Katholieke Universiteit Leuven

Faculteit Psychologie en
Pedagogische Wetenschappen

Departement Psychologie



Doctoraatsprojecten

Context-dependent perception for asthma symptoms and its importance for asthma treatment

Janssens, Thomas — 30 juni 2009

Promotor: Prof. Dr. O. Van den Bergh

Begeleidingscommissie 30 juni 2009 - Psychologie

Context-dependent perception of asthma symptoms and its importance for asthma treatment

Doctoral project of Thomas Janssens

Research Group on Health Psychology
Department of Psychology
K.U.Leuven

Promotors:
Prof. Dr. Omer Van den Bergh
Prof. Dr. Geert Verleden

Introduction and theoretical framework[1]

Asthma is a chronic inflammatory disorder characterized by airway hyperresponsiveness and episodes of respiratory complaints (wheezing, shortness of breath, dyspnea, cough), often concurring with reversible obstruction of the airways (Global Initiative for Asthma (GINA), 2006).

Poor symptom perception, or a low congruence between symptom reports and pulmonary function measures has been reported in asthma patients using a variety of methods (Boulet, Leblanc, & Turcotte, 1994; Kendrick, Higgs, Whitfield, & Laszlo, 1993; Magadle, Berar-Yanay, & Weiner, 2002; Rubinfeld & Pain, 1976; Teeter & Bleecker, 1998). It is considered an important factor in asthma morbidity, with an estimated prevalence ranging from 15 to 60% of asthma patients, depending on the measurement used (Kendrick et al., 1993; Magadle et al., 2002; Rubinfeld & Pain, 1976; Teeter & Bleecker, 1998). The group of poor perceivers is further divided into two distinct subtypes, namely under- and overperceivers (Ciccone, Chandler, Pate-Carolan, Janal, & Lavietes, 2007; Magadle et al., 2002; Teeter & Bleecker, 1998; Yoos, Kitzman, McMullen, & Sidora, 2003). An implicit assumption underlying this distinction is that under- and overperception of asthma is a stable, one-dimensional trait-like characteristic, analogous to near- and farsightedness in visual perception. This assumption can be challenged, based on evidence that (a) apart from a small group of patients with a perceptual deficit, asthma patients with poor symptom perception are not consistent in their under- or overperception, and (b) poor symptom perception is largely influenced by expectation and emotional factors, interacting with personality and situational context. These observations are a first step towards constructing a model of symptom perception that may be used to describe both accurate and inaccurate perception of asthma symptoms and may guide psychological interventions aimed at improving asthma outcome.

The instability of over- or underperception of asthma symptoms.

A small group of asthma patients are stable underperceivers. Using respiratory related evoked potentials (RREP), Davenport and colleagues identified patients with a stable perceptual deficit in a sample of children with a history of life-threatening asthma (LTA) (Davenport, Cruz, Stecenko, & Kifle, 2000). This perceptual deficit is probably due to permanent throughput deficits in the neurobiological pathways from the peripheral to the central processing areas.

Nonetheless, there are several pieces of evidence that suggest that, apart from this small group with a proven neurological deficit, the vast majority of asthma patients showing inaccurate perception cannot be categorized as dispositional under- or overperceivers.

Firstly, studies comparing different methods to assess symptom perception in asthma have produced mixed results. Some studies found a relationship between different symptom perception measures. (Julius, Davenport, & Davenport, 2002; Yamamoto, Inaba, Nishimura, Kishi, & Kawakami, 1987), while in other studies there was no relationship between different measures of symptom perception (Bijl-Hofland et al., 2000; Fritz et al., 2007; Nouwen, Freeston, Cournoyer, Deschesnes, & Boulet, 1994). Such findings may either show that the validity and reliability of under- and overperception assessment methods is problematic, or that perceptual accuracy is variable over time and contexts. The latter interpretation implies that patients may be accurate or not, depending on the circumstances. Standard laboratory assessment is unable to detect this time and context-dependent variability, because such assessment typically involves a measurement with limited frequency that occurs in a laboratory context, which may not compare well to daily life contexts.

Secondly, commonly used measurements of symptom perception in asthma all conceive of symptom perception accuracy as representing either a categorical or a one-dimensional variable. Common to these conceptions is the view that, within a person, indices of under- and overperception should be negatively correlated. This negative correlation is not found (Fritz et al., 2007), which suggests that under- vs. overperception of asthma is not a one-dimensional variable and that a patient can both qualify as an

[1] "Introduction and theoretical framework" is based on Janssens, T., Verleden, G., De Peuter, S., Van Diest, I., & Van den Bergh, O. (in press). Inaccurate perception of asthma symptoms: A cognitive-affective framework and implications for asthma treatment. *Clinical Psychology Review.*

underperceiver and as an overperceiver. Therefore, it is likely that several underlying variables contribute to either under- or overperception of asthma or both.

Which variables modulate symptom perception accuracy?

A wide variety of psychological variables that influence symptom perception in general (Pennebaker, 1982), and respiratory symptom perception in particular (De Peuter et al., 2004; Von Leupoldt & Dahme, 2007) have been listed. However, inaccurate perception of asthma symptoms can be conceived as dependent on two major groups of overarching psychological variables: expectancy-related and affective variables.

Expectancy-related variables

Several sources of evidence show that asthma patients are more likely to report symptoms when they expect to have symptoms. These expectations can be unrelated to the pulmonary state of a patient. Returning to a context in which previous symptoms have occurred (De Peuter et al., 2007b; Nouwen et al., 1994; Wilson & Jones, 1990), or merely directing attention towards previous experience (Meek, 2000) influences the perception of asthma symptoms. Furthermore, being confronted with a cue that has been associated systematically with a previous symptom episode or with a symptom relief episode (De Peuter et al., 2005; Lemaigre, Van den Bergh, Smets, De Peuter, & Verleden, 2006; Put et al., 2004; Rietveld, Kolk, Prins, & Colland, 1997) changes the perception of asthma symptoms. Finally, explicit suggestions about the likelihood of symptoms also influences symptom perception (Isenberg, Lehrer, & Hochron, 1992a; Isenberg, Lehrer, & Hochron, 1992b; Put et al., 2004).

Affective variables

Affective factors are related to differences in self-reported symptoms independent of pulmonary status. The stable personality trait Negative Affectivity (NA), reflecting the tendency to experience negative emotions (Watson & Pennebaker, 1989), is positively related to elevated symptom levels in general, but also to specific respiratory symptoms (Put, Demedts, Van den Bergh, Demyttenaere, & Verleden, 1999; Smith & Nicholson, 2001; Van Diest et al., 2005). In fact, NA explains more variance in asthma symptoms than pulmonary function measures do (Put et al., 1999). However, rather than characterizing stable overperception or overreporting of symptoms, recent evidence suggests that NA moderates the effect of several factors mentioned above. For example, both suggested bronchoconstriction and bronchodilation have more effect on self-reported symptoms in persons with high compared to low NA (Put et al., 2004). NA also moderates the associative learning effect on self-reported symptoms, that is, a distinctive cue induces elevated symptoms after that cue has been associated with previous symptom episodes, but this is most pronounced in persons with high NA (Stegen, De Bruyne, Rasschaert, Van de Woestijne, & Van den Bergh, 1999; Van den Bergh, Stegen, & Van de Woestijne, 1997; Van den Bergh, Stegen, & Van de Woestijne, 1998; Devriese et al., 2000). In addition, studies directly measuring the interoceptive accuracy of high and low NA persons during respiratory symptom perception showed that high NA persons were less accurate than low NA persons, but only in a distressing context, and not in a positive context (Bogaerts et al., 2005; Van den Bergh et al., 2004).

Apart from personality traits, transient negative emotional states have also been reported to elevate asthma symptoms. This effect has been observed in laboratory experiments as well as in real-life situations (Affleck et al., 2000; Main, Moss-Morris, Booth, Kaptein, & Kolbe, 2003; Rietveld & Brosschot, 1999; Rietveld, Everaerd, & Creer, 2000; Rietveld & Prins, 1998). Also the reverse effect has been found: In an induced positive state, persons with asthma tend to experience less symptoms (Rietveld & van Beest, 2006; Von Leupoldt, Riedel, & Dahme, 2006), although this effect might be contaminated with effects of distraction. When differentiating between the sensory (intensity) and affective (unpleasantness) dimension of dyspnea, emotion induction has been found to influence the unpleasantness, but not the intensity of dyspneic sensations (Von Leupoldt, Mertz, Kegat, Burmester, & Dahme, 2006b).

Constructing a model of symptom perception in asthma

Drawing from research on (asthma) symptom perception, and findings in other relevant domains, such as pain (because of the similarity with dyspnea sensations; (Banzett & Moosavi, 2001; Von Leupoldt & Dahme, 2005), and anxiety (because of the association of asthma with anxiety disorders; (Deshmukh, Toelle, Usherwood, O'Grady, & Jenkins, 2007; Katon, Richardson, Lozano, & McCauley, 2004) we discuss processes that may be involved in the perception of asthma symptoms and may explain the influence of affective and contextual information on the perception of asthma symptoms. Subsequently, we integrate these processes as building blocks into a working model of symptom perception in asthma.

Attention

General symptom perception theories rely on attentional deployment and vigilance to somatic sensations as key mechanisms to model the symptom perception process (Brown, 2004; Cameron, Leventhal, & Love, 1998; Cioffi, 1991). One of the determinants of attentional deployment is the threat level of the perceived stimuli. Furthermore, trait anxiety or NA can be seen as a marker for threat level evaluation (cf. Mogg and Bradley, 1998). Persons scoring high on this characteristic tend to evaluate respiratory sensations as more threatening (Stegen, Van Diest, Van de Woestijne, & Van den Bergh, 2000; Stegen, Van Diest, Van de Woestijne, & Van den Bergh, 2001). Thus, attention will be drawn to stimuli with a high threat value and diverted from stimuli with a low threat value. Furthermore, negative affective or high-threat cues may inhibit attentional disengagement from the symptoms (McCracken & Turk, 2002; Van Damme, Crombez, & Eccleston, 2004). Therefore, the various attentional processes involved in the perception of asthma symptoms can be seen as highly dependent on threat-level evaluations.

Associative learning

The effect of contextual and affective cues on asthma symptom perception may rely on an associative learning mechanism. Learning of specific symptoms in people with asthma has been documented in response to symptom related cues (De Peuter et al., 2005), and strong evidence has been collected documenting respiratory symptom learning in response to affective cues in non-asthmatic persons, especially in persons with high levels of NA (Devriese et al., 2000; Stegen et al., 1999). Therefore we hypothesize that affective symptom learning may occur in people with asthma. Because an asthma exacerbation causes a negative affective state[2], an association between such a state and asthma symptoms may become established, particularly if a patient responds with negative affect to such exacerbations (which is likely to happen in high NA persons). Subsequent negative affective states may then act as associated cues inducing subjective symptom experiences (Put et al., 2004).

Respiratory learning may be influenced by cognitive factors. For example, a selective learning effect to negative affective cues (negative imagery, foul smelling odors) versus neutral and positive cues is found in respiratory symptom learning (Devriese et al., 2000; Stegen et al., 1999). Selective learning effects have been linked to cognitive biases (for example inflated expectancy ratings) that could result from the (semiotic) similarity of negative affective cues and symptoms (Davey, 1995), and is congruent with influences of cognitive factors in contemporary learning models of anxiety disorders (Hofmann, 2008; Mineka & Zinbarg, 2006). Furthermore, research has shown that interoceptive sensations, including respiratory sensations, consist of both a sensory and an affective component (Banzett, Dempsey, O'Donnell, & Wamboldt, 2000; Craig, 2003; De Peuter et al., 2007a; Von Leupoldt et al., 2006b). Because of the high degree of similarity between the affective component of asthma symptoms and general affective symptoms, it is likely that the affective component of asthma symptoms is especially vulnerable to symptom learning.

[2] Stress has been linked with asthma-related immunological response (Liu et al., 2002). The bi-directional relationship between negative emotions and asthma may further increase the association of asthma and negative emotions in the mental representations of asthma symptoms.

Mental representations of asthma symptoms

Illness representations are implicit or explicit schemata that consist of cognitive and affective information about a specific illness (Moss-Morris et al., 2002). They can be based upon previous experience with the illness, experiences of others, societal belief or suggestion (Brown, 2004). Expectancies, affective, contextual, and spatiotemporal information about symptom episodes may all be encoded in asthma representations.

