Attentional distraction reduces the affective but not the sensory dimension of perceived dyspnea

Andreas von Leupoldt*, Nadine Seemann, Tatiana Gugleva, Bernhard Dahme

Psychological Institute III, University of Hamburg, Von-Melle-Park 5, 20146 Hamburg, Germany

Received 26 March 2006; accepted 26 June 2006

Summary
The perception of dyspnea shows many similarities to the perception of pain. Both are multidimensional processes, which are not only influenced by sensory input but also by nonsensory factors like attention. Recent research has suggested that attentional distraction might reduce the perception of dyspnea but results are conflicting. Furthermore, the specific impact of attentional distraction on the distinct dimensions of perceived dyspnea has not been studied yet. Therefore, the present study examined the specific impact of changes in the attentional focus on the sensory and affective dimension of perceived dyspnea.

Dyspnea was induced in forty-four healthy volunteers (mean age: 27.7 years, range: 18–47 years) by breathing through an inspiratory resistive load (3.57 kPa/L/s), while attention was directed either to breathing or distracted by reading texts. Inspiratory time (T_i) and breathing frequency (f) were measured continuously. After each condition the experienced intensity (i.e., sensory dimension) and unpleasantness (i.e., affective dimension) of dyspnea were rated on separate visual analog scales (VAS), presented in randomized order. ANOVAs showed that attentional distraction during loaded breathing reduced the perceived unpleasantness of dyspnea (P<0.05), while the perceived intensity of dyspnea as well as T_i and f remained unchanged.

The results show that attentional distraction reduces the affective, but not the sensory dimension of induced dyspnea in healthy volunteers. Future studies are needed to clarify whether attentional distraction can effectively be used as intervention technique for reducing the unpleasant aspects of dyspnea in different patients groups.

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Introduction
Dyspnea or breathlessness is the subjective experience of uncomfortable breathing comprising of distinct sensations, which can vary in their quality and intensity. 1 It is an
impairing symptom in asthma, COPD and other cardiovascular or neuromuscular diseases and associated with severe disability and significant reductions in quality of life. On the other hand, bluntened perception of dyspnea might lead to delayed treatment and has been reported to be associated with (near) fatal asthma attacks. Breathlessness results from various interactions between multiple physiological, psychological, social and environmental factors. The perception of dyspnea is therefore a complex individual interpretation process of sensory input that is highly influenced by many nonsensory factors such as attention, emotions, motivation, memory, personality, expectation or prior experience. However, there is little precise information on modulation of dyspnea by these factors.

Previous work explicated that dyspnea and pain have various similarities. For example, Banzett and Moosavi illustrated that both are subjectively perceived physiological sensations and both are of an unpleasant nature. The perception of pain and dyspnea warns the conscious brain of a disturbed physiological state, which motivates adaptive behavior to modify the aversive situation. Behavioral plans and motor actions can be initiated following the perceptual process. A direct experimental comparison of dyspnea and pain demonstrated previously that the unpleasant character of both sensations is perceived and expressed in a similar fashion. Killian et al. showed that some patients with asthma experience their dyspneic sensations as 'chest pain'; results that demonstrate similarities on the level of symptom labeling. Moreover, recent studies have suggested that dyspnea and pain might be mediated by a common cortical network including the anterior cingulate cortex, anterior insula, thalamus, cerebellum and sensory areas. Therefore, it has been suggested to adopt successful methods and strategies from pain research, which is by far more advanced, for investigations into dyspnea.

An important finding in pain research was the realization that attentional distraction can reduce the level of perceived pain. A further cornerstone in pain research was the realization of the difference between sensory and affective aspects of pain, which led to the development of highly useful pain measurement instruments and intervention techniques. Various studies have revealed that these sensory and affective aspects of pain are differentially influenced by attentional distraction. which can be used in cognitive interventions to reduce the perception of pain. Neuroimaging studies have underlined that this different impact has also a cortical basis, i.e., distinct components of the central nervous system process these different dimensions of perceived pain.

