand?) and “What is your living situation?” (Wie ist Ihre Wohnsituation?). Additionally, the participants were asked about their musical experiences, that is, “Do you play an instrument, or have you ever played an instrument in the past?” (Spielten Sie ein Instrument oder haben Sie früher einmal ein Instrument gespielt?), and “Would you consider yourself interested in music?” (Würden Sie sich selbst als musikalisch interessiert einschätzen?). Finally, information regarding the existence of chronic illnesses and current medications was compiled.

Quality of life was assessed with the 12-Item Short-Form Health Survey (SF-12; German version by Morfeld et al., 2011) that consists of 12 self-rated items that represent two different scales: the physical component score and the mental component score. The scores for physical and mental health can range between 0 and 100, with higher scores indicating a better health status. The participants in the CLD group further completed the SGRQ, a questionnaire for disease severity. It has been shown that higher scores are related to a higher disease severity (Ståhl et al., 2005). The SGRQ includes three subscales, namely, symptoms, activity, and impact. The total score declares the entire influence of the lung disease on the health status. The scores range from 0 to 100 where 100 represents the worst possible health status, and 0 indicates the best possible health status (Jones & Forde, 2009).

The Positive and Negative Affect Schedule (PANAS, German version by Krohne et al., 1996) consists of 20 items that represent two scales, namely, positive (PA) and negative affect (NA). The participants were instructed to rate their current feelings on 5-point scales that range from 1 (= very slight or not at all) to 5 (= extremely). The total scores for each scale can range from 1 to 5, with higher scores indicating higher levels of affect.

### Physiological measures

We used a biofeedback device (NeXus-10 MKII® from Mind Media®) and its corresponding software Biotrace® to continuously measure the respiratory rate and SpO2-saturation. Additionally, we measured skin conductance, finger temperature, and heart rate. However, since these measures are not of particular interest for the aim of our study, we refrained from reporting these measures in the main manuscript and transferred them to the appendix (please see Supplemental Material).

The biofeedback device was placed on a table and the respective sensors were connected to the device by cable. The respiratory rate was assessed by using an elastic breathing belt, which was placed between the extension of the breastbone and the belly button. The sensor of the belt measured the extension of the abdomen during inhalation and exhalation and transferred it to an electrical signal. A pulse oximeter was clipped on the index finger of the dominant hand to measure oxygen saturation ($\text{SpO}_2$-saturation). The data were transferred to a computer through a Bluetooth connection. All signals were monitored during the sessions. The electrode cables of the NeXus-10 are active shielded, which ensures that artefacts as caused by movements of the cables as well as mains interference are reduced to a minimum. Furthermore, the NeXus-10 does not have any high or low pass filter that could cause significant phase shifts or filter overflows for frequencies up to half of the sampling frequency.

### Design and Procedure

The participants were tested in single sessions (60-90 min) at the Speech & Music Lab of the University of Oldenburg. First, the participants were seated comfortably in a chair at a desk facing one of the interior walls in a 4.60 m × 5.60 m room. Subsequently, the sociodemographic questionnaire was filled out, and the participants completed the first PANAS, which served as a baseline measurement. The finger sensors and elastic breathing belt were applied as described and following recommendations in the NeXus-10 MKII® system manual. The recordings of the physiological data were started approximately 5 min before the test procedure began to ensure that the participants adjusted well to the testing situation. Music was presented via speakers that were placed at approximately 1.15 m from the participants’ ears. At the beginning, the
participants had the opportunity to adjust the loudness levels for comfort upon listening to a preparatory piece of music. Participants were quasi-randomly allocated to Experiment 1 or Experiment 2 (participants with and without CLD were assigned approximate balanced on both experiments). In Experiment 1, participants were instructed to relax as much as possible and focus their attention on the music while listening to the two subsequent pieces of music (“Please try to relax yourself and listen to the music. Focus your attention to the sound of the music consistently.”), while in Experiment 2 they were instructed to breathe slowly with the music with a breathing cycle of 4–6 breath cycles/minute and a prolonged exhalation phase (“Please try to breathe with the music. Breathe about four to six times per minute. Pay attention on a preferably long exhalation-phase. Your exhalation should be approximately twice as long as your inhalation”). The instruction of Experiment 2 was adapted from yoga breathing techniques that already showed positive effects on breathing-related outcomes in CLD patients (Jayawardena et al., 2020).