Representations of asthma may influence symptom perception. According to the common sense model of illness (CSM) of Leventhal and colleagues (Cameron, Leventhal, & Love, 1998; Leventhal, Meyer, & Nerenz, 1980), the perception of a symptom occurs when some form of somatic sensation is interpreted consistent with activated illness representations. The detection of such a somatic sensation further strengthens the activation of the illness representations, so additional symptoms will be interpreted more easily as part of the same illness.

Illness representations may be activated by specific cues or events, but also a diagnosis or a chronic condition or illness worries can trigger activation of these representations. Furthermore, individuals with high levels of trait anxiety or NA may present a chronic activation of illness representations (Cameron, Leventhal, & Love, 1998). Consequently, when illness representations are activated inappropriately, they may bias symptom perception. For example, when an asthma representation is triggered by asthma-related cues, such as a negative affective state, the interoceptive information from this state may be interpreted as an asthma symptom (Main et al., 2003; Rietveld & Prins, 1998). Often, this heightens anxiety producing somatic sensations, which in turn are interpreted according to salient concerns, starting a vicious circle. This may, in part, explain the high comorbidity rate of asthma and panic disorder (Carr, 1998; Katon et al., 2004). Conversely, if illness representations are not activated, for instance because the meaning of a specific situation or a current mood state override asthma concerns, somatic sensations will not be interpreted as asthma symptoms (Cioffi, 1991; Rietveld & Prins, 1998; Rietveld & van Beest, 2006).

Integration of bottom-up and top-down processes

Research on visual perception and the perception of emotions has shown that perceptual processes can be thought of as an integration of top-down and bottom-up processes. Input from perceptual and memory systems generates perceptual hypotheses through spread of activation. The most active perceptual hypothesis is then selected to organize the input into a phenomenal percept (Brown, 2004; Marcel, 1983). An example of such integration can be seen in the relative ease in which an experienced radiologist can identify subtle changes in an X-ray, compared to a person who is inexperienced at 'reading' X-rays (Patel, Arocha, & Kaufman, 2001). It may also explain why the same visual input of a famous optical illusion may lead to the perception of a young or and old woman, or how the same physiological information may lead to the perception of a different emotion (Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2008).

If sensory, affective and contextual information and mental representations of asthma all play a part in the perception of asthma symptoms, a model of asthma perception must include an interface that can integrate these bottom-up and top-down processes. If the integration of sensory, affective, contextual information and mental representation of asthma results in a match, a subjective asthma symptom will be experienced.

Inhibitory control

In their neurovisceral integration model of emotion regulation, Thayer and Lane (2000) put an emphasis on the importance of inhibitory pathways in emotion regulation. Inhibitory pathways are essential for a flexible reaction to environmental challenges. When inhibitory mechanisms are compromised, this may result in inflexible affective processing, which is a key feature of affective disorders.

We hypothesize that in the perception of asthma symptoms, inhibitory dysfunction may result in a reduced inhibition of threat processing, which in turn may lead to an overperception of asthma

symptoms. Furthermore, inhibitory dysfunction may also lead to an inflexible way of dealing with asthma symptoms, more specifically problems with disengaging from asthma symptoms. These effects on attentional processing may then start a feedback loop which further hampers inhibitory control (Thayer & Lane, 2000).

Model outline

Combining the processes listed above, we present a working model of symptom perception in asthma. The aim of the model is to explain the occurrence of both accurate and inaccurate perception of asthma symptoms, explaining differences across individuals as well as within the individual.

Central to the working model is the integration of various sources of information, originating both from top-down and bottom-up processes, and a check of the affective and motivational (threat-level) value of this information (Fig.1, central). Like physical symptoms in general (Skelton & Pennebaker, 1989), or anxiety and pain (Eccleston & Crombez, 1999; Mogg & Bradley, 1998), asthma symptoms have affective-motivational effects. They signal that something is wrong with the body and action has to be taken. In line with this view, we propose that the evaluation of incoming sensations is an essential part of the perception of asthma symptoms. Similar to the processing of anxiety-related information (Mogg & Bradley, 1998), the outcome of this evaluation depends on different sources of momentary information (sensory, affective and contextual information; Fig. 1, left) as well as schematic information (asthma representations; Fig. 1, top),which are all fed into the system.

As we outlined in the previous section, mental representations of asthma contain cognitive and affective information about asthma, which are typically based on learning experiences such as previous experiences with asthma. Information regarding the sensory, affective and contextual (spatiotemporal) qualities of asthma symptoms and asthma exacerbations is stored in the asthma representations. Moreover, more elaborate cognitive and affective information may also be a part of asthma representations, such as catastrophic thoughts, or beliefs about the transient or chronic nature of asthma symptoms.

If and only if there is a good enough fit between the momentary input and the mental representation of asthma symptoms, the integration of momentary and schematic information results in the perception of asthma symptoms. Conversely, if there is no fit between mental representations of asthma and momentary input, or a non-asthma representation fits the information better, the perception of asthma symptoms will not occur.

Processes of executive control, such as inhibitory processes (Fig. 1, center), may play a part in the sensitivity of the evaluation and integration of momentary input and mental representations. For example, the selection of a symptom representation may result from an inhibitory failure, causing the system to err on the safe side matching 'neutral' somatosensory information to asthma symptom representations instead of a non-asthma representation, leading to the perception of asthma symptoms. This is comparable to a disinhibitory 'jumping to conclusions' in anxiety pathology, which leads to the perception of neutral information as negative (Thayer & Lane, 2000).

On top of the perception of asthma symptoms, a match between sensory, affective and contextual input and the mental representation of asthma symptoms results in motivational responses aimed at monitoring and relieving asthma symptoms.

One example of such a motivational response is the mobilization of attentional mechanisms (Fig. 1, bottom). If a somatic sensation or an associated cue is evaluated as having a high threat value, attention may be directed and sustained towards somatic sensations. This may lead to an intensified somatic sensation and elevated level of asthma symptoms, which is comparable to the effect of attention on pain perception (McCracken & Turk, 2002). A similar attentional effect towards predictive cues may also lead to increased asthma symptoms. Conversely, in persons with a defensive processing style, a high threat-level may lead to the diversion of attention away from the threatening sensation or cue.

We hypothesize that other types of motivational responses, such as the intention to take medication, or other ways of coping with asthma are also guided by the perception of asthma symptoms or the motivation to action resulting from the symptom perception process (Fig.1, right), but since we focus mainly on symptom perception, these responses are beyond the scope of our model.

Explaining interindividual differences in the perception of asthma symptoms

Because mental representations of asthma symptoms are based on learning experiences, it can be expected that there are considerable interindividual differences in the content of these representations. Therefore, similar momentary input may lead to different results in different persons. For example, if mental representations of asthma symptoms in a particular person contain a relatively large amount of negative affective information, a negative affective state may be enough to surpass the threshold of symptom perception in this person. Similarly, mental representations of asthma symptoms may differ in the amount of contextual information included, which may explain differences in context-related perception of asthma symptoms.

Apart from differences in the content of mental representations of asthma exacerbations, interindividual differences in the perception of asthma symptoms may also depend on differences in the general threshold of the symptom perception system. What is considered a good enough match may differ across persons. More specifically, the general threshold of the symptom perception process may be related to the quality of inhibitory processes. An inhibitory failure may lead to the interpretation of 'neutral' somatosensory information as 'symptom-related' information.

Two variables may be used to index the differences in interindividual threshold of the symptom perception system. First, findings concerning the relationship between NA and physical symptoms and the relationship between NA and anxiety disorders suggest that NA can be seen as an index for the set point or threshold of the evaluative system (Mogg & Bradley, 1998; Mogg et al., 2000; Put et al., 1999; Smith & Nicholson, 2001; Watson & Pennebaker, 1989). In individuals with high levels of NA afferent information of a certain intensity may surpass the threshold for a threat evaluation more easily, compared to individuals with low levels of NA. As a result, high NA persons can be seen as hypervigilant towards interoceptive sensations or contextual cues predicting asthma symptoms: more stimuli will be perceived to activate the asthma memory schemata and bias the perception of any kind of interoceptive information. Second, Heart rate variability (HRV) has been proposed as an objective marker of flexible emotion regulation, resulting from neural inhibitory pathways (Appelhans & Luecken, 2006; Thayer & Lane, 2000). Based on the neurovisceral integration model of emotion regulation (Thayer & Lane, 2000), baseline measures of HRV can be seen as a trait-like variable, indexing a person's general tendency to process emotions in a flexible way. Low baseline HRV may be seen as an index of a disinhibitory 'jumping to conclusions' and could also be a measure of reactivity of the symptom perception system.

Explaining intraindividual differences in the perception of asthma symptoms

According to our working model, sensory, affective and contextual input is integrated to match schematic information. In this integration, the (relative) intensity of the momentary input may be important. When somatic sensations are intense and specific, the interpretation of the sensations as asthma symptoms is straightforward. However, when the sensations are vague and/or ambiguous and in themselves not specific enough to trigger the asthma illness representation, contextual cues previously associated with asthma episodes may activate the schematic representation and, as a result, bias the symptom experience. This bias may result in both underperception as well as overperception of asthma symptoms, and its magnitude is moderated by NA (Put et al., 2004). Furthermore, contextual input, such as current concerns (Abraham, Costa-Pereira, Du, & Ogston, 1999), or the experience of riding a rollercoaster (Rietveld & van Beest, 2006), may even override other types of input and provide a match with a non-symptom representation, regardless of somatosensory input.

Finally, in persons with illness representations being fraught with anxiety, anxious sensations and anxiety-related contextual cues may easily activate the memory schema and bias the interpretation of vague and ambiguous sensations as asthma symptoms. When illness representations contain catastrophic thoughts, the activation of these schemata may even increase state anxiety, which in turn may influence the perception of asthma symptoms, creating a positive feedback loop similar to the feedback loop proposed in the catastrophic misinterpretation model of panic disorder (Austin & Richards, 2001).

Clinical implications

Implications of the model on existing treatment programs

Several types of complementary asthma treatment have been shown to reduce asthma symptoms. (Huntley, White, & Ernst, 2002; Passalacqua et al., 2006; Ram, Holloway, & Jones, 2003; Warsi, Wang, LaValley, Avorn, & Solomon, 2004; Yorke, Fleming, & Shuldham, 2007). Many of these treatment effects can be elucidated by our model.

First, asthma symptoms often are not in accordance with actual bronchoconstriction. Therefore, bronchodilators may be used without a need for bronchodilation. Nevertheless, our working model predicts that the use of a bronchodilator will reduce asthma symptoms. In asthma patients who are familiar with bronchodilators, its use will not only diminish respiratory sensations, but also change contextual and affective information and therefore stop the perception of asthma symptoms, in spite of concurrent bronchoconstriction. The onset of symptom relief is much quicker than actual bronchodilation, and at that moment indistinguishable from placebo (Lemaigre et al., 2006), which may explain why an estimated 16% of the asthma population tends to overuse their bronchodilator (Diette et al., 1999).

Second, several breathing interventions have been shown to improve asthma symptoms, asthma control and quality of life despite the lack of effect on lung function (RAM et al., 2003; Slader et al., 2006). The beneficial effects of breathing exercises may result from reductions in threat levels instead of changes in specific physiological pathways. The similar effect of two quite different breathing exercises on asthma outcome (Slader et al., 2006) may illustrate this. In this study, the change in symptoms may have occurred because of *the reinforcement of a message of relaxation and self-efficacy, and the fact that the program offered a deferral strategy for* β2*-agonist use (If symptoms are not relieved at first by the exercises, try them again. If symptoms persist, use reliever; italics ours, p 652, 656).*

Third, educational and self-management interventions, designed to improve knowledge, self-efficacy and perceived control in patients (Katz, Yelin, Eisner, & Blanc, 2002) may improve asthma symptom reports because perceived control and self-efficacy become part of the asthma representations, which in turn may lower threat-level evaluations. Integrating several psychological treatment options with education in a self-management program has led to improvement on a broad range of outcome measures, including adherence, PEFR, asthma symptoms, asthma related quality of life, self-efficacy and NA (Put, Van den Bergh, Lemaigre, Demedts, & Verleden, 2003). A limitation of efficacy studies is that the causal pathways leading to the effect of the interventions are not clear. However, the effect of the program on NA may point towards a change of the threat level set point, resulting in fewer asthma symptoms.