In analogy to pain studies, research on the field of dyspnea has demonstrated that the perception of breathlessness also consists of at least two distinct dimensions: a sensory (i.e., intensity) and an affective (i.e., unpleasantness) one. These dimensions can be differentiated during resistive load breathing, physical exercise tests or in real-life settings by healthy volunteers and by patients with asthma or COPD. However, the influence of attention and attentional distraction, respectively, on the distinct dimensions of perceived dyspnea is unknown. Moreover, the influence of distraction on a global measure of the perception of breathlessness (i.e., without differentiating between the sensory and affective dimension) is still uncertain, because only few respective studies have been performed with some showing clear methodological shortcomings. While some of these studies suggest that distraction might be associated with decreases in perceived dyspnea, others found no such effect. Since, there is often no treatment available providing adequate relieve from dyspnea, it is of utmost interest to examine whether a cognitive intervention like attentional distraction can reduce the perception of this impairing symptom and which dimension of perceived dyspnea is most affected by this intervention.

Therefore, the present study examined the specific impact of attentional distraction on the sensory and affective dimension of dyspnea during resistive load breathing in healthy volunteers.

Methods and materials

Participants

Forty-four healthy Caucasian participants were studied. Their mean baseline characteristics are summarized in Table 1. Acute complaints of the respiratory tract, pregnancy or any chronic medical conditions, such as asthma or chronic pain were exclusion criteria. After providing informed consent volunteers underwent a screening spirometry. Participants were free to withdraw at any time during the tests. The study protocol was approved by the local ethics committee and was in accordance with the recommendations of the Helsinki Declaration.

Measurement of baseline lung function

Spirometry was performed before the tests using a Spiroset 3000 (Hörmann Medizintechnik GmbH, Germany) according to the guidelines published by the European Respiratory Society with participants standing and wearing a nose clip.

Inspiratory resistive loads

Inspiratory resistive loads increase inspiratory time and decrease breathing frequency and are commonly used for the induction of dyspnea by increasing the work and effort of breathing. Participants breathed via a mouthpiece through a breathing circuit consisting of a two-way valve.
Attentional distraction reduces the affective but not the sensory dimension of perceived dyspnea

At the beginning of the experiment, all biosignals were stored on the notebook (Apple, Cupertino, CA). All biosignals were stored on the notebook (Apple, Cupertino, CA), run on a notebook (Apple, Cupertino, CA), which was connected with the conveying of biosignals to a MP30 biosignal recording unit (Biopac Systems Inc., Santa Barbara, CA), run on a notebook (Apple, Cupertino, CA). All biosignals were stored on the notebook and analyzed offline.

Attentional distraction

In the distraction condition participants read pre-tested texts about several topics, which were not related to the experimental situation (e.g., dreaming, discoveries, linguistics). These were presented on a monitor and were individually paged down by participants pressing a mouse button.

Measurement of ventilation

Inspiratory time ($T_i$) and breathing frequency ($f$) were measured continuously at the mouthpiece using a ZAN fast response transducer (Korn Medizintechnik, Germany) to control effects of dyspnea induction. Output signals were conveyed to a MP30 biosignal recording unit (Biopac Systems Inc., Santa Barbara, CA), which was connected with the biosignal software package Biopac student lab pro (Biopac Systems Inc., Santa Barbara, CA), run on a notebook (Apple, Cupertino, CA). All biosignals were stored on the notebook and analyzed offline.

Measurement of perceived dyspnea

Dyspnea was defined as the sensation of uncomfortable restricted breathing with the connotation that all other sensations (e.g., uncomfortable nose clip or seat) are not to be rated. After each experimental condition the experienced degree of intensity (affective) was rated on separate visual analog scales (VAS), ranging from 0 to 10 cm ($0 = \text{not noticeable/unpleasant}$ and $10 = \text{maximally imaginable intensity/unpleasant}$). VAS for intensity and unpleasantness were presented in random order. The distinct dimensions of perceived dyspnea were explained in detail with standardized examples and the experimenter made sure that the phrases were adequately understood.

Experimental protocol

Before the test participants were familiarized with all instruments and the measurement procedure. After standardized instructions, volunteers were seated in a recliner and the light was dimmed. Participants breathed through the breathing circuit during a 2 min baseline condition without the resistive load being introduced. After a 5 min resting interval two experimental loaded breathing conditions of 5 min each followed, separated by a 5 min resting interval. During the ‘attend condition’ participants were instructed to focus their attention on their breathing. In the ‘distraction condition’ participants were reading the distractive texts on a monitor standing in front of them. After each condition the perceived degree of intensity and unpleasantness of dyspnea was rated on separate VAS presented in permuted order. Following the ‘distraction condition’ volunteers were required to report back on what they read to make sure that the texts were read and distraction was achieved. The order of the two experimental conditions was counterbalanced across participants.

