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Emotional reactivity of the airways in asthma: Consistency across emotion-induction techniques and emotional qualities

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ABSTRACT

Considerable individual differences exist in asthma patients' airway responses to emotional stimuli, but little is known about the generalization of such responses across situations or states of airways constriction. Fifty-four asthma patients and 25 healthy controls viewed in two separate sessions, films and blocks of pictures from each of three emotional qualities, pleasant, unpleasant, and neutral. At the beginning of each session, patients received a placebo or anti-cholinergic bronchodilator (ipratropium bromide), respectively, in a randomized double-blind design. Respiratory resistance, reactance and impedance were recorded throughout stimulus presentations with impulse oscillometry. Resistance increases showed a moderate degree of generalization across unpleasant films and pictures, unpleasant and pleasant pictures, as well as cholinergic blockade and placebo. Thus, the intensity of airway responses to unpleasant emotional stimuli is a moderately stable characteristic of asthma patients. In addition to the central airway, peripheral and extrathoracic airways may also contribute the consistency of such responses.

Asthmatic airway constriction in response to emotional stimuli has been well-documented by prior research. Most studies suggest significant responding to unpleasant stimuli, but some also to pleasant or exciting stimuli (for reviews see, Isenberg et al., 1992; Ritz, 2004; Ritz and Kullowatz, 2005). Studies also suggest considerable differences between asthmatic individuals in the intensity of airway responses to emotional stimuli. Typically, 20–40% of patients show airway responses that would be viewed as clinically significant by one or the other criterion (Isenberg et al., 1992; Ritz and Steptoe, 2000; Ritz et al., 2010). Other psychological paradigms such as bronchoconstrictive suggestion have demonstrated similar percentages of responders although its relationship to emotion is not well studied (Isenberg et al., 1992; Butler and Steptoe, 1986). In addition, patients' reports of major triggers of their asthma attacks have suggested a susceptibility of 15–25% of patients to emotions and stress and in one study these reports were found to be positively associated with respiratory resistance increases during negative and positive emotional films (Ritz et al., 2006, 2008). Laboratory airway responses to emotion have also been found to be positively associated to the extent of lung function decline in daily life during states of strong negative mood (Ritz and Steptoe, 2000), although not always significant (von Leupoldt et al., 2006).

Thus, a number of lines of inquiry suggest that asthma patients can be distinguished in the extent to which their airways respond to emotional stimuli. Given the association of these stimuli with decrements in airway function it would be useful to identify those patients whose airways are most susceptible to emotional triggers and provide them with individualized advice on how to cope with such triggers or avoid them. However, to date little is known about the consistency of emotion-induces airway responses across classes of emotional stimuli. We thus sought to study the consistency of between-individual differences in airway responses across emotion-induction techniques and across qualities of emotion. For that we used data from a recent study that had explored the role of cholinergic mechanisms of emotion-induced airway constriction (Ritz et al., 2010). Because vagal excitation is a strong determinant of airway smooth muscle tone (Barnes, 1986) and prior systemic blockade studies had demonstrated the importance of this pathway in bronchoconstrictive suggestion (McFadden et al., 1969; Neild and Cameron, 1986), we had hypothesized that this pathway would also determine emotion-induced airway constriction. Indeed, a double-blind study of our group (Ritz et al., 2010) demonstrated that inhalation of an anti-cholinergic bronchodilator (ipratropium bromide that blocks postganglionic muscarinic

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receptors), substantially attenuated the emotion-induced airway response, which was measured by changes in respiratory resistance (R_{rs}) at various frequencies using impulse oscillometry (IOS; Smith et al., 2005; Goldman, 2001; Hellinckx et al., 2001). In the present report we used data from this study to explore the consistency of individual differences in airway responses to emotional stimuli. Because the study included the cholinergic blockade condition, we were also able to study consistency with respect to the specific cholinergic component of airway responding. If airway responses were completely due to cholinergic mechanisms, individual differences in responding would be more consistently demonstrated with unblocked than with blocked muscarinic transmission at the airway smooth muscle across emotion-induction techniques and emotional qualities.