Instability of inaccurate symptom perception.

According to our model, accuracy of symptom perception is not a stable characteristic but the result of a context-dependent process. Therefore, a training program focusing on the detection of respiratory sensations in a laboratory context may fail to achieve results on symptom perception in real life situations and asthma outcome. Although this type of training improves the detection of respiratory sensations in a laboratory context so far, evidence is lacking on the effects of load detection training on the perception of respiratory symptoms or asthma sensations in real life (Harver, 1994; Stout, Kotses, & Creer, 1997; Von Leupoldt & Dahme, 2007). Peak-flow perception training, which trains peak-flow estimation in a daily life context, appears to produce favorable effects on symptom accuracy, perceived asthma symptoms and asthma-related quality of life (Fritz et al., 2007; Von Leupoldt & Dahme, 2007).

Interindividual differences in the perception of asthma symptoms

Although the perception of asthma symptoms is dependent on contextual factors, this doesn't cancel out the effect of interindividual differences. There still are parts of the population of persons with asthma who have an increased risk of inaccurate perception of asthma symptoms, although these persons will not show inaccurate perception of asthma symptoms in every situation. The key question (similar to a question raised by De Peuter et al. (2004) to ask is which persons, under which circumstances are prone to inaccurate perception of asthma symptoms (and which type of intervention may be helpful for this specific person-context dyad).

Research on persons with both asthma and panic disorder suggest this population may be a target population for interventions (Feldman, Siddique, Thompson, & Lehrer, 2009; Huntley et al., 2002; Lehrer, Feldman, Giardino, Song, & Schmaling, 2002; Yorke et al., 2007). In a recent study, a specific treatment for asthma-panic comorbidity substantially improved asthma outcomes and resulted in a decreased use of asthma relief medication (Lehrer et al., 2008). Because our working model includes evaluative processes that are also important in anxiety disorders, it may provide an explanation of the perception of asthma symptoms in persons with both asthma and panic disorder and may guide interventions for this specific subgroup.

Apart from persons with asthma and panic disorder, individual differences in sensitivity to specific contextual and affective cues as triggers of asthma symptoms, differences in catastrophic interpretations or even a general tendency towards negative interpretations may be an important factor in identifying persons who are prone to inaccurate perception of asthma symptoms and may particularly benefit from psychological interventions.

Identification of persons who are prone to inaccurate perception of asthma symptoms may be a key task in improving inaccurate perception, especially if this is done in an early stage of asthma diagnosis and treatment. An inventory of relevant personality variables and mental representations may be a good screening strategy. Another strategy is the direct observation of the perception of asthma symptoms in a standardized situation that is designed to elicit inaccurate perception. Because of individual differences in contexts eliciting inaccurate perception of asthma symptoms, a final strategy is to make an inventory of relevant contexts for a specific person and assess inaccurate perception in these contexts.

Improving inaccurate perception of asthma symptoms: an overview of possible interventions

The working model can be used to make specific predictions on how the perception of asthma symptoms may be improved. Because of the various factors influencing symptom perception in asthma, there are many possibilities for interventions targeting symptom perception. Based on the components of our model, interventions are listed that can be used to target these components and thereby improve symptom perception in asthma.

Affective and contextual input

A straightforward way to reduce biased symptom perception lies in altering affective and contextual input. If contextual information serving as an asthma trigger is identified, patients can learn to avoid these triggers. A strong limitation of this approach is that avoidance of contextual input is often difficult and may interfere with a patient's well-being and quality of life. Therefore approaches focusing on other mechanisms of the working model may have strategic benefits over the reduction of contextual input.

Anxiety related avoidance behavior may reduce the affective input fed into the symptom perception model, but has the same downsides as avoiding specific contexts. Alternatively, anxiety can be reduced using relaxation and (interoceptive) exposure techniques, which also result in a decrease of affective input, which is related to altered threat-level evaluations (cf. infra).

Attention

Because of the effect of attentional bias on the perception of asthma symptoms, the change of attentional bias could be a focal point of intervention. Two main types of attention-focused interventions have been proposed or used in the treatment of anxiety and chronic pain (Mathews & MacLeod, 2002; Morley, Shapiro, & Biggs, 2004). In a first type, the automatic orientation towards threatening cues is changed in an automatic orientation bias directing attention away from threatening cues (Macleod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2002). The second treatment strategy tries to modify attentional coping strategies. For instance, instead of suppressing thoughts about pain, patients are instructed to direct their attention to a specific thought or sensation, or to pay attention to the sensory features of the pain and to try to disregard affective features (Morley et al., 2004).

However, according to our working model, attentional processes in asthma as determined by the affective-motivational value (threat-level). Therefore, interventions directly targeting the threat-level may

be more economical than interventions aimed at targeting attentional processes. Furthermore, research on distraction is inconclusive at best (Goubert, Crombez, Eccleston, & Devulder, 2004), and seems only helpful for patients with catastrophic thoughts (Quartana, Burns, & Lofland, 2007). On top of that, it is not unlikely that in the case of asthma, changing a patient's general orientation away from high threat cues, may have a further biasing effect on symptom accuracy.

Associative learning and threat-level evaluation

A more helpful strategy may lie in changing the threat-level evaluations. According to the working model, representational information and the evaluative response are interconnected and influenced by associative learning. Therefore, exposure to the affective and contextual cues alone (i.e. not associated with actual bronchial responses) may change the representations of these sensations and cues, which may lead to extinction of the symptom response to contextual and affective cues. Furthermore, exposure to conditioned cues also leads to an extinction of biases in attentional processing of these cues (Kelly & Forsyth, 2007; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006).

An important first step in changing the evaluative response to contextual and affective cues is to identify these cues. This can be done through self-monitoring of the sequence leading to asthma symptoms, or by using a questionnaire such as the Asthma Trigger Inventory (Ritz, Steptoe, Bobb, Harris, & Edwards, 2006). The next step, then, is exposure itself. This can be imaginative exposure, which may be especially important for exposure to affective cues, or exposure to the actual contextual cues. In the same sense, exposure to asthma sensations may be an interesting treatment option, since repeated exposure to asthma sensations may change the threat level of these sensations. This type of interoceptive exposure, which is already implemented in the treatment of panic disorder (Beck, Shipherd, & Zebb, 1997; Craske & Barlow, 2007; Craske, Rowe, Lewin, & Noriega-Dimitri R., 1997), may also be helpful to patients with asthma, especially those with a panic-like reaction towards their internal sensations.

Mental representations of asthma

Because mental representations of asthma and threat level evaluations are interconnected it is also possible to intervene on the level of illness representations to improve symptom perception in asthma. This could be done by education on asthma and psychological factors influencing asthma perception, but also by using a cognitive restructuring approach to target catastrophic thinking about asthma (De Peuter, Lemaigre, Van Diest, & Van den Bergh, 2008). Working on this part of illness representations would not only reduce the threat level of asthma symptoms, but could also reduce anxiety that is a result from catastrophic thinking and therefore could reduce affective input into the symptom perception system.

Negative affectivity and inhibitory processes

An overarching strategy to improve the perception of asthma symptoms is using an intervention which targets the threshold of the evaluative system by lowering NA. According to our working model, this type of intervention may have the additional benefit of reducing further expansion of illness representation with novel contextual and affective information. Because NA is a broad construct, it may not be easy to find a specific intervention leading to a reduction in NA, but the wide range of methods used in the psychotherapy for affective disorders (Mennin & Farach, 2007) may give us some direction.

Apart from trying to improve NA, a specific way of targeting the threshold of the symptom perception system is by improving inhibitory processes in patients with low HRV. Improvement of inhibitory processes (measured by an increase in HRV) may be one of the results of psychotherapy (Friedman, Thayer, & Borkovec, 1993), but may also be achieved by means of HRV-biofeedback training, which has yielded promising results in asthma patients (Lehrer et al., 2003; Lehrer et al., 2004; Lehrer et al., 2006).

Several treatment programs for asthma already include some of the interventions listed above (e.g. (Lehrer et al., 2008; Put et al., 2003). However, the relative importance of these interventions in the improvement of asthma symptom perception remains an open question. Testing different combinations of interventions in a population of asthma patients may lead to an optimal treatment package for patients who are vulnerable towards using contextual and affective information in inferring asthma symptoms. Subsequently, these interventions can be included in the already multifaceted treatment of asthma.

Research Lines

Research questions stemming from on our model of the perception of asthma symptoms, can be grouped into three slightly overlapping research lines.

A diagnostic tool for context-dependent symptom perception in asthma

A first research line, deals with the construction and validation of a test to identify persons who are prone to context-dependent perception of asthma symptoms. Based on the model of symptom perception in asthma, we adapted the histamine challenge test, which is often used in the process leading to an asthma diagnosis, to include a situation wherein contextual information may suggest a state of asthma symptoms despite physiological recovery and therefore may lead to inaccurate perception of asthma symptoms. In a first study we proposed indices of inaccurate (context-dependent) perception based on the modified histamine challenge and investigated the relationship between inaccurate perception and asthma severity, personality and perceptual sensitivity. In a planned follow up study, we will investigate the relationship between inaccurate perception and asthma outcome, to validate the modified histamine challenge test as a measure of inaccurate perception of asthma symptoms. In a final validation study, we will investigate whether inaccurate perception during the histamine challenge test predicts inaccurate perception of asthma symptoms during daily life. We can achieve this by recruiting participants from the histamine challenge study to participate in the diary study (cf. infra). Additionally, we want to compare the predictive validity of assessment of symptom perception in daily life to the histamine challenge test indices.

Test and elaboration of the model of symptom perception in asthma in a real life situation

In a second research line, we will test our working model of the perception of asthma symptoms in a daily life context using a diary study. Using a time-sampling procedure, we will investigate the relationship between affective states, lung function and asthma symptoms and the interaction between these factors and personality variables related to inhibitory mechanisms and mental representations of asthma symptoms. Using an event-sampling procedure, we will focus on asthma symptoms as a motivational state leading to an action. We will study the factors leading to medication intake and the result of medication intake and relate this to the variables of our model (focusing of mood ratings and specific contexts).

An Experimental inquiry into the mechanisms of context-dependent perception of asthma symptoms.

In a third research line, we want to investigate the role of threat level, attention and avoidance behavior in the symptom perception process, and investigate how these variables are related.

The interrelatedness of threat level, attention and avoidance has already been studied in the context of anxiety and pain. A replication in the domain of asthma and respiratory sensations would strengthen our model and can lead information about an optimal way of constructing psychological interventions for inaccurate perception of asthma symptoms. The use of an experimental research design, provides greater flexibility and more control over several factors of our model. Furthermore, using an experimental design makes it possible to investigate aspects of symptom perception - e.g. attentional processing - that are inaccessible in a more naturalistic design.

An overview of completed and planned studies

A diagnostic tool for context-dependent symptom perception in asthma

Study 1.1: context-dependent perception of asthma symptoms in a modified histamine challenge test

Background

The main purpose of this study was to design a diagnostic test to identify persons at risk of inaccurate perception of asthma symptoms. We wanted to find out if the histamine provocation test (Cockcroft, Killian, Mellon, & Hargreave, 1977) could be used to identify persons with asthma who have a risk of inaccurate perception of asthma symptoms. The histamine provocation test was adapted to include situations in which the expectancy of asthma symptoms would differ from respiratory distress at these moment. In this first study we wanted to investigate if inaccurate (context-dependent) perception of asthma symptoms during the histamine challenge test was related to asthma severity, personality and perceptual sensitivity.

Methods

Participants

Participants (n=110) were patients at the department of respiratory medicine at the university hospital. They were referred for a histamine challenge test by their physician to confirm an asthma diagnosis. All participants performed the histamine challenge test for the first time. Only the data of participants with a positive histamine challenge test (a drop in FEV1 of at least 20% compared to baseline FEV1, n=60) were used in the study.

Self-report measures

Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988) Catastrophizing about Asthma Scale (CAS) (De Peuter et al., 2006) Asthma Symptom Checklist (ASC) (Ritz, Bobb, Edwards, & Steptoe, 2001) VAS-scales, sensorial and affective dimension of respiratory symptoms (Von Leupoldt, Mertz, Kegat, Burmester, & Dahme, 2006a).

Apparatus

Spirometry was performed using a Jaeger MasterScope pneumotachograph (Hoechberg, Germany). Histamine and salbutamol were administered through a Devilbiss nebulizer.