Statistical analysis

Results are reported as means ± standard deviations of the mean (SD). $T_i$, $f$ and ratings for intensity and unpleasantness for each of the three conditions were analyzed as dependent variables in repeated measures analyses of variance (ANOVA) with a Greenhouse–Geisser correction of degrees of freedom being applied. Bonferroni-corrected, univariate, pairwise comparisons were calculated for further exploration of the main effects. All analyses were calculated with SPSS 13.0 software (SPSS Inc., Chicago, IL) using a 0.5 significance level.

Results

Ventilation

As expected, breathing through inspiratory resistive loads induced a significant increase in $T_i$ during the ‘attend-condition’ ($2.51 ± 1.23$ s) and the ‘distraction-condition’ ($2.38 ± 1.13$ s) when compared to the baseline condition ($1.91 ± 0.84$ s), $P < 0.001$. This was paralleled by significant decreases in $f$ during loaded breathing in the ‘attend condition’ ($11.87 ± 4.94$ breaths/min) and the ‘distraction condition’ ($12.52 ± 4.26$ breaths/min) compared to baseline ($15.20 ± 6.00$ breaths/min), $P < 0.001$. Differences between the ‘attend-condition’ and the ‘distraction-condition’ were found neither for $T_i$ nor for $f$.

Perceived dyspnea

VAS-ratings for experienced intensity and unpleasantness of dyspnea showed significant increases for both the ‘attend-condition’ ($4.65 ± 2.27$ and $4.47 ± 2.58$ cm) and the ‘distraction-condition’ ($4.50 ± 2.20$ and $3.68 ± 2.35$ cm) when compared to the baseline condition ($1.92 ± 2.13$ and $2.28 ± 1.86$ cm), $P < 0.01$. Post-hoc tests revealed that only the perceived unpleasantness of dyspnea was significantly reduced during the ‘distraction-condition’ when compared to the ‘attend-condition’, $P < 0.05$. As illustrated in Fig. 1, no such difference was found for the experienced intensity of dyspnea.

Discussion

Besides various physiological mechanisms psychological factors such as attention are increasingly recognized has having an important influence on the perception of dyspnea, but little is known on how dyspnea is specifically modulated by these factors. Findings from research on the perception of pain, which has many similarities with the perception of dyspnea, have shown that focusing the attention away from painful sensations can decrease the level of perceived pain. Further results have revealed that sensory and affective aspects of pain are differentially influenced by attentional...
decreases in pain affect than in pain intensity during heat differently influenced by attentional distraction.27 Various pain perception studies demonstrating that the sensation.

affective dimension but not the sensory dimension of this attentional distraction reduces the subjectively perceived conclusion that during similar sensory levels of dyspnea changes of dyspnea was not influenced by attentional distraction and attention was focused on breathing. The perceived intensity significantly decreased compared to a condition, where the distraction the perceived unpleasantness of dyspnea sign-

ificantly decreased compared to a condition, where the attention was focused on breathing. The perceived intensity of dyspnea was not influenced by attentional distraction and showed no differences between the two conditions. Changes in ventilation did not contribute to these results, as inspiratory time and breathing frequency were comparable between these experimental conditions. Therefore, we conclude that during similar sensory levels of dyspnea attentional distraction reduces the subjectively perceived affective dimension but not the sensory dimension of this sensation.

These observations are converging with results from various pain perception studies demonstrating that the sensory and affective dimension of perceived pain are differentially influenced by attentional distraction.37-31 Thus, our results add further incidence to the suggested similarities in the perception of dyspnea and pain. Mitchell and colleagues29 showed that listening to music successfully reduced the affective dimension of perceived cold-pressure pain while the intensity dimension was not affected. In a study using fMRI, Valet et al.31 demonstrated stronger decreases in pain affect than in pain intensity during heat pain stimulation when participants where distracted by a Stroop-task. Moreover, the authors observed decreases in the underlying brain activity in cortical areas related to affective processing (e.g., medial thalamic nuclei, anterior cingulate cortex, anterior insula) compared to sensory areas (e.g., somatosensory cortex II). Similar decreases in brain activity during vibratory distraction from noxious heat pain were reported by Longe et al.53 for areas associated with affective processing (e.g., anterior cingu-

late cortex, anterior insula). Although recent imaging studies suggested an involvement of similar areas in the cortical processing of dyspnea,15 it remains speculative whether reduced activity in these areas was also underlying the decreases in perceived unpleasantness of dyspnea obtained in the present study after attentional distraction.