Following these preparations, the experiment started with 5 min of silence, which served as a baseline for the physiological measures. Then, the first piece of music was presented. The order of the music pieces was quasi-randomized (balanced across participants). Because of the different length of the original music pieces, the relaxing music faded out at an appropriate passage so that both pieces had a length of approximately 5 min. A research assistant triggered the duration of the music sections manually. After the first piece of music, the participants completed the PANAS for the second time, which was presented orally by the research assistant. The participants were also asked about their subjective responses regarding the musical pieces. This oral form of data collection was chosen to reduce the participants’ bodily movements. When the 5-min silence was over, the second music piece started automatically. Again, the PANAS and subjective responses were prompted by the research assistant. At the end, the recordings were stopped, and the sensors were removed. Finally, the participants completed the SF-12 questionnaire and the SGRQ (please see Figure 1 for the graphical illustration of the timeline of the experiment).

Data Preparation and Analysis

The assessments from the questionnaires (SF-12, SGRQ, and PANAS) were conducted by following the instructions of the respective manuals. Before exporting the physiological data, we checked the data for artefacts. First, we detected artefacts manually and then used the automatic artefact rejection provided by the software Biotrace®. In the automatic artefact rejection, you can set one or two criteria for data rejection. Whenever a signal meets a criterion, this area is marked in the data and excluded in the analysis. Whenever an area is marked as an artefact, data of all channels at that certain time point will be marked as artefacts and excluded in the analysis.

We used this automatic tool to clean the data. The physiological data were exported with a rate of 32 samples per second and were stored as .txt files. To avoid the influence of orienting and fatiguing responses, the initial 60 s of recordings of the baseline measurement and the last 60 s of the baseline measurement were omitted. Likewise, only the 180-s intervals from the middle of the music pieces were considered for analysis. A python-based script was used to cut the time-sections and to calculate the means from the sections for each participant.

Due to incomplete data, three participants for the positive affect scale and one participant for the negative affect scale of the PANAS had to be excluded from further analysis in Experiment 1. In addition, one data set of electrodermal activity was not applicable for further analysis due to a malfunction of the sensor. In Experiment 2, one incomplete data set of positive affect, one incomplete data set of negative affect, and three measurements of electrodermal activity had to be excluded from further analysis.

Both experiments employed a quasi-randomized between-group design with repeated measures. The dependent variables were analyzed by a 3 × 2 analysis of variance (ANOVA) with condition (baseline/“relaxing” music/“activating” music) as a within-subject factor and group (CLD/N-CLD) as a between-subjects factor. As follow-up analyses, we performed dependent and independent samples t tests. The descriptive and inferential statistics were acquired by using the SPSS/IBM package 24.0. The significance level was set to p < .05 and corrected for multiple comparisons where appropriate. In this case, the p-values were set to .016 (p = .05/3 = .016).

Results

Experiment 1

Participants with and without CLD showed different scores in health related quality of life (measured by the SF-12) indicating that people with CLD showed lower levels of physical health-related quality of life, t(24) = −4.89, p < .001, d = 1.92. However, the mean values for mental
Table 2. Means (and standard deviations) of the psychological measures during baseline and music listening (Exp. 1).