Proceduce

While waiting for the histamine challenge test to start, we asked patients whether they would participate in the study. After informed consent, patients filled out the questionnaires in the waiting room. The histamine challenge test was based on the protocol of Cockcroft et al (Cockcroft et al., 1977). After baseline spirometry, participants inhaled a nebulized solution of 0,09% NaCl, followed by doubling dosages of nebulized histamine (0,25-8 mg/ml). After each period of inhalation, spirometry was performed according to ERS guidelines (Quanjer et al., 1993). Inhalation of nebulized histamine continued until a drop of 20% FEV1 occurred, or until the 8 mg/ml histamine inhalation. The modification of the histamine challenge test consisted of a different administration of salbutamol (Ventolin, GlaxoSmithKline). Salbutamol was given in nebulized form, instead of metered dose inhaler(MDI). This was not known to the participants, rendering the situation similar to previous nebulizer inhalations. After each inhalation participants rated the intensity and unpleasantness of there respiratory symptoms. At the end of the test participants were given a placebo MDI (propellant only, Allen & Hanburys) to suggest symptom relief.

Data-analysis

We used Multilevel regression analysis to evaluate the concurrent effects of moment of measurement, lung function and NA on asthma symptoms during the histamine challenge test. In search of the best fit for our data, we fitted multilevel models of increasing complexity. We started with a random intercept model (model 0). Subsequently, FEV1 was added as a fixed effect (model 1), and as a random effect (model 2). Moment of measurement was added as a fixed effect, as would be the case in a repeated measures ANOVA (Model 3). Finally, NA (model 4) and NA*Moment interactions (model 5) were added.

To evaluate the effect of inaccurate perception we constructed the following indices: intercepts and slopes of the individual relationship between FEV1 and asthma symptoms (Bijl-Hofland et al., 2000), rank order correlations of this relationship (Spinhoven, van Peski-Oosterbaan, Van der Does, Willems, & Sterk, 1997) and several difference scores comparing symptom levels in different contexts. Difference scores were also reduced to a binary variable (high vs. low inaccurate perception). We used linear regression to evaluate the proposed indices of inaccurate perception of asthma symptoms.

Results

The result of the model comparison can be found in Tables 1-2. Both for the intensity and unpleasantness of asthma symptoms, model 4 (including FEV1, Moment of measurement and NA) was the best fit for our data (based on the AIC information criterion). This means that asthma severity during the histamine challenge test is dependent on the decline in lung function, the faze of the histamine challenge test, and the individual level of NA. The interaction between moment of measurement and NA was not significant.

Using correlations, linear regression and logistic regression, we compared several indices of inaccurate perception of asthma symptoms. Crosscorrelations between the indices of inaccurate perception can be found in Tables 3-4, Correlations of indices with other variables in Table 5. Correlations of the binary variables can be found in Table 6.

Discussion

The results of the multilevel analysis replicate the importance of non-physiological effects on the perception of asthma symptoms and symptoms in general. We found a main effect of NA. This is in line with previous findings related to NA and asthma symptoms (Put et al., 1999; Van Diest et al., 2005; Watson & Pennebaker, 1989). However, it is often argued and found, that NA, or other anxiety related influences on (asthma) symptom perception decline when more severe symptoms occur (Pennebaker, 1982; Chen, Hermann, Rodgers, Oliver-Welker, & Strunk, 2006). In this study, we did not find an interaction between NA and moment of measurement. It is possible that the decline in lung function during the histamine challenge test is small enough, so that the effect of NA did not decline, or that NA may have more general biasing effect.

Another important finding is that, even when controlling for the decline in lung function, asthma symptoms during the histamine challenge test are influenced by the moment of measurement. The context of the histamine challenge test (anticipation of asthma symptoms, increasing asthma symptoms over time, because of a decline in lung function) elicits asthma symptoms. Contrary to our predictions, the context effect was not moderated by NA.

Looking at the results of the analysis of the proposed indices of inaccurate perception, we observe that the indices are highly correlated. Correlations with physiological parameters may be a sign of poor construct validity, because the proposed index may not be solely targeting inaccurate perception. Therefore, slope measures and rank order correlations of FEV and asthma symptoms may be unsuitable as indices of inaccurate perception. Based on our model of symptom perception (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, in press) a modest relationship with NA would be warranted. The analysis of the binary variables shows this effect. Because the data were collected during asthma diagnosis, only a small amount of patients (n=22) found the CAS questionnaire relevant to their situation and was inclined to complete the CAS. Therefore these results could not be analyzed. The follow-up

study that is under way may shed some further light on which indices are most suited to predict problems related to inaccurate symptom perception.

Study 1.2: inaccurate perception of asthma symptoms and asthma status: a three month follow-up

Background

Because of the expected influence of poor symptom perception on asthma outcome we collected three month follow-up data on the participants of study 1.1. We expected that context-dependent perception during the histamine challenge test would have an effect on perceived asthma severity, asthma control and asthma quality of life. Furthermore we wanted to explore whether persons who showed context-dependent asthma during the histamine challenge test would have catastrophic thoughts about asthma

Methods

Participants

Participants (n=60) participated already in study 1.1. They had an asthma diagnosis according to GINA guidelines (ref), and a positive histamine challenge test.

Self-report measures

Catastrophizing about Asthma Scale (CAS) (De Peuter et al., 2006), Asthma Symptom Checklist (ASC) (Ritz et al., 2001), Asthma Control Test (ACT) (Schatz et al., 2006), Asthma-related Quality of Life Questionnaire (AQLQ)(Juniper et al., 1992). Medication use.

Procedure

Three months after participation in study 1.1, participants received the questionnaires by mail, and were reminded by email that they could expect the questionnaires. Participants returned the questionnaires using an enclosed envelope. If participants did not return the questionnaire within 2 weeks, they received a phone call to remind them of the questionnaires.

Data-analysis

The data will be analyzed using linear regression analysis

Results

Data are being collected: The questionnaires have been sent out (December-March), and will shortly be analyzed.

Test and elaboration of the model of symptom perception in asthma in a real life situation

Study 2: context-dependent perception of asthma symptoms in real life + the influence of symptom perception on reliever medication use.

Background

Previous studies on the perception of asthma symptoms show that specific, contextual and affective cues all play a part in the perception of asthma symptoms. (De Peuter et al., 2005; De Peuter et al., 2007b; Main et al., 2003; Put et al., 2004). Furthermore, an interaction exists between these different cues and personality (De Peuter et al., 2007b; Put et al., 2004). Because of the cross-temporal differences in asthma symptoms and the perception of asthma symptoms in daily life (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, in press), we will investigate these differences using diary methods to find external validity for the symptom perception model proposed above.

Diary studies have already shown a correlation between asthma symptoms and affective states (Affleck et al., 2000; Main et al., 2003). The relationship between personality and asthma symptoms however has not been studied in a real life context.

The aim of this study is to replicate the influence of negative affective states and contextual cues on asthma symptoms and to investigate whether this effect is moderated by general personality characteristics (e.g. negative affectivity), and more specific personality variables (fear of suffocation, asthma catastrophizing, context-dependency). A final aim of the study is to investigate whether an asthma diary can be used to identify context dependent perception of asthma symptoms, both from the viewpoint of the caregiver, as from the viewpoint of the user (does asthma diary use inform persons with asthma about contingencies between affective and contextual cues and asthma symptoms). Both factors may be important in the treatment of context-dependent perception of asthma symptoms.

Asthma treatments often include the administration of medication on an as-needed basis (Global Initiative for Asthma (GINA), 2006). In order for this self management of asthma symptoms to be effective, an accurate perception of asthma symptoms is needed. However, because inaccurate perception of asthma symptoms occurs widely (Kendrick et al., 1993; Magadle et al., 2002; Rubinfeld & Pain, 1976; Teeter & Bleecker, 1998), optimal use of as-needed medication may not be achieved.

Inaccurate perception of asthma symptoms is influenced by contextual cues and affective states, as well as personality. In this study, we want to investigate the effect of these variables on asthma reliever medication use in a real life setting using diary methods. Based on the findings by Main et al. (2003), we expect that the influence of contextual cues and affective states on the use of reliever medication will be mediated by the severity of perceived asthma symptoms.

Methods

Participants

50 participants, with a diagnosis of asthma according to Gina guidelines (Global Initiative for Asthma (GINA), 2006). To participate in the part about reliever medication, participants must use as-needed asthma medication at least once a week We will try to have participants who participated in the histamine studies.

Self-report measures

Asthma Control Test (ACT)(Schatz et al., 2006), Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988), Catastrophizing about Asthma Scale (CAS)(De Peuter et al., 2006), Asthma Symptom Checklist(ASC) (Ritz et al., 2001), ASC-short (De Peuter et al., 2007a), Affect circumplex scales (Affleck et al., 2000), VAS-scales, sensorial and affective dimension of respiratory symptoms (Von Leupoldt et al., 2006a) Asthma Trigger Inventory (ATI)(Ritz et al., 2006). Questionnaire on experiences during diary study.

Procedure

Participants of the histamine studies are asked to participate in this study. Recruitment of other participants is done based on advertisements in the university newsletter, and targeted advertising towards medical students and psychology students.

After informed consent participants complete baseline measurements, which consist of spirometry, asthma diagnosis, information about previous hospitalizations, demographic information and self report measures (ASC, ACT, ATI, PANAS and CAS).

Subsequently, participants get familiarized with the diary equipment: a PDA to fill out the questionnaires and a pocket spirometer for lung function measurement. During this training, the participants will also get information about a hotline which they can call when they have a problem with the equipment or other problems. The phone number of the hotline can also be found on the PDA and the pocket spirometer.

The next 21 days, participants use the PDA and pocket spirometer to answer questions and measure lung function. Three time a day, they answer questions about their affective state, context, asthma

symptoms and medication use, and use the pocket spirometer to perform a lung function measurement. The three moments are random in a specified time interval (time sampling). Participants also have to perform the same measurements at wake-up and before going to sleep. The time sampling protocol is summarized in Table 7.

During the diary assessment, participants with at least one inhalation of as-needed asthma medication a week are asked to fill out a diary entry every time they use their as-needed medication (event sampling, Table 7). They fill out the diaries immediately before medication use, just after medication use, and 20 min after medication use. At these moments, participants fill out questions about affective state, symptom level and contextual cues. Participants also perform a FEV1 measurement at each of these moments, using the pocket spirometer.

Time sampling	Event sampling
3 times/day, random in given intervals • Affect (circumplex, 16 items) • Symptoms (VAS-affective, VAS-sensorial, 2 items) • Medication use • FEV1 *At wake-up / before going to bed* • Affect (circumplex, 16 items) • Symptoms (VAS-affective, VAS-sensorial, 2 items) • Medication use • FEV1	*When there is an intention to use as-needed (reliever) asthma medication* • Context • Affect (circumplex, 16 items) • Symptoms (VAS-affective, VAS-sensorial, 2 items) • FEV1 *Immediately after medication use* • Affect (circumplex, 16 items) • Symptoms (VAS-affective, VAS-sensorial, 2 items) • FEV1 *20 min after medication use* • Context • Affect (circumplex, 16 items) • Symptoms (VAS-affective, VAS-sensorial, 2 items) • FEV1

Table 7: Procedure of the time sampling and event sampling protocol.

At the end of the time sampling period (after three weeks), patients return the equipment. At this moment, they get a questionnaire about their experiences as a participant, and are debriefed.

Data-analysis

Because of the large amount of repeated measurements, we will use multilevel analysis to analyze the data.

An Experimental inquiry into the mechanisms of context-dependent perception of asthma symptoms.

Study 3.1: Perception of asthma-like sensations in a threatening context: the influence of attention and avoidance behavior.

Background

Affective and contextual information can influence the perception of respiratory symptoms. Our model of the perception of asthma symptoms take into account various factors influencing this relationship, including attentional processes. So far, however, evidence is lacking on the role of attention in the perception of asthma symptoms.

General models of symptoms perception (Cioffi, 1991; Skelton & Pennebaker, 1989), models of the perception of pain (Eccleston & Crombez, 1999; Pincus & Morley, 2001) and anxiety (Mogg & Bradley, 1998), include attentional processes as an important factor. In these models, the attentional processing of

anxiety-related cues and pain related cues, is seen as dependent on the potential threat these cues pose to the individual. In this study, we want to investigate the influence of a threatening context on the perception of asthma symptoms and the attentional processing of asthma cues. We hypothesize that not only the perception of asthma symptoms is influenced by a threatening context (De Peuter et al., 2007b), but also the attentional processing of asthma cues changes in a threatening context.