However, first evidence for reduced brain activity during distraction from short dyspneic stimulation was demonstrated by Harver and colleagues.54 They obtained increased latencies and reduced amplitudes of respiratory-related evoked potentials (RREP), which were recorded after short inspiratory occlusions using electroencephalography (EEG). A possible explanation for the reported decreases in perceived dyspnea and pain due to distraction, which is furthermore converging with the obtained reductions in associated brain activity, is Pennebaker's prominent theory of competition of cues.55 It assumes that internal and external stimuli compete for the limited attentional resources in an individual. If attention is focused on external stimuli, less capacity is available for the processing of internal stimuli such as dyspnea and pain. Future imaging studies, however, are clearly required to provide more detailed insights into the specific cortical areas and processes modulating the effects of attention on the perception of dyspnea.

Our findings are furthermore in line with some of the few previous studies, which examined the influence of distraction on the perception of dyspnea with rather global measures of breathlessness, but without differentiating between sensory and affective aspects. Bartlett39 demonstrated that squeezing a rubber bulb could prolong the breath-hold time of volunteers. Similar prolongations of breath-hold times were obtained by Alpher et al.40 during distraction by squeezing a rubber bulb as well as by mental arithmetic. However, both studies were not formally assessing breathlessness with respective scales and are furthermore limited by small sample sizes. In a study by Meek43 the attentional focus during magnitude estimation of resistive load breathing was directed either to typical breathing patterns or to clearest memory of breathlessness. During the former condition patients with COPD showed decreased perception of dyspnea, while the latter condition led to increased ratings of dyspnea. Thornby et al.41 demonstrated in patients with COPD that distraction with music during several physical exercise tests decreased the associated levels of dyspnea. Similarly, Bauldoff and colleagues42 reported reduced dyspnea ratings in patients with COPD being distracted by music during treadmill exercise in their home environment when compared to patients who were not distracted during exercise. Most important from a practical perspective is the finding that in both latter studies reductions of dyspnea were paralleled by significant increases in the training intensity during auditory

Figure 1 Mean VAS ratings (±SD) for intensity (□) and unpleasantness (■) of dyspnea during baseline, during attention focused on breathing and during attentional distraction by reading texts. During both the attend and distraction condition dyspnea was induced by resistive load breathing, which increased the intensity and unpleasantness of perceived dyspnea when compared to the unloaded baseline (P<0.01). During attentional distraction only the unpleasantness dimension showed a significant decrease when compared to the attend condition (P<0.05).
Attentional distraction reduces the affective but not the sensory dimension of perceived dyspnea

distraction. This suggests a possible value of distraction as an intervention technique for both the reduction of dyspnea and the enhancement of the intensity of exercise trainings, which are a key component of pulmonary rehabilitation for some dyspneic patient groups (e.g., in COPD). Since deconditioned patients often experience aversive dyspnea at the beginning of exercise trainings attentional distraction might lead to increased adherence to these trainings by reducing the perceived level of dyspnea. With regard to the findings of the present study these beneficial effects of distraction might be caused by the specific reduction of perceived unpleasantness of dyspnea. This converges with previous remarks of Banzett and colleagues emphasizing the particular importance of the affective dimension of dyspnea in motivating patients to initiate adequate health care behavior (i.e., physician visits, medical treatment, exercise training). However, since the present study examined healthy volunteers the generalizability of our findings to patients with asthma or COPD is somewhat limited. Although there is little reason to assume general differences in the pathways mediating the effects of distraction on the perception of physiologic sensations between healthy and dyspneic volunteers, future investigations are clearly required to confirm the present results in dyspneic patient groups.

However, the optimistic results of the studies discussed above are limited by other findings. Alpher and Blanton were distracting patients with COPD from a 10- and 6-min walking test, respectively, by listening to music. Both studies found no beneficial effect between conditions with and without musical distraction, i.e., neither reductions in dyspnea or increases in distances walked were obtained. This underlines the need for future studies in different patient groups to examine whether attentional distraction has the potential for being employed as effective intervention technique.

Conclusion

In summary, our findings demonstrate that attentional distraction reduces the affective, but not the sensory dimension in the perception of experimentally induced dyspnea in healthy volunteers. These results add further incidence to the similarities in the perception of dyspnea and pain. Future studies are required to clarify whether attentional distraction might serve as an intervention technique for reducing the impairing symptom of dyspnea in different patients groups.

References