|                | Baseline M (SD) | Activating music M (SD) | Relaxing music M (SD) |
|----------------|-----------------|------------------------|-----------------------|
| **PA**         |                 |                        |                       |
| CLD            | 3.20 (0.49)     | 3.18 (0.87)            | 2.86 (0.76)           |
| N-CLD          | 3.18 (0.72)     | 3.31 (0.85)            | 3.41 (0.57)           |
| Overall        | 3.19 (0.61)     | 3.24 (0.85)            | 3.14 (0.71)           |
| **NA**         |                 |                        |                       |
| CLD            | 1.19 (0.25)     | 1.16 (0.19)            | 1.10 (0.22)           |
| N-CLD          | 1.11 (0.14)     | 1.08 (0.11)            | 1.05 (0.09)           |
| Overall        | 1.15 (0.20)     | 1.12 (0.16)            | 1.07 (0.16)           |
| **"happy"**    |                 |                        |                       |
| CLD            | —               | 3.43 (1.28)            | 2.57 (1.02)           |
| N-CLD          | —               | 3.43 (1.09)            | 3.21 (0.97)           |
| Overall        | —               | 3.43 (1.17)            | 2.89 (1.03)           |
| **"sad"**      |                 |                        |                       |
| CLD            | —               | 1.29 (0.61)            | 2.86 (1.29)           |
| N-CLD          | —               | 1.14 (0.36)            | 1.79 (1.25)           |
| Overall        | —               | 1.21 (0.50)            | 2.32 (1.36)           |
| **"activating"** |              |                        |                       |
| CLD            | —               | 3.64 (1.22)            | 3.57 (1.28)           |
| N-CLD          | —               | 4.21 (1.12)            | 3.07 (1.07)           |
| Overall        | —               | 3.93 (1.18)            | 3.32 (1.19)           |
| **"calming"**  |                 |                        |                       |
| CLD            | —               | 1.86 (0.77)            | 4.29 (0.83)           |
| N-CLD          | —               | 2.50 (1.61)            | 4.50 (0.52)           |
| Overall        | —               | 2.18 (1.28)            | 4.39 (0.69)           |
| liking         |                 |                        |                       |
| CLD            | —               | 3.57 (0.76)            | 4.50 (0.65)           |
| N-CLD          | —               | 4.29 (0.83)            | 4.79 (0.43)           |
| Overall        | —               | 3.93 (0.86)            | 4.64 (0.56)           |

Note: PA = positive affect; NA = negative affect; “happy” = perceived happiness in the music; “sad” = perceived sadness in the music; “activating” = perceived level of activation in the music; “calming” = perceived level of calming in the music.

health did not differ significantly between the groups, \( t(24) = -0.36, p = .97, d = 0.1 \) (see Table 1, first column, for details).

Tables 2 and 3 summarizes the descriptive statistics for the psychological measures. The subjective evaluation of the emotional expression for the “activating” and “relaxing” music pieces revealed similar levels of ratings for happiness and arousal, \( t(20) > 1.25, p > .21, d > -0.37 \), whereas ratings for sadness were rated significantly higher for the “relaxing” music, \( t(20) = -4.36, p < .01, d = 1.22 \). The same piece was also perceived significantly more calming compared to the “activating” piece, \( t(20) = -9.22, p < .001, d = 2.54 \). Although the ratings for liking were significantly higher for the “relaxing” music compared to the “activating” music, \( t(20) = -4.00, p < .001, d = 1.06 \), the ratings for the “activating” music were still in a positive range.

When comparing the CLD and N-CLD participants, the CLD group rated the “relaxing” music significantly less happy, \( t(19) = -2.29, p < .05, d = 1.00 \), and more sad, \( t(19) = 4.50, p < .001, d = 1.97 \) than the N-CLD group. The “activating” piece was familiar to approximately half of the participants \( n = 10 \), whereas a majority had heard the “relaxing” piece of music before \( n = 17 \). There were no significant differences between groups in ratings for familiarity neither for the relaxing \( \chi^2(1) = 0.043, p = .835 \) nor for the activating piece of music, \( \chi^2(1) = 1.01, p = .314 \). Furthermore, there were no differences between groups in ratings for liking neither for the relaxing \( t(20) = -1.01, p = .1, d = 0.4 \) nor for the activating piece of music \( t(20) = -1.725, p = .325, d = 0.7 \).

Regarding positive and negative affect in response to the music, the repeated measures ANOVA for the positive affect scale did neither reveal a significant main effect for condition \( F(2, 46) = 0.47, p = .65, \eta_p^2 = 0.02 \) nor group \( F(1, 23) = 0.71, p = .41, \eta_p^2 = 0.03 \). However, the analyses showed a significant group \( \times \) condition interaction \( F(2, 46) = 3.51, p = .038, \eta_p^2 = 0.13 \). Successive 2 \( \times \) 2 ANOVAs indicated no significant main effects for condition, group or interaction comparing baseline and the activating.
music (all Fs < 0.5 and all ps > 0.05) or comparing the activating and the relaxing (all Fs < 2.8 and all ps > 0.05).