Apart from attentional mechanisms and respiratory symptoms we will also explore whether a threatening context influences avoidance behavior in persons with asthma. Because both attentional and behavioral avoidance are implicated in the precipitation of anxiety disorders and fear of pain (Asmundson, Norton, & Norton, 1999), we hypothesize that a threatening context will elicit avoidance, and may subsequently influence the perception of respiratory symptoms.

The influence of a threatening context on asthma symptoms depends on personality characteristics, such as negative affectivity (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, in press; Put et al., 2004). We predict that this is also the case for the influence of a threatening context on attentional processing of asthma-related cues. Including personality characteristics in the research design makes it also possible to investigate the asthma-specificity of the hypothesized effects. It may be possible that instead of asthma status, variables such as negative affectivity of fear of suffocation are predictors of the hypothesized effects.

Methods

Participants

Participants (n=50) are undergraduate students, who participate for course credit. Half of the participants have asthma, the other half are control participants.

Cross-modal cueing task

Research on the attentional processing of anxiety and pain has resulted in the identification of different components of attentional processing (Fox, Russo, Bowles, & Dutton, 2001). Both engagement (the allocation of attention to a cue) as disengagement (diverting attention away from a cue) can be influenced by threat perception and may influence the perception of asthma stimuli in a different way.

Cueing tasks (Fox, Russo, Bowles, & Dutton, 2001; Van Damme, Crombez, & Eccleston, 2002) are a method of studying the engagement and disengagement component of attentional processing. In this study we opt to use a version of the cross-modal cueing task, used by Van Damme et al. (2002).

In our version of the task, a cue word (TONE or BREATH) is followed by a sensation (tone or occlusion), with an interval (100, 400 ms) between the onset of the cue and the sensation. Tones are presented via headphones, occlusions are presented using the occlusion module of the Jaeger pneumotachograph. Both tones and occlusions have a duration of 400 ms To standardize the effect of the occlusion, occlusions are given 100, 400 ms into inspiration. Participants are asked to react as quickly as possible to the sensations, by categorizing them as tone or breath-related sensations. Apart from cued sensations, trials of the task also include non-cued sensations (preceded by the 'word' XXXX) as well as catch trials (cue without sensation following) and number trials (in which a number is presented, and participants have to say which number they are seeing, to control for general attentiveness). Prior to conducting study 3.1, feasibility of the cross-modal cueing task will be investigated in a pilot study using an analog sample.

Threat manipulation

Threat of suffocation (ToS) is manipulated using a modified form of a threat of pain paradigm (Grillon, 2002). During the experiment, participants are told that they may experience a suffocating feeling, at any moment during danger trials, when a danger cue (blue rectangle) is presented. During safety trials, when a safety cue (green rectangle) is presented, the suffocation feeling will not occur. The suffocating feeling is elicited by an intense respiratory resistance (40cmH2O/l/s). In reality the suffocating feeling will only occur at the end of each danger trial, for 30 seconds.

Self-report measures
Asthma Symptom Checklist (Ritz et al., 2001), Catastrophizing about Asthma Scale (De Peuter et al., 2006), Fear of suffocation scale (Radomsky, Rachman, Thordarson, McIsaac, & Teachman, 2001), Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988),
VAS ratings of Intensity, unpleasantness, threatfulness.

Apparatus

Breathing behavior will be captured using a heated pneumotachograph (Jaeger, Hoechberg, Germany). Avoidant breathing behavior is defined in this experiment as a decrease in minute ventilation relative to threat (Fannes et al., 2008). Respiratory data is stored and processed offline using PSPHA software (De Clerck, Verschuere, Crombez, & De Vlieger, 2006).

In further experiments with this paradigm, psychophysiological measures related to emotional valence and arousal will also be used.

Affect software (Hermans, Clarysse, Baeyens, & Spruyt, 2005) is used to administer the questionnaires, to present the cueing task and the threat cues, to administer the tones and occlusions and to record the reaction times of the cueing task.

Procedure

Participants are informed about the experiment using the informed consent form. As a cover story participants are told that they will have to react to different types (lengths) of occlusions and rate these asthma like sensations on intensity and unpleasantness. After signing the consent form, they start with filling out the questionnaires (PANAS, fear of suffocation, ASC). Following the questionnaires, participants receive instructions for the cross-modal cueing task, and a practice trial follows. After the cueing trail, participants rate the intensity, unpleasantness and threatfulness of the occlusions, and rate how anxious they were during the trail. An Exposure to the suffocation stimulus follows. Participants rate the intensity, unpleasantness and threatfulness and rate how similar they think the suffocating stimulus is to an asthma attack. Subsequently, the danger and safety instructions are introduced. Finally, the cross-modal cueing task is combined with the ToS. 3 danger and 3 safety trials are administered in semi-random order (with no more than two subsequent danger or safety trials). After each trials, participants rate the intensity, unpleasantness and threatfulness of the short occlusions, and how anxious they were during the trial. After the last trial, participants are debriefed.

Data-analysis

The data will be analyzed using repeated measures ANOVA. To test for potential mediators and moderators, we will use multilevel analysis.

Study 3.2 Influence of exposure/sensory monitoring on the perception of asthma-like sensations in a threatening context

Background

If the influences of threatening information and personality-related sensitivity to threatening information can be investigated using the combination of a threat of suffocation manipulation and a cross-modal cuing task proposed in study 3.1, a next step would be to investigate whether interventions aimed at changing inaccurate perception of asthma symptoms can be evaluated using the same experimental setup. Based on our working model, we proposed various interventions that can improve inaccurate perception of asthma symptoms (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, in press). Using analogous interventions in a laboratory context can provide us with insights on the processes involved in improving asthma symptom perception. Furthermore it may indicate the efficacy of the interventions in a well controlled situation and provide evidence on how the various interventions induce change in the underlying mechanisms of symptom perception.

Methods

Participants

Participants (n=75) are students with asthma, some of them are first year psychology students, who participate for course credit, others are recruited from the broad student community, or via general practitioners.

Treatment strategies

Exposure to the threatening stimulus

The exercise is designed to habituate the anxious response to the suffocating stimulus. In a 20 minute task, the suffocating stimulus (the same respiratory load as in the first part of the experiment) will be administered several times to the participants. After each administration, participants have to rate the intensity and unpleasantness of the stimulus.

Maintaining a sensory focus

The exercise is designed to help participants maintain a sensory focus during the experience of the suffocating stimulus. In a 20 minute task, participants first are reminded of the difference in perception of intensity and unpleasantness. Subsequently, they get instructions on how to focus on sensory information. Afterwards they practice maintaining a sensory focus on a variety of stimuli, ending with the suffocation stimulus.

Distraction task

The exercise is designed to help participants distract from the unpleasant feeling of the suffocation stimulus by engaging them in a attention-demanding task. In a 20 minute task, participants are introduced to the distracting task and practice this task in various context, ending with anticipation of, and confrontation with the suffocation stimulus.

Materials

The self-report measures and apparatus are the same as in study 3.1.

Procedure

Participants are informed about the experiment using the informed consent form. As in study 3.1, the attentional task is introduced as a task in which the participants will have to react to different types (lengths) of occlusions and rate these asthma like sensations on intensity and unpleasantness. After signing the consent form, they start with filling out the questionnaires (PANAS, fear of suffocation, ASC). Following the questionnaires, participants receive instructions for the cross-modal cueing task, and a practice trial follows. After the cueing trail, participants rate the intensity, unpleasantness and threatfulness of the occlusions, and rate how anxious they were during the trail. An Exposure to the suffocation stimulus follows. Participants rate the intensity, unpleasantness and threatfulness and rate how similar they think the suffocating stimulus is to an asthma attack. Subsequently, the danger and safety instructions are introduced. Finally, the cross-modal cueing task is combined with the ToS: a danger trial and a safety trial are administered, (counterbalanced). After each trial, participants rate intensity, unpleasantness and threatfulness and how anxious they were during the trial. Following the danger and safety trial, participants receive the treatment. Treatment is randomized across participants. After the treatment, a danger and safety trial follows (counterbalanced), again with ratings of intensity, unpleasantness and threatfulness of the short occlusions, and how anxious they were during the trial. Finally, participants are debriefed.

Data-analysis

The data will be analyzed using repeated measures ANOVA. To test for potential mediators and moderators, we will use multilevel analysis.

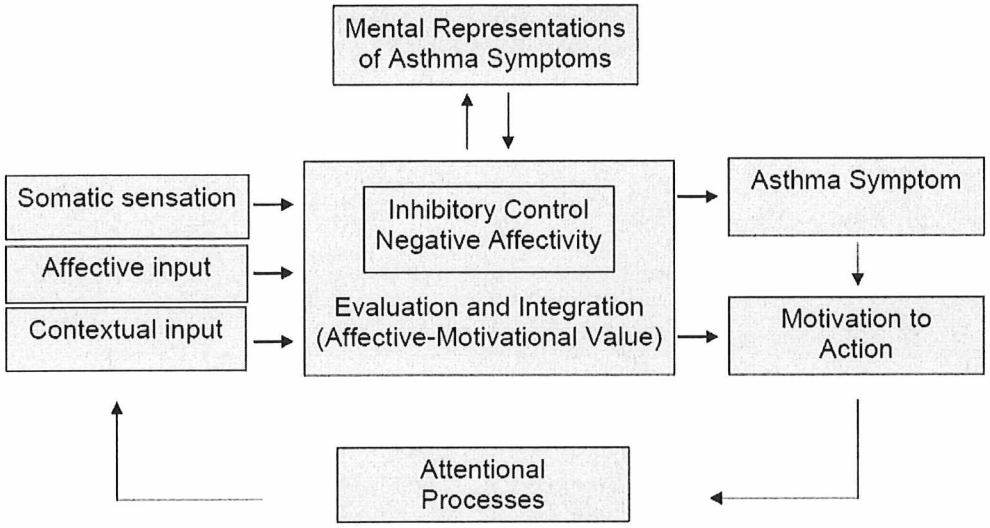


Figure 1. A working model of symptom perception in asthma

Table 1: Results of the multi-level analysis (dependent variable: intensity of asthma symptoms)

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
fixed effects: F(df)						
intercept	172.22 (1,59.2)***	84.35 (1,64.34)***	78.46 (1,60.12)***	114.11 (1,97.84)***	16.49 (1,71.34)***	12.97 (1,77.11)**
FEV1		339.69 (1,365.82)***	133.12 (1,61.46)***	24.26 (1,130.44)***	24.30 (1,130.26)***	22.72 (1,126.85)***
Moment				5.14 (8,331.18)***	5.24 (8,330.86)***	1.14 (8,323.05)
NA					6.48 (1,60.39)*	8.45 (1,67.42)**
NA*Moment						1.40 (8,307.85)
random effects: (co)variance (SE)						
intercept	279.48 (59.74)***	308.34 (60.76)***	329.27 (64.65)***	323.20 (63.15)***	306.26 (60.34)***	303.95 (59.51)***
FEV1			0.47 (0.12)***	0.39 (0.10)***	0.39 (0.10)***	0.39 (0.10)***
int,FEV1			2.38 (2.02)	2.11 (1.86)	3.10 (1.89)	2.54 (1.83)
residual	309.48 (22.96)***	159.77 (11.85)***	104.69 (8.46)***	95.35 (7.71)***	95.30 (7.70)***	91.92 (7.46)***
model fit						
deviance	3754	3514	3442	3403	3397	3386
AIC	3760	3522	3454	3431	3427	3431

df: Satterthwaite's approximation

*: p<.05 **:p<.01 ***p<.001

Table 2: Results of the multi-level analysis (dependent variable: unpleasantness of asthma symptoms)