Furthermore, we were also able to address questions regarding the consistency of resistance changes linked to different locations within the airways. It has been suggested that effects of emotion on the airways would be manifested predominantly in the central airways (Lehrer et al., 1993). This is compatible with evidence that cholinergic innervation is not found in the peripheral airways of humans (Barnes, 2006). It has been proposed that the IOS measurement technique for R_{rs}, which we employed in this study, can be useful in distinguishing between contributions of locations to overall airway responding (Smith et al., 2005). A contribution of the central airways exclusively would be reflected in equally strong responses in resistance across the range of oscillation frequencies. Significant responding across all frequencies with stronger increases at lower frequencies would indicate responsiveness of both large and small airways. The latter was indeed confirmed in our recent study (Ritz et al., 2010). Thus, we attempted to explore the consistency of individual differences in airway responses when measured across both central and peripheral airways (interpreting resistance changes at low frequencies as consistent with peripheral airways) or when measured more selectively for the central airways (resistance changes at higher frequencies). Furthermore, the IOS technique was also able to separate respiratory resistance (R_{rs}) from reactance (X_{rs}) of the airways, which are combined in respiratory impedance (Z_{rs}) measures that are obtained with single-frequency forced oscillation techniques. Z_{rs} has been used in a number of prior psychophysiological studies (e.g. Levenson, 1979; Mass et al., 1993; McQuaid et al., 2000; Ritz, 2004; Butler and Steptoe, 1986). R_{rs} reflects more purely frictional properties of the respiratory system (resistance to airflow). X_{rs} reflects compliance of the respiratory system thought to be composed of contributions of the peripheral airways (at low oscillation frequencies) and inertial forces in the central airways (at high oscillation frequencies). Thus, we attempted to study the extent to which consistency in airway responses is dependent on different components. Finally, by comparing consistency of airway responses between asthma patients and healthy controls we sought to examine the extent to which consistent individual differences in airway responding to emotion are a general or asthma-specific characteristic of the airways.

1. Method

1.1. Participants

Fifty-four asthma patients (35 women; mean age = 27.5, *SD* = 6.8) and 25 healthy controls (16 women; mean age = 28.0, *SD* = 6.2) participated in two laboratory assessments. Participants were recruited by advertisements at university departments and hospitals. Additional patients were recruited from a specialty research facility (Pulmonary Research Institute Hospital Grosshansdorf, Germany). Inclusion criteria were a physician's diagnosis of asthma, which took into account findings from a physical examination, asthma and allergy history, reported asthma symptoms, spirometric lung function, skin prick testing, exhaled nitric oxide, and nonspecific hyperreactivity by methacholine provocation. Additional inclusion criteria were non-smoking status for at least 6 months (<10 life-time pack-years) and current stable physical and mental health (the latter explored by the Structured Clinical Interview for DSM-IV-TR (SCID-I), Wittchen et al., 1997). Exclusion criteria were episodes of major depression, suicide risk, schizophrenia, or substance abuse. Patients were instructed to remain on a stable anti-asthmatic medication regimen between laboratory assessments. Prior to both assessments, short-acting bronchodilators were to be discontinued for 6 h, long-acting beta-agonists for 12 h, and leukotriene inhibitors for 3 days. Patients who had taken oral corticosteroids in the previous 3 months were excluded. Each laboratory appointment was reimbursed with €45. Approval of the study was obtained from local ethics committees and participants signed informed consent before entering the study.

1.2. Instruments

1.2.1. Pulmonary function measurements

Z_{rs}, R_{rs} and X_{rs} of the total respiratory tract were measured continuously with IOS (Masterscreen, CareFusion Jaeger/Toennies, Germany), a variant of the forced oscillation technique (Smith et al., 2005; Ritz et al., 2002a, 2002b). The device superimposes brief, 45-ms air pulses 5 times/s onto the participants' breathing. The pulses can be decomposed into frequencies between 5 and 35 Hz. Pressure and flow changes of the impulse signal are measured at the mouth and used in the calculation of resistance. Upper airway shunt was reduced by elastic chin straps with extra padding to stabilize the cheek region. For this report we extracted Z_{rs10} for comparison with prior research in which we had used a 10 Hz single-frequency technique that provides a measure of Z_{rs10} (R_{os}, see Ritz, 2004, for review). We also analyzed R_{rs} at 5, 10, and 20, as well as X_{rs} at 5, 10 and 20 Hz. At low frequencies, R_{rs} is believed to be sensitive to both the peripheral and central airways, while at higher frequencies, resistance of the central airways more exclusively. X_{rs5} usually has a negative value that becomes less negative (has a smaller magnitude) in airways with more compliance, whereas X_{rs20} has a positive value that increases with greater opening of the central airways. In Z_{rs10}, effects on both R_{rs10} and X_{rs10} are combined, but because it is close to resonance frequency in health and well-controlled asthma, X_{rs} can be expected to contribute only to a small extent to Z_{rs} at this frequency. The IOS pneumotachograph was calibrated daily with a 3-l syringe, after which measurements were taken with a standard reference impedance.

1.2.2. Self-report of emotion

Ratings of valence and arousal were obtained with the Self-Assessment Manikin (Hodes et al., 1985). For scoring these scales, 1 was assigned to their 'low valence' and 'calm' poles and 9 to their 'high valence' and 'aroused' poles.

1.3. Emotion-induction material

Two parallel blocks of affective pictures (nine pictures per block, each 20 s) from the International Affective Picture System (Center for the Study of Emotion and Attention, 1999) and emotion-evoking film sequences of a pleasant, neutral, and unpleasant emotional quality (3–5 min each) were presented. Pictures were presented in blocks of homogeneous valence. Individual pictures portrayed laughing couples, babies, adventure sports, etc. for pleasantness, blood, mutilation and dead bodies for unpleasantness, and house-