However, the analyses for baseline and the relaxing music showed a significant group × condition interaction, F(1, 23) = 7.82, p = 0.010, η² = 0.25. Descriptively considered, it seemed that participants from the CLD group had lower positive affect after listening to the relaxing piece of music compared to baseline. However, the dependent t test was not significant (t(11) = 2.20, p = 0.050, d = 0.48. Also, there were no significant differences in positive affect between conditions for the N-CLD group, t(12) = -1.71, p = 0.112. Moreover, the group comparison between the CLD group and the N-CLD group after listening to the relaxing piece of music indicated no significant difference, t(23) = -2.05, p = 0.052, d = 0.85. Regarding negative affect, our analyses revealed neither a main effect of condition and group nor a significant condition × group interaction (all Fs < 2.29, all ps > 0.05).

Repeated measures ANOVAs for physiological variables showed for the respiratory rate a significant main effect of condition, F(2, 50) = 5.98, p = 0.005, η² = 0.19, but no significant main effect of group, F(2, 50) = 0.12, p = 0.73, η² = 0.05, and no significant condition × group interaction, F(2, 50) = 0.31, p = 0.74, η² = 0.01. Paired t tests showed an overall higher respiratory rate during the activating music compared to baseline, t(26) = -3.23, p = 0.003, d = -0.50. There was no significant difference in comparison to the relaxing piece of music, t(26) = 2.38, p = 0.025, d = 0.34. Moreover, the analyses showed no significant difference between baseline and the relaxing piece of music, t(26) = -1.23, p = 0.23. Concerning SpO₂-saturation, the repeated measures ANOVA revealed neither a significant main effect of condition, F(2, 50) = 1.56, p = 0.22, η² = 0.06 or group, F(1, 25) = 3.27, p = 0.08, η² = 0.12 nor a significant condition × group interaction, F(2, 50) = 0.04, p = .96, η² = 0.00.

**Experiment 2.** Regarding health-related quality of life, there were no differences between the CLD and N-CLD groups for the two scales of the SF-12, all ts < -0.52, all ps > .60. Tables 4 and 5 summarize the descriptive statistics for the psychological measures during baseline and music listening. The subjective evaluation of the music pieces showed that the “activating” piece was perceived as more happy, t(22) = 2.11, p < 0.05, d = 0.64, and more activating, t(22) = 2.21, p < 0.05, d = 0.71, while the “relaxing” music was perceived as more sad, t(22) = 3.54, p < 0.05, d = 0.92, and more calming, t(22) = 5.03, p < 0.001, d = 1.69. The participants in the CLD and N-CLD groups rated the pieces similarly (all ts < -2.02, all ps > 0.05), which contrasts with Experiment 1. Finally, the listeners liked the “relaxing” piece significantly better than the “activating” music, t(22) = -2.24, p < 0.05, d = 0.72. Note that the ratings of liking were all in the positive range. Interestingly, most listeners were familiar with the “relaxing” music (n = 19), and only few (n = 10) were familiar with the “activating” music. Regarding the positive and negative affect, we found no effect of music listening on either of the scales, all Fs < 2.10, all ps > 0.10.

Regarding the respiratory rate, the analyses showed a significant main effect of condition, F(2, 56) = 5.50, p = 0.007, η² = 0.16. We did not observe a significant main effect of group, F(1, 28) = 3.10, p = 0.089, η² = 0.10 and there was no condition × group interaction, F(2, 56) = 0.59, p = 0.554, η² = 0.02. Successive analyses for the main effect of condition revealed a significant higher respiratory rate during the activating piece of music compared to the relaxing piece of music, t(29) = 3.39, p = 0.002, d = 0.44, but not compared to baseline, t(29) = -2.45, p = 0.021, d = -0.35. There was also no significant difference during listening to the relaxing piece of music compared to baseline, t(29) = 0.81, p = 0.426. For SpO₂-saturation, we found a significant main effect of condition, F(2, 56) = 4.48, p = 0.016, η² = 0.14. The main effect of group, F(1, 28) = 3.50, p = 0.072, η² = 0.11 and the condition × group interaction were both nonsignificant F(2, 56) = 0.22, p = 0.800, η² = 0.01. Successive analyses for the main effect of condition revealed no significant difference in SpO₂-saturation for the activating piece of music compared to baseline, t(29) = 2.14, p = 0.041, d = 0.29 and compared to the relaxing piece of music, t(29) = 2.14, p = 0.021, d = -0.30. We found no differences in SpO₂-saturation between baseline and the relaxing piece of music, t(29) = -0.20, p = 0.842.