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
fixed effects: F(df)						
intercept	143.24 (1,58.14)***	70.98 (1,62.99)***	68.43 (1,58.98)***	110.77 (1,95.81)***	14.24 (1,68.00)***	12.53 (1,75.52)**
FEV1		302.26 (364.63)***	111.79 (1,59.48)***	14.07 (1,127.71)***	13.94 (1,127.58)***	12.92 (1,123.31)***
Moment				6.15 (8,323.73)***	6.23 (8,323.93)***	1.79 (8,309.12)
NA					7.65 (1,58.40)**	7.51 (1,66.81)**
NA*Moment						0.38 (8,294.63)
random effects: (co)variance (SE)						
intercept	366.43 (77.82)***	391.99 (77.80)***	407.14 (80.71)***	404.43 (79.72)***	368.61 (73.65)***	369.27 (73.86)***
FEV1			0.60 (0.15)***	0.48 (0.12)***	0.48 (0.12)***	0.50 (0.13)***
int,FEV1			2.46 (2.54)	1.78 (2.31)	2.43 (2.25)	2.44 (2.30)
residual	359.31 (26.66)***	196.49 (14.59)***	129.26 (10.46)***	118.10 (9.66)***	118.00 (9.64)***	119.30 (9.88)***
model fit						
deviance	3819	3602	3530	3455	3448	3443
AIC	3823	3606	3538	3463	3456	3452

df: Satterthwaite's approximation

*: p<.05 **:p<.01 ***p<.001

Table 3: Cross-correlations inaccurate perception of symptom intensity

	rho intens fev	SENS SLOPE	SENS INT	SENS V20-BL	SENS V20-SALINE	SENS V20-FINAL h	SENS PLACEBO-V20	SENS V20-V20 PRED
rho intens fev	1,00	0,59	0,06	-0,13	0,10	0,55	-0,11	0,09
SENS SLOPE	0,59	1,00	0,24	-0,27	-0,08	0,79	0,11	-0,04
SENS INT	0,06	0,24	1,00	-0,30	-0,23	0,05	0,10	-0,33
SENS V20-BL	-0,13	-0,27	-0,30	1,00	0,63	0,23	-0,10	0,68
SENS V20-SALINE	0,10	-0,08	-0,23	0,63	1,00	0,38	-0,24	0,83
SENS V20-FINAL h	0,55	0,79	0,05	0,23	0,38	1,00	-0,04	0,44
SENS PLACEBO-V20	-0,11	0,11	0,10	-0,10	-0,24	-0,04	1,00	-0,19
SENS V20-V20 PRED	0,09	-0,04	-0,33	0,68	0,83	0,44	-0,19	1,00

Table 4: Cross-correlations inacuurate perception of symptom unpleasantness

	AFF SLOPE	AFF INT	rho aff fev	AFF V20-BL	AFF V20-SALINE	AFF V20-FINAL H	AFF PLACEBO-V20	AFF V20-V20 PRED
AFF SLOPE	1,00	0,26	0,66	-0,17	-0,13	0,77	0,09	0,02
AFF INT	0,26	1,00	0,34	-0,41	-0,44	-0,02	0,14	-0,43
rho aff fev	0,66	0,34	1,00	-0,20	-0,11	0,47	0,03	-0,06
AFF V20-BL	-0,17	-0,41	-0,20	1,00	0,80	0,35	-0,13	0,77
AFF V20-SALINE	-0,13	-0,44	-0,11	0,80	1,00	0,38	-0,26	0,85
AFF V20- FINAL H	0,77	-0,02	0,47	0,35	0,38	1,00	-0,02	0,53
AFF PLACEBO-V20	0,09	0,14	0,03	-0,13	-0,26	-0,02	1,00	-0,23
AFF V20-V20 PRED	0,02	-0,43	-0,06	0,77	0,85	0,53	-0,23	1,00

Table 5: Correlation of indices of inaccurate perception with NA, Symptoms, lung function

	rho aff fev	rho intens fev	AFF SLOPE	AFF INT	SENS SLOPE	SENS INT	SENS V20-BL	SENS V20-SALINE	SENS V20-FINAL h	SENS PLACEBO-V20	SENS V20-V20 PRED	AFF V20-BL	AFF V20-SALINE	AFF V20-FINAL H	AFF PLACEBO-V20	AFF V20-V20 PRED
NA	0,16	0,04	0,00	0,29	-0,14	0,20	0,16	0,00	-0,03	0,00	0,09	0,00	-0,07	0,05	0,00	0,02
ASC	-0,05	-0,15	0,03	0,42	0,03	0,35	-0,01	-0,01	0,03	0,15	0,05	-0,09	-0,14	-0,03	0,17	-0,04
PC20	-0,19	-0,15	-0,42	-0,15	-0,30	-0,12	0,22	0,15	-0,16	0,11	-0,01	0,21	0,17	-0,26	0,09	0,01
BL % pred	-0,24	-0,34	-0,05	0,02	-0,08	0,02	-0,03	-0,08	-0,05	0,15	-0,08	-0,05	-0,02	-0,04	0,17	-0,06
ASC Anxiety	-0,04	-0,11	0,05	0,40	0,02	0,31	-0,01	-0,08	0,00	0,10	0,01	-0,15	-0,22	-0,06	0,14	-0,11

Table 6: Correlations between binary indices of inaccurapte perception with NA, symptoms and lung function

	Cutoff 1,5 SD above mean							Cutoff 1SD above Mean				
	Sens V20-BL	**Sens V20-Saline**	**Sens V20-V20 pred**	**Aff V20-BL**	**Aff V20-Saline**	**Aff V20-V20 pred**	**Sens V20-BL**	**Sens V20-Saline**	**Sens V20-V20 pred**	**Aff V20-BL**	**Aff V20-Saline**	**Aff V20-V20 pred**
NA	0,18	0,28*	0,18	0,19	0,24$	0,18	0,25$	0,25$	0,24$	0,28*	0,19	0,18
ASC	0,02	0,07	0,02	-0,06	-0,04	-0,04	0,00	0,02	0,02	0,07	-0,06	-0,07
PC20	0,22$	0,15	0,22$	0,08	0,17	0,18	0,14	0,13	0,10	0,12	0,29*	0,26$
BL % pred	0,04	0,05	0,04	0,00	0,03	0,10	-0,07	0,02	0,06	-0,09	0,07	0,12
ASC Anxiety	-0,01	0,04	-0,01	-0,08	-0,06	-0,07	-0,02	0,01	-0,03	0,03	-0,08	-0,12

*: p<.05 $: p<.10

Reference List

Abraham, C., Costa-Pereira, A., Du, V. F., & Ogston, S. (1999). Cognitions associated with initial medical consultations concerning recurrent breathing difficulties: a community-based study. *Psychology & Health, 14,* 913.

Affleck, G., Apter, A., Tennen, H., Reisine, S., Barrows, E., Willard, A. et al. (2000). Mood States Associated With Transitory Changes in Asthma Symptoms and Peak Expiratory Flow. *Psychosomatic Medicine, 62,* 61-68.

Appelhans, B. M., & Luecken, L. J. (2006). Heart Rate Variability as an Index of Regulated Emotional Responding. *Review of General Psychology, 10,* 229-240.

Asmundson, G. J. G., Norton, P. J., & Norton, G. R. (1999). Beyond pain: The role of fear and avoidance in chronicity. *Clinical Psychology Review, 19,* 97-119.

Austin, D. W., & Richards, J. C. (2001). The catastrophic misinterpretation model of panic disorder. *Behaviour Research and Therapy, 39,* 1277-1291.

Banzett, R. B., Dempsey, J. A., O'Donnell, D. E., & Wamboldt, M. Z. (2000). Symptom Perception and Respiratory Sensation in Asthma. *American Journal of Respiratory and Critical Care Medicine, 162,* 1178-1182.

Banzett, R. B., & Moosavi, S. H. (2001). Dyspnea and pain: Similarities and contrasts between two very unpleasant sensations. *American Pain Society Bulletin, 11,* 1-6.

Beck, J. G., Shipherd, J. C., & Zebb, B. J. (1997). How does interoceptive exposure for Panic Disorder work? an uncontrolled case study. *Journal of Anxiety Disorders, 11,* 541-556.

Bijl-Hofland, I. D., Cloosterman, S. G. M., van Schayck, C. P., Elshout, F. J. J., Akkermans, R. P., & Folgering, H. T. (2000). Perception of Respiratory Sensation Assessed by Means of Histamine Challenge and Threshold Loading Tests. *Chest, 117,* 954-959.

Bogaerts, K., Notebaert, K., Van Diest, I., Devriese, S., De Peuter, S., & Van den Bergh, O. (2005). Accuracy of respiratory symptom perception in different affective contexts. *Journal of Psychosomatic Research, 58,* 537-543.

Boulet, L. P., Leblanc, P., & Turcotte, H. (1994). Perception scoring of induced bronchoconstriction as an index of awareness of asthma symptoms. *Chest, 105,* 1430-1433.

Brown, R. J. (2004). Psychological Mechanisms of Medically Unexplained Symptoms: An Integrative Conceptual Model. *Psychological Bulletin, 130,* 793-812.

Cameron, L. D., Leventhal, H., & Love, R. R. (1998). Trait Anxiety, Symptom Perceptions, and Illness-Related Responses Among Women With Breast Cancer in Remission During a Tamoxifen Clinical Trial. *Health Psychology, 17,* 459-469.

Carr, R. E. (1998). Panic disorder and asthma: Causes, effects and research implications. *Journal of Psychosomatic Research, 44,* 43-52.

Chen, E., Hermann, C., Rodgers, D., Oliver-Welker, T., & Strunk, R. C. (2006). Symptom Perception in Childhood Asthma: The Role of Anxiety and Asthma Severity. *Health Psychology May, 25,* 389-395.

Ciccone, D. S., Chandler, H. K., Pate-Carolan, L., Janal, M. N., & Lavietes, M. H. (2007). A Test of the Symptom Amplification Hypothesis in Patients With Asthma. *Journal of Nervous & Mental Disease, 195,* 119-124.

Cioffi, D. (1991). Beyond Attentional Strategies: A Cognitive-Perceptual Model of Somatic Interpretation. *Psychological Bulletin, 109,* 25-41.

Cockcroft, D. W., Killian, D. N., Mellon, J. J. A., & Hargreave, F. E. (1977). Bronchial reactivity to inhaled histamine: a method and clinical survey. *Clinical Allergy, 7,* 235-243.

Craig, A. D. (2003). Interoception: the sense of the physiological condition of the body. *Current Opinion in Neurobiology, 13,* 500-505.

Craske, M. G., & Barlow, D. H. (2007). *Mastery of Your Anxiety and Panic: Therapist Guide.* (4th ed.) Oxford, UK: Oxford University Press.

Craske, M. G., Rowe, M., Lewin, M., & Noriega-Dimitri R. (1997). Interoceptive exposure versus breathing retraining within cognitive-behavioural therapy for panic disorder with agoraphobia. *British Journal of Clinical Psychology, 36,* 85-99.

Davenport, P. W., Cruz, M., Stecenko, A. A., & Kifle, Y. (2000). Respiratory-related Evoked Potentials in Children with Life-threatening Asthma. *American Journal of Respiratory and Critical Care Medicine, 161,* 1830-1835.

Davey, G. C. L. (1995). Preparedness and phobias: Specific evolved associations or a generalized expectancy bias. *Behavioral and Brain Sciences, 18,* 289-325.

De Clerck, A., Verschuere, B., Crombez, G., & De Vlieger, P. (2006). Psychophysiological analysis (PSPHA): a modular script based program for analyzing psychophysiological data. *Behavior Research Methods, 38,* 504-510.

De Peuter, S., Van Diest, I., Lemaigre, V., Verleden, G., Demedts, M., & Van den Bergh, O. (2004). Dyspnea: The role of psychological processes. *Clinical Psychology Review, 24,* 557-581.

De Peuter, S., Victoir, A., Lemaigre, V., Van Diest, I., Verleden, G., Demedts, M. et al. (2006). Catastrophic Thinking And Symptom Perception In Asthma: Validation Of A Questionnaire. *The Internet Journal of Asthma, Allergy and Immunology, 5.*

De Peuter, S., Lemaigre, V., Van Diest, I., & Van den Bergh, O. (2008). Illness-Specific Catastrophic Thinking and Overperception in Asthma. *Health Psychology January, 27,* 93-99.

De Peuter, S., Lemaigre, V., Van Diest, I., Verleden, G., Demedts, M., & Van den Bergh, O. (2007a). Differentiation between the sensory and affective aspects of histamine-induced bronchoconstriction in asthma. *Respiratory Medicine, 101,* 925-932.

De Peuter, S., Put, C., Lemaigre, V., Demedts, M., Verleden, G., & Van den Bergh, O. (2007b). Context-evoked overperception in asthma. *Psychology & Health, 22,* 737-748.