**Table 3.** Means (and standard deviations) of breathing-related measures during baseline and music listening (Exp. 1).

|                | Baseline M (SD) | Activating music M (SD) | Relaxing music M (SD) |
|----------------|-----------------|-------------------------|-----------------------|
| RR CLD         | 16.53 (4.00)    | 18.66 (4.51)            | 17.02 (4.23)          |
| N-CLD          | 17.04 (4.14)    | 18.67 (2.51)            | 17.88 (2.90)          |
| Overall        | 16.79 (4.00)    | 18.66 (3.54)            | 17.46 (3.55)          |
| SpO₂ CLD       | 94.17 (2.37)    | 93.97 (2.17)            | 93.96 (2.40)          |
| N-CLD          | 95.48 (1.30)    | 95.30 (1.51)            | 95.22 (1.51)          |
| Overall        | 94.85 (1.97)    | 94.66 (1.94)            | 94.61 (2.05)          |

Note: RR = respiratory rate; SpO₂ = oxygen saturation.
We investigated the effects of listening to pre-selected “activating” and “relaxing” pieces of music in older adults with and without CLD. We hypothesized that music listening modulates the respiratory rate and oxygen saturation in participants with and without lung problems. However, our results suggest that the respiratory rate as well as the oxygen saturation of all individuals diagnosed with or without a lung condition were not affected by listening to relaxing music, irrespective of the music-oriented (Exp. 1) or breathing-oriented (Exp. 2) instructions. However, in both experiments we found that the respiratory rate increased in response to “activating” music, compared to baseline (Exp. 1) and compared to relaxing music (Exp. 2). Additionally, in Experiment 2, there was a trend for a decreasing oxygen saturation during listening to activating music. Therefore, our results suggest that listening to music once is not an appropriate strategy to improve breathing in people suffering from CLD and that activating music with a high tempo can even have negative effects. Moreover, regarding the emotional responses to the music stimuli, we found in Exp. 1 that participants affected by CLD perceived the relaxing music piece significantly sadder than healthy participants. This observation can be interpreted as a novel finding and suggests that music listening not only induces distinct patterns of psychological or physiological responses (e.g., Bernardi et al., 2009; Innes et al., 2016) but also, vice versa, that the physical health status of an individual may modulate the affective processing of music that has been selected for its relaxation potential. Additionally, in Exp. 1 participants suffering from CLD seemed to experience lower positive affect after the relaxing music. However, this finding failed to reach significance due to the correction of multiple testing. Nevertheless, these results might be some indication that people suffering from CLD show a different music perception than healthy people. Surprisingly, these findings were not confirmed in Exp. 2. However, unlike Exp 1, participants with and without CLD did not differ in health-related

Table 4. Means (and standard deviations) of the psychological measures during baseline and music listening (Exp. 2).