De Peuter, S., Van Diest, I., Lemaigre, V., Li, W., Verleden, G., Demedts, M. et al. (2005). Can Subjective Asthma Symptoms Be Learned? *Psychosomatic Medicine, 67,* 454-461.

Deshmukh, V. M., Toelle, B. G., Usherwood, T., O'Grady, B., & Jenkins, C. R. (2007). Anxiety, panic and adult asthma: A cognitive-behavioral perspective. *Respiratory Medicine, 101,* 194-202.

Devriese, S., Winters, W., Stegen, K., Van Diest, I., Veulemans, H., Nemery, B. et al. (2000). Generalization of Acquired Somatic Symptoms in Response to Odors: A Pavlovian Perspective on Multiple Chemical Sensitivity. *Psychosomatic Medicine, 62,* 751-759.

Diette, G. B., Wu, A. W., Skinner, E. A., Markson, L., Clark, R. D., McDonald, R. C. et al. (1999). Treatment Patterns Among Adult Patients With Asthma: Factors Associated With Overuse of Inhaled {beta}-Agonists and Underuse of Inhaled Corticosteroids. *Archives of Internal Medicine, 159,* 2697-2704.

Eccleston, C., & Crombez, G. (1999). Pain Demands Attention: A Cognitive-Affective Model of the Interruptive Function of Pain. *Psychological Bulletin, 125,* 356-366.

Fannes, S., Van Diest, I., Meulders, A., De Peuter, S., Vansteenwegen, D., & Van den Bergh, O. (2008). To inhale or not to inhale: Conditioned avoidance in breathing behavior in an odor--20% CO2 paradigm. *Biological Psychology, 78,* 87-92.

Feldman, J. M., Siddique, M. I., Thompson, N. S., & Lehrer, P. M. (2009). The role of panic-fear in comorbid asthma and panic disorder. *Journal of Anxiety Disorders, 23,* 178-184.

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do Threatening Stimuli Draw or Hold Visual Attention in Subclinical Anxiety?. *Journal of Experimental Psychology: General, 130,* 681-700.

Friedman, B. H., Thayer, J. F., & Borkovec, T. D. (1993). Heart rate variability in generalized anxiety disorder. Psychophysiology 30, S28.

Fritz, G. K., Adams, S. K., McQuaid, E. L., Klein, R., Kopel, S., Nassau, J. et al. (2007). Symptom Perception in Pediatric Asthma: Resistive Loading and In Vivo Assessment Compared. *Chest, 132,* 884-889.

Global Initiative for Asthma (GINA) (2006). *Global Strategy for Asthma Management and Prevention.*

Goubert, L., Crombez, G., Eccleston, C., & Devulder, J. (2004). Distraction from chronic pain during a pain-inducing activity is associated with greater post-activity pain. *Pain, 110,* 220-227.

Grillon, C. (2002). Startle reactivity and anxiety disorders: aversive conditioning, context, and neurobiology. *Biological Psychiatry, 52,* 958-975.

Harver, A. (1994). Effects of Feedback on the Ability of Asthmatic Subjects to Detect Increases in the Flow-Resistive Component to Breathing. *Health Psychology, 13,* 52-62.

Hermans, D., Clarysse, J., Baeyens, F., & Spruyt, A. (2005). Affect (Version 4.0) [Computer software; retrieved from http://www.psy.kuleuven.ac.be/leerpsy/affect4]. University of Leuven, Belgium.

Hofmann, S. G. (2008). Cognitive processes during fear acquisition and extinction in animals and humans: Implications for exposure therapy of anxiety disorders. *Clinical Psychology Review, 28,* 199-210.

Huntley, A., White, A. R., & Ernst, E. (2002). Relaxation therapies for asthma: a systematic review. *Thorax, 57,* 127-131.

Isenberg, S. A., Lehrer, P. M., & Hochron, S. (1992a). The effects of suggestion on airways of asthmatic subjects breathing room air as a suggested bronchoconstrictor and bronchodilator. *Journal of Psychosomatic Research, 36,* 769-776.

Isenberg, S. A., Lehrer, P. M., & Hochron, S. (1992b). The effects of suggestion and emotional arousal on pulmonary function in asthma: a review and a hypothesis regarding vagal mediation. *Psychosomatic Medicine, 54,* 192-216.

Janssens, T., Verleden, G., De Peuter, S., Van Diest, I., & Van den Bergh, O. (in press). Inaccurate perception of asthma symptoms: A cognitive-affective framework and implications for asthma treatment. *Clinical Psychology Review.*

Julius, S. M., Davenport, K. L., & Davenport, P. W. (2002). Perception of intrinsic and extrinsic respiratory loads in children with life-threatening asthma. *Pediatric Pulmonology, 34,* 425-433.

Juniper, E. F., Guyatt, G. H., Epstein, R. S., Ferrie, P. J., Jaeschke, R., & Hiller, T. K. (1992). Evaluation of impairment of health related quality of life in asthma: development of a questionnaire for use in clinical trials. *Thorax, 47,* 76-83.

Katon, W. J., Richardson, L., Lozano, P., & McCauley, E. (2004). The Relationship of Asthma and Anxiety Disorders. *Psychosomatic Medicine, 66,* 349-355.

Katz, P. P., Yelin, E. H., Eisner, M. D., & Blanc, P. D. (2002). Perceived control of asthma and quality of life among adults with asthma. *Annals of Allergy, Asthma and Immunology, 89,* 251-258.

Kelly, M. M., & Forsyth, J. P. (2007). Observational Fear Conditioning in the Acquisition and Extinction of Attentional Bias for Threat: An Experimental Evaluation. *Emotion, 7,* 324-335.

Kendrick, A. H., Higgs, C. M. B., Whitfield, M. G., & Laszlo, G. (1993). Accuracy of perception of severity of asthma: patients treated in general practice. *BMJ, 307,* 422-424.

Larsen, J. T., Berntson, G. G., Poehlmann, K. M., Ito, T. A., & Cacioppo, J. T. (2008). The Psychophysiology of Emotion. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of Emotions* (3rd ed., pp. 180-195). New York: Guilford.

Lehrer, P., Feldman, J., Giardino, N., Song, H. S., & Schmaling, K. (2002). Psychological aspects of asthma. *Journal of Consulting and Clinical Psychology, 70,* 691-711.

Lehrer, P., Vaschillo, E., Lu, S. E., Eckberg, D., Vaschillo, B., Scardella, A. et al. (2006). Heart Rate Variability Biofeedback: Effects of Age on Heart Rate Variability, Baroreflex Gain, and Asthma. *Chest, 129,* 278-284.

Lehrer, P. M., Karavidas, M. K., Lu, S. E., Feldman, J., Kranitz, L., Abraham, S. et al. (2008). Psychological treatment of comorbid asthma and panic disorder: A pilot study. *Journal of Anxiety Disorders, 22,* 671-683.

Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S. E., Eckberg, D. L., Edelberg, R. et al. (2003). Heart Rate Variability Biofeedback Increases Baroreflex Gain and Peak Expiratory Flow. *Psychosomatic Medicine, 65,* 796-805.

Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S. E., Scardella, A., Siddique, M. et al. (2004). Biofeedback Treatment for Asthma. *Chest, 126,* 352-361.

Lemaigre, V., Van den Bergh, O., Smets, A., De Peuter, S., & Verleden, G. M. (2006). Effects of long-acting bronchodilators and placebo on histamine-induced asthma symptoms and mild bronchusobstruction. *Respiratory Medicine, 100,* 348-353.

Leventhal, H., Meyer, D., & Nerenz, D. (1980). The common sense representation of illness danger. *Contributions to medical psychology, 2,* 7-30.

Macleod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111,* 107-123.

Magadle, R., Berar-Yanay, N., & Weiner, P. (2002). The Risk of Hospitalization and Near-Fatal and Fatal Asthma in Relation to the Perception of Dyspnea. *Chest, 121,* 329-333.
Main, J., Moss-Morris, R., Booth, R., Kaptein, A. A., & Kolbe, J. (2003). The Use of Reliever Medication in Asthma: The Role of Negative Mood and Symptom Reports. *Journal of Asthma, 40,* 357-365.
Marcel, A. J. (1983). Conscious and unconscious perception: An approach to the relations between phenomenal experience and perceptual processes. *Cognitive Psychology, 15,* 238-300.
Mathews, A., & MacLeod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognition & Emotion, 16,* 331-354.
McCracken, L. M. P., & Turk, D. C. P. (2002). Behavioral and Cognitive-Behavioral Treatment for Chronic Pain: Outcome, Predictors of Outcome, and Treatment Process. *Spine, 27,* 2564-2573.
Meek, P. M. (2000). Influence of Attention and Judgment on Perception of Breathlessness in Healthy Individuals and Patients With Chronic Obstructive Pulmonary Disease. [Article]. *Nursing Research, 49,* 11-19.
Mennin, D., & Farach, F. (2007). Emotion and Evolving Treatments for Adult Psychopathology. *Clinical Psychology: Science and Practice, 14,* 329-352.
Mineka, S., & Zinbarg, R. (2006). A Contemporary Learning Theory Perspective on the Etiology of Anxiety Disorders: It's Not What You Thought It Was. *American Psychologist, 61,* 10-26.
Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36,* 809-848.
Mogg, K., McNamara, J., Powys, M., Rawlinson, H., Seiffer, A., & Bradley, B. P. (2000). Selective attention to threat: A test of two cognitive models of anxiety. *Cognition & Emotion, 14,* 375-399.
Morley, S., Shapiro, D. A., & Biggs, J. (2004). Developing a treatment manual for attention management in chronic pain. *Cognitive Behaviour Therapy, 33,* 1-11.
Moss-Morris, R., Weinman, J., Petrie, K. J., Horne, R., Cameron, L. D., & Buick, D. (2002). The Revised Illness Perception Quetionnaire(IPQ-R). *Psychology & Health, 17,* 1.
Nouwen, A., Freeston, M. H., Cournoyer, I., Deschesnes, F., & Boulet, L. P. (1994). Perceived symptoms and discomfort during induced bronchospasm: the role of temporal adaptation and anxiety. *Behaviour Research and Therapy, 32,* 623-628.
Passalacqua, G., Bousquet, P. J., Carlsen, K. H., Kemp, J., Lockey, R. F., Niggemann, B. et al. (2006). ARIA update: I--Systematic review of complementary and alternative medicine for rhinitis and asthma. *Journal of Allergy and Clinical Immunology, 117,* 1054-1062.
Patel, V. L., Arocha, J. F., & Kaufman, D. R. (2001). A Primer on Aspects of Cognition for Medical Informatics. *Journal of the American Medical Informatics Association, 8,* 324-343.
Pennebaker, J. W. (1982). *The Psychology of Physical Symptoms*. New York: Springer.
Pincus, T., & Morley, S. (2001). Cognitive-Processing Bias in Chronic Pain: A Review and Integration. *Psychological Bulletin, 127,* 599-617.
Put, C., Demedts, M., Van den Bergh, O., Demyttenaere, K., & Verleden, G. (1999). Asthma symptoms: influence of personality versus clinical status. *European Respiratory Journal, 13,* 751-756.
Put, C., Van den Bergh, O., Lemaigre, V., Demedts, M., & Verleden, G. (2003). Evaluation of an individualised asthma programme directed at behavioural change. *European Respiratory Journal, 21,* 109-115.
Put, C., Van den Bergh, O., Van Ongeval, E., De Peuter, S., Demedts, M., & Verleden, G. (2004). Negative affectivity and the influence of suggestion on asthma symptoms. *Journal of Psychosomatic Research, 57,* 249-255.
Quanjer, P., Tammeling, G., Cotes, J., Pederson, O., Peslin, R., & Yernault, J. (1993). Lung volumes and forced ventilatory flows. Report working party standardization of lung function tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. *European Respiratory Journal, 16,* 250-267.
Quartana, P., Burns, J., & Lofland, K. (2007). Attentional Strategy Moderates Effects of Pain Catastrophizing on Symptom-Specific Physiological Responses in Chronic Low Back Pain Patients. *Journal of Behavioral Medicine, 30,* 221-231.
Radomsky, A. S., Rachman, S., Thordarson, D. S., McIsaac, H. K., & Teachman, B. A. (2001). The Claustrophobia Questionnaire. *Journal of Anxiety Disorders, 15,* 287-297.
Ram, F. S. F., Holloway, E. A., & Jones, P. W. (2003). Breathing retraining for asthma. *Respiratory Medicine, 97,* 501-507.
Rietveld, S., & Brosschot, J. F. (1999). Current perspectives on symptom perception in asthma: a biomedical and psychological review. *International Journal of Behavioral Medicine, 6,* 120-134.
Rietveld, S., Everaerd, W., & Creer, T. L. (2000). Stress-induced asthma: a review of research and potential mechanisms. *Clinical and Experimental Allergy, 30,* 1058-1066.
Rietveld, S., & Prins, P. J. M. (1998). The relationship between negative emotions and acute subjective and objective symptoms of childhood asthma. *Psychological Medicine, 28,* 407-416.
Rietveld, S., & van Beest, I. (2006). Rollercoaster asthma: When positive emotional stress interferes with dyspnea perception. *Behaviour Research and Therapy, 45,* 977-987.
Rietveld, S., Kolk, A. M., Prins, P. J. M., & Colland, V. T. (1997). The Influence of Respiratory Sounds on Breathlessness in Children With Asthma: A Symptom-Perception Approach. *Health Psychology, 16,* 547-553.
Ritz, T., Bobb, C., Edwards, M., & Steptoe, A. (2001). The structure of symptom report in asthma: A reevaluation. *Journal of Psychosomatic Research, 51,* 639-645.
Ritz, T., Steptoe, A., Bobb, C., Harris, A. H. S., & Edwards, M. (2006). The Asthma Trigger Inventory: Validation of a Questionnaire for Perceived Triggers of Asthma. *Psychosomatic Medicine, 68,* 956-965.
Rubinfeld, A. F., & Pain, M. C. F. (1976). Perception of Asthma. *Lancet, 1,* 882.
Schatz, M., Sorkness, C. A., Li, J. T., Marcus, P., Murray, J. J., Nathan, R. A. et al. (2006). Asthma Control Test: Reliability, validity, and responsiveness in patients not previously followed by asthma specialists. *Journal of Allergy and Clinical Immunology, 117,* 549-556.
Skelton, J. A., & Pennebaker, J. W. (1989). The Psychology of Physical Symptoms and Sensations. In G. S. Sanders & J. Suls (Eds.), *Social Psychology of Health and Illness* (pp. 99-128). Hillsdale, NJ: Lawrence Erlbaum Associates.