|               | Baseline M (SD) | Activating music M (SD) | Relaxing music M (SD) |
|---------------|-----------------|------------------------|-----------------------|
| **PA**        |                 |                        |                       |
| CLD           | 3.10 (0.54)     | 2.93 (0.75)            | 2.79 (0.79)           |
| N-CLD         | 3.32 (0.46)     | 3.17 (0.85)            | 2.99 (0.89)           |
| Overall       | 3.20 (0.51)     | 3.03 (0.79)            | 2.88 (0.83)           |
| **NA**        |                 |                        |                       |
| CLD           | 1.02 (0.04)     | 1.22 (0.44)            | 1.24 (0.34)           |
| N-CLD         | 1.08 (0.10)     | 1.08 (0.14)            | 1.08 (0.17)           |
| Overall       | 1.04 (0.08)     | 1.16 (0.35)            | 1.18 (0.29)           |
| **“happy”**   |                 |                        |                       |
| CLD           | —               | 3.47 (1.13)            | 2.41 (1.50)           |
| N-CLD         | —               | 3.54 (1.20)            | 3.08 (0.95)           |
| Overall       | —               | 3.50 (1.14)            | 2.70 (1.32)           |
| **“sad”**     |                 |                        |                       |
| CLD           | —               | 1.53 (1.07)            | 2.47 (1.18)           |
| N-CLD         | —               | 1.69 (1.03)            | 2.08 (0.86)           |
| Overall       | —               | 1.60 (1.04)            | 2.30 (1.06)           |
| **“activating”** |             |                        |                       |
| CLD           | —               | 3.71 (1.21)            | 3.18 (1.38)           |
| N-CLD         | —               | 4.15 (0.90)            | 3.15 (1.28)           |
| Overall       | —               | 3.90 (1.09)            | 3.17 (1.32)           |
| **“calming”** |                 |                        |                       |
| CLD           | —               | 2.18 (1.33)            | 3.94 (1.25)           |
| N-CLD         | —               | 2.31 (0.95)            | 4.54 (0.66)           |
| Overall       | —               | 2.23 (1.17)            | 4.20 (1.06)           |
| **liking**    |                 |                        |                       |
| CLD           | —               | 3.76 (1.03)            | 4.35 (1.40)           |
| N-CLD         | —               | 4.08 (0.86)            | 5.00 (0.00)           |
| Overall       | —               | 3.90 (0.96)            | 4.63 (1.03)           |

Note: PA = positive affect; NA = negative affect; “happy” = perceived happiness in the music; “sad” = perceived sadness in the music; “activating” = perceived level of activation in the music; “calming” = perceived level of calming in the music.

Discussion
We investigated the effects of listening to pre-selected “activating” and “relaxing” pieces of music in older adults with and without CLD. We hypothesized that music listening modulates the respiratory rate and oxygen saturation in participants with and without lung problems. However, our results suggest that the respiratory rate as well as the oxygen saturation of all individuals diagnosed with or without a lung condition were not affected by listening to relaxing music, irrespective of the music-oriented (Exp. 1) or breathing-oriented (Exp. 2) instructions. However, in both experiments we found that the respiratory rate increased in response to “activating” music, compared to baseline (Exp. 1) and compared to relaxing music (Exp. 2). Additionally, in Experiment 2, there was a trend for a decreasing oxygen saturation during listening to activating music. Therefore, our results suggest that listening to music once is not an appropriate strategy to improve breathing in people suffering from CLD and that activating music with a high tempo can even have negative effects. Moreover, regarding the emotional responses to the music stimuli, we found in Exp. 1 that participants affected by CLD perceived the relaxing music piece significantly sadder than healthy participants. This observation can be interpreted as a novel finding and suggests that music listening not only induces distinct patterns of psychological or physiological responses (e.g., Bernardi et al., 2009; Innes et al., 2016) but also, vice versa, that the physical health status of an individual may modulate the affective processing of music that has been selected for its relaxation potential. Additionally, in Exp. 1 participants suffering from CLD seemed to experience lower positive affect after the relaxing music. However, this finding failed to reach significance due to the correction of multiple testing. Nevertheless, these results might be some indication that people suffering from CLD show a different music perception than healthy people. Surprisingly, these findings were not confirmed in Exp. 2. However, unlike Exp 1, participants with and without CLD did not differ in health-related
quality of life. Rather, both healthy participants and those with CLD showed similar health-related quality of life. As reflected in the scores of the SF-12 and the SGRQ in Exp 1 participants with CLD show lower health and disease-related quality of life than participants with CLD from Exp 2, suggesting that participants from Exp 1 were more severely affected by CLD. However, it is also possible that the instruction in Experiment 2, which focused on breathing and not on music listening, influenced the perception of music. In sum, more research is needed to investigate the influences of differences in instructions and sample characteristics (health status) on emotional music processing.