Slader, C. A., Reddel, H. K., Spencer, L. M., Belousova, E. G., Armour, C. L., Bosnic-Anticevich, S. Z. et al. (2006). Double blind randomised controlled trial of two different breathing techniques in the management of asthma. *Thorax, 61,* 651-656.
Smith, A., & Nicholson, K. (2001). Psychosocial factors, respiratory viruses and exacerbation of asthma. *Psychoneuroendocrinology, 26,* 411-420.
Spinhoven, P., van Peski-Oosterbaan, A. S., Van der Does, A. J., Willems, L. N., & Sterk, P. J. (1997). Association of anxiety with perception of histamine induced bronchoconstriction in patients with asthma. Thorax, 52, 149-152.
Stegen, K., De Bruyne, K., Rasschaert, W., Van de Woestijne, K. P., & Van den Bergh, O. (1999). Fear-Relevant Images as Conditioned Stimuli for Somatic Complaints, Respiratory Behavior, and Reduced End-Tidal pCO2. *Journal of Abnormal Psychology, 108,* 143-152.
Stegen, K., Van Diest, I., Van de Woestijne, K. P., & Van den Bergh, O. (2001). Do persons with negative affect have an attentional bias to bodily sensations? *Cognition & Emotion, 15,* 813-829.
Stegen, K., Van Diest, I., Van de Woestijne, K. P., & Van den Bergh, O. (2000). Negative affectiviy and bodily sensations induced by 5.5% CO2 enriched air inhalation: is there a bias to interpret bodily sensations negatively in persons with negative affect? *Psychology & Health, 15,* 513.
Stout, C., Kotses, H., & Creer, T. L. (1997). Improving perception of air flow obstruction in asthma patients. *Psychosomatic Medicine, 59,* 201-206.
Teeter, J. G., & Bleecker, E. R. (1998). Relationship between airway obstruction and respiratory symptoms in adult asthmatics. *Chest, 113,* 272-277.
Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders, 61,* 201-216.
Van Damme, S., Crombez, G., & Eccleston, C. (2002). Retarded disengagement from pain cues: the effects of pain catastrophizing and pain expectancy. *Pain, 100,* 111-118.
Van Damme, S., Crombez, G., & Eccleston, C. (2004). Disengagement from pain: the role of catastrophic thinking about pain. *Pain, 107,* 70-76.
Van Damme, S., Crombez, G., Hermans, D., Koster, E. H. W., & Eccleston, C. (2006). The role of extinction and reinstatement in attentional bias to threat: A conditioning approach. *Behaviour Research and Therapy, 44,* 1555-1563.
Van den Bergh, O., Stegen, K., & Van de Woestijne, K. P. (1997). Learning to have psychosomatic complaints: conditioning of respiratory behavior and somatic complaints in psychosomatic patients. *Psychosomatic Medicine, 59,* 13.
Van den Bergh, O., Stegen, K., & Van de Woestijne, K. P. (1998). Memory effects on symptom reporting in a respiratory learning paradigm. *Health Psychology, 17,* 241-248.
Van den Bergh, O., Winters, W., Devriese, S., Van Diest, I., Vos, G., & De Peuter, S. (2004). Accuracy of respiratory symptom perception in persons with high and low negative affectivity. *Psychology & Health, 19,* 213-222.
Van Diest, I., De Peuter, S., Eertmans, A., Bogaerts, K., Victoir, A., & Van den Bergh, O. (2005). Negative affectivity and enhanced symptom reports: Differentiating between symptoms in men and women. *Social Science & Medicine, 61,* 1835-1845.
Von Leupoldt, A., Mertz, C., Kegat, S., Burmester, S., & Dahme, B. (2006a). The impact of emotions on the sensory and affective dimension of perceived dyspnea. *Psychophysiology, 43,* 382-386.
Von Leupoldt, A., & Dahme, B. (2007). Psychological aspects in the perception of dyspnea in obstructive pulmonary diseases. *Respiratory Medicine, 101,* 411-422.
Von Leupoldt, A., & Dahme, B. (2005). Cortical Substrates for the Perception of Dyspnea. *Chest, 128,* 345-354.
Von Leupoldt, A., Mertz, C., Kegat, S., Burmester, S., & Dahme, B. (2006b). The impact of emotions on the sensory and affective dimension of perceived dyspnea. *Psychophysiology, 43,* 382-386.
Von Leupoldt, A., Riedel, F., & Dahme, B. (2006). The impact of emotions on the perception of dyspnea in pediatric asthma. *Psychophysiology, 43,* 641-644.
Warsi, A., Wang, P. S., LaValley, M. P., Avorn, J., & Solomon, D. H. (2004). Self-management Education Programs in Chronic Disease: A Systematic Review and Methodological Critique of the Literature. *Archives of Internal Medicine, 164,* 1641-1649.
Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54,* 1063-1070.
Watson, D., & Pennebaker, J. W. (1989). Health complaints, stress, and distress: Exploring the central role of negative affectivity. *Psychological Review, 96,* 234-254.
Wilson, R. C., & Jones, P. W. (1990). Influence of prior ventilatory experience on the estimation of breathlessness during exercise. *Clinical Science, 78,* 149-153.
Yamamoto, H., Inaba, S., Nishimura, M., Kishi, F., & Kawakami, Y. (1987). Relationship between the ability to detect added resistance at rest and breathlessness during bronchoconstriction in asthmatics. *Respiration, 52,* 42-48.
Yoos, H. L., Kitzman, H., McMullen, A., & Sidora, K. (2003). Symptom Perception in Childhood Asthmas: How Accurate Are Children and Their Parents? *Journal of Asthma, 40,* 27-39.
Yorke, J., Fleming, S. L., & Shuldham, C. (2007). Psychological interventions for adults with asthma: A systematic review. *Respiratory Medicine, 101,* 1-14.

Context-Dependent Perception of Asthma Symptoms

Thomas Janssens
Research Group on Health Psychology – Pneumology Section, Fac. Medicine
Promotors: Prof. Dr. Omer Van den Bergh & Prof. Dr. Geert Verleden

Background: Asthma is a chronic inflammatory disorder characterized by airway hyperresponsiveness and episodes of respiratory complaints (wheezing, shortness of breath, dyspnea, cough), often concurring with reversible airway obstruction (Global Initiative for Asthma (GINA), 2006). Poor symptom perception - a low congruence between
symptom reports and pulmonary function measures - is highly prevalent and considered an important factor in asthma morbidity. It may present itself as overperception or underperception. Research on inaccurate symptom perception has not yet been translated into clinical practice. This may be due to: (1) a conceptualisation of under- and overperception as stable trait-like variables; (2) a lack of easy to use diagnostic tools; (3) a lack of protocols to remediate inaccurate perception. In this research project, we present and test a theoretical framework challenging the assumption that under- and overperception are trait-like variables and present research aimed at further improving this framework and its implications on diagnosis and treatment of inaccurate perception of asthma symptoms.

Theoretical framework: In a recent review paper (Janssens et al., in press), we showed that under- and overperception of asthma symptoms can occur within the same person and that inaccurate perception of asthma symptoms is context-dependent. We developed a new theoretical model, which can predict if the perception of asthma symptoms by a specific person in a specific situation will be accurate or inaccurate, and whether under- or overperception will occur. Furthermore, the model can explain why some interventions improve asthma symptoms and quality of life, despite generating no changes in underlying asthma physiology. The model is built on the premise that asthma symptoms are the result of an integration of different types of information, and consists of an evaluation of the affective and motivational (threatening) value of this information. Types of information involved in this evaluation are (1) the intensity of the sensation; (2) concurrent contextual and affective information; (3) mental representations of asthma symptoms; (4) a general tendency to have negative experiences (negative affectivity).

Overview of studies:

1. A diagnostic tool for context-dependent symptom perception in asthma
Based on the model of symptom perception in asthma, we adapted the histamine challenge test, which is standardly used in the diagnostic process for asthma, to include a measure of context-dependent perception of asthma symptoms. In a *first study*, we developed several indices of context-dependent perception and related these to measures of asthma severity, personality and perceptual sensitivity. Multi-level results show that even when controlling for decline in lung function, asthma symptoms are influenced by the context of the histamine challenge test. Furthermore, logistic regression shows a higher level of NA increases the odds a patient shows inaccurate perception of asthma symptoms, according to the symptom perception index ($OR=1.18$, $\chi2(df=1)=4.10$; $p<.05$).In a *follow up study,* the predictive value of context-dependent perception for asthma outcome and mental representations of asthma symptoms is investigated.

2. Test and elaboration of the model of symptom perception in asthma in a real life context
Using a *diary methodology*, we want to test the predictions of the model in a setting that goes beyond the laboratory setting. We want to replicate the finding that negative affective states and contextual cues influence asthma symptoms and investigate whether this effect is moderated by personality characteristics. Furthermore, we will investigate the influence of the symptom perception process on medication intake.

3. An experimental inquiry into the mechanisms of context-dependent perception of asthma symptoms.
Using *a series of laboratory studies*, we will investigate the role of threat level, attention and avoidance behavior - and their interrelatedness - in the symptom perception process. The interrelatedness of these variables has already been studied in the context of anxiety and pain and a replication in the domain of asthma and respiratory sensations would strengthen our model and can lead information about an optimal way of constructing psychological interventions for inaccurate perception of asthma symptoms.

Janssens, T., Verleden, G., De Peuter, S., Van Diest, I., & Van den Bergh, O. (2009, in press). Inaccurate perception of asthma symptoms: A cognitive-affective framework and implications for asthma treatment. Clinical Psychology Review (doi:10.1016/j.cpr.2009.02.006)

Committee members
President : G. D'Ydewalle; promotors : O. Van den Bergh & G. Verleden (Fac Geneeskunde, KULeuven); members : I. Van Diest (PPW, K.U.Leuven), L. Dupont (Fac Geneeskunde, KULeuven), P. Kuppens (PPW, KULeuven), G.Crombez (U.Gent), P. Lehrer (UMDNJ -- Robert Wood Johnson Medical School, New Jersey)