To our knowledge, this is the first study that has addressed the immediate effects of listening to “relaxing” music on breathing-related outcomes as well as mood in people suffering from CLD. Our results suggest that there is no immediate benefit from listening to “relaxing” music irrespective of a “music oriented” (Exp. 1) or a “breathing oriented” (Exp. 2) instruction of participants. However, the lack of short-term effects does not preclude the possibility in longer-term adaptation of breathing patterns to music interventions, as previous work has shown (Jayawardena et al., 2020; Lee et al., 2015; Lord et al., 2010). Moreover, people affected by a chronic lung disease need regular exercise to improve their breathing (van Gestel, Steier, & Teschler, 2010; Panigrahi et al., 2014). Therefore, it might be more beneficial to use patient selected music than experimenter selected music to enhance affect (Groarke & Hogan, 2019). At this point, however, it should also be mentioned that the participants of our studies particularly liked the relaxing piece of music and that most participants were familiar with the relaxing piece of music. Therefore, the indication of worse positive affect after listening to the relaxing piece of music is rather surprising, since previous studies revealed that liking and familiarity are associated with positive affect in response to music listening (Tan et al., 2012). Moreover, this finding was not confirmed in Experiment 2. As already mentioned, this may be due to the difference in disease severity between the samples of the two experiments. In addition, it is also possible that a music-centered instruction influences affect more, whereas a breathing-centered instruction combined with music might influence breathing more. Nevertheless, since we did not find an effect of any instruction and since we conducted the two studies with different samples, we cannot make a statement on this point. That would be a matter for future studies to examine. In this context, it should also be noted again that longer interventions may be more likely to have an influence, as people with lung disease need to practice regulating their breathing.

**Limitations**

This study was designed to investigate the immediate effects of music listening on breathing regulation and emotional affect participants suffering from CLD and healthy participants. Although significant psychophysiological responses to music listening can occur in short time windows (e.g., Grewe et al., 2007), it is unclear whether such changes can be expected in older adults, who participated in the current study. Another limitation is that the music selections do not allow for generalizing the interpretations of their “relaxing” or “activating” impact or affective quality. Our music selection is based on the pretest as well as on the experience from a previous study (Modesti et al., 2010). For a better music selection, it would be advisable to review a broader selection of literature from health and wellbeing studies dealing with music listening. In this context, it would also be worth examining to what extent strongly pulsed music might be particularly suitable for regulating breathing in lung patients. Moreover, recruiting

### Table 5. Means (and standard deviations) of breathing-related measures during baseline and music listening (Exp. 2).

|        | Baseline  | Activating music | Relaxing music |
|--------|-----------|------------------|---------------|
|        | $M$ (SD)  | $M$ (SD)         | $M$ (SD)      |
| **RR** |           |                  |               |
| CLD    | 15.16 (4.24) | 16.35 (5.35)    | 13.93 (5.75)  |
| N-CLD  | 11.64 (3.55) | 13.83 (4.10)    | 11.89 (4.24)  |
| Overall| 13.63 (4.28) | 15.26 (4.93)    | 13.05 (5.17)  |
| **SpO₂** |          |                  |               |
| CLD    | 94.69 (2.30) | 93.97 (2.41)    | 94.62 (1.93)  |
| N-CLD  | 96.09 (1.74) | 95.21 (3.51)    | 96.28 (1.52)  |
| Overall| 95.30 (2.16) | 94.51 (2.95)    | 95.34 (1.93)  |

*Note: RR = respiratory rate; SpO₂ = oxygen saturation.*
participants from a recreational singing choir might increase the risk of a selection bias. It is possible that participants with less music experience show different responses. Finally, it should be mentioned that the procedure in which the questionnaire of the PANAS was asked orally might have affected the participants’ responses.

**Conclusion**

Taken together, the two experiments show that there is no short-term benefit in listening to “relaxing” music for people with chronic lung problems and that the affective processing of music in physically vulnerable older adults is not found to be unequivocally positive. Longitudinal intervention studies with prolonged training periods may be required to ascertain the usefulness of music listening in managing respiratory problems in older adults. The question of whether music listening can be used to better control breathing rate in people affected by CLD needs further investigation.

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**Supplemental material**

Supplemental material for this article is available online.

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