26th Annual Meeting of the International Society for the Advancement of Respiratory Psychophysiology

October 4-6, 2019

Vevey, Switzerland

PROGRAM and ABSTRACTS
**ISARP Conference Committee**

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**ISARP Mission Statement**

The purpose of ISARP is to promote and advance knowledge of the interrelationships between psychological and physiological aspects of respiration in research and application.
Past ISARP Presidents

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1998-1999  Harry Kotses
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2004-2005  Omer Van den Bergh
2005-2006  Paul Lehrer
2006-2007  Paul Grossman
2007-2008  Elizabeth McQuaid
2008-2009  Andreas Von Leupoldt
2009-2010  Nicholas Giardino
2010-2011  Paul Davenport
2011-2012  Jonathan Feldman
2012-2013  Ilse Van Diest
2013-2014  Daphne Koinis-Mitchell
2014-2015  Alicia Meuret
2015-2017  Karen Hegland
2017-2019  Michelle Troche
Past Meeting Locations and Program Chairs

1994 - Saint Flour, France; Gila Benchetrit and Ronald Ley
1995 - Toronto, Canada; Andrew Harver
1996 - Nijmegen, The Netherlands; Hans Folgering
1997 - Cape Cod, United States; Ronald Ley and Lawrence Schleifer
1998 - Perpignan, France; Francois Ceugniet and Jorge Gallego
1999 - Granada, Spain; Berhard Dahme
2000 - San Diego, United States; Dick Gevirtz
2001 - Oxford, United Kingdom; Bill Gardner
2002 - Washington, United States; Thomas Ritz
2003 - Leuven, Belgium; Omer Van den Bergh
2004 - Princeton, United States; Paul Lehrer
2005 - Hamburg, Germany; Andreas von Leupoldt
2006 - Newport, United States; Beth McQuaid
2007 - Bristol, England; Adrian Kendrick and Sandy Jack
2008 - Ann Arbor, United States; Nicholas Giardino
2009 - Berlin, Germany; Ilse Van Diest
2010 - New York, United States; Jonathan Feldman
2011 - Athens, Greece; Daphne Koinis Mitchell
2012 - Orlando, United States; Paul Davenport
2013 - Leuven, Belgium; Elke Vlemincx
2014 - New Brunswick, United States; Paul Lehrer
2015 - Seville, Spain; Thomas Janssens and Thomas Ritz
2016 – Seattle; USA, Jan-Marino Ramirez
2017 - Lille, France; Cecile Chenevesse
2018 – Gainesville, United States; Karen Hegland
2019 – Vevey, Switzerland; Paul Davenport, Cecile Chenevesse, Sarah Miller, Matthew Davenport and Pei-Ying Chan
## Program overview

### FRIDAY, October 4

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<td>Emotional consequences of dyspnea variability</td>
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<td>15:00</td>
<td>Soraya Bordier, Cecile Chenivesse, Thierry Perez &amp; Nathalie Bautin</td>
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<td>15:00</td>
<td>Everyday cognitive failure in patients suffering from hyperventilation syndrome Soraya Bordier, David Nunes, Nathalie Bautin, Camille Audousset, Thierry Perez &amp; Cecile Chenivesse</td>
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<td>15:20</td>
<td>Odor-induced placebo/nocebo effects on FeNO in asthma: Exploring potential mediators and moderators Thomas Janssens, Daniel Vigo, Lieven Dupont, &amp; Omer Van den Bergh</td>
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<td>16:00</td>
<td>Invited Address: Dr. Bruce D. Miller</td>
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<td>16:00</td>
<td>Where Asthma Fits in Respiratory Psychophysiology: An Inverse Translational Approach</td>
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SATURDAY, October 5

8:30  9:00  Registration and Welcome coffee

9:00  10:20  Symposium 2:  
Chair: Dr. Thomas Janssens

9:00  9:20  S2.1  Is breathing always in phase with heart rate variability during resonance frequency breathing?  
Paul Lehrer, Vinay Vidali & Evgeny Vaschillo

9:20  9:40  S2.2  The relaxation effects of slow breathing beyond breathing awareness  
Elke Vlemincx, Sabrina Mohammed Nasir & Elsa-Pauline Noelle Du Rietz Burke

9:40  10:00  S2.3  Respiratory variability in university music students with low and high levels of music performance anxiety  
A. Guyon, R. Cannavò, R.K. Studer, H. Hildebrandt, E. Vlemincx & P. Gomez

10:00  10:20  S2.4  Using rhythmical sighing to test mechanisms of regulation in the baroreflex system  
Evgeny G. Vaschillo, Bronya Vaschillo & Jennifer F. Buckman

10:20  10:40  Coffee/Tea Break

10:40  11:20  Symposium 3:  
Chair: Dr. Matthew P. Davenport

10:40  11:00  S3.1  Unpredictability increases dyspnea unpleasantness, anxiety and interoceptive error processing  
Yafei Tan, Omer Van den Bergh, Jiang Qiu & Andreas von Leupoldt

11:00  11:20  S3.2  Brain activation patterns during symptom induction through negative picture viewing in patients with somatic symptom disorder  
Omer Van den Bergh, Daniëlle Jongen, Maaike Van Den Houte, Katleen Bogaerts & Lukas Van Oudenhove

11:30  12:30  Invited Address: Dr. Justin Feinstein  
Searching for the source of suffocation false alarms in the human brain

12:30  14:00  Lunch (on your own)
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<td>14:00</td>
<td>S4.1</td>
<td>The occlusion differentiation task: a new measure of accuracy of respiratory Sensations</td>
<td>Maaike Van Den Houte, Elke Vlemincx, Omer Van den Bergh, Lukas Van Oudenhove, Ilse Van Diest &amp; Olivier Luminet</td>
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<td>14:20</td>
<td>S4.2</td>
<td>Categorical interoception and the role of threat in healthy women</td>
<td>Nadia Zacharioudakis, Elke Vlemincx &amp; Omer Van den Bergh</td>
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<td>14:40</td>
<td>S4.3</td>
<td>Relationship between Perception, Inspiratory Work, Power, Drive and Load Compensation Index During Multiple Breath Extrinsic Resistive Loading in Healthy Adults</td>
<td>Matthew Davenport, Justin Feinstein, Sahib Khalsa, Andreas von Leupoldt &amp; Paul Davenport</td>
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<td>15:00</td>
<td>S4.4</td>
<td>Functional Near-Infrared Spectroscopy (fNIRS) modulation by Inspiratory Resistive (R) and Pressure Threshold (PT) Load Perception</td>
<td>Paul W. Davenport, Matthew P. Davenport &amp; Joseph F. Welch</td>
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<td>15:20</td>
<td>S4.5</td>
<td>Brain rhythms related to awareness of breathing: a pilot study with intracranial EEG</td>
<td>Edwin Alexander Cerquera S., Giridhar Kalamangalam and Paul W. Davenport</td>
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<td>16:00</td>
<td>S5.1</td>
<td>The effect of dyspnea-specific fear on breathing patterns and dyspnea perception in COPD patients</td>
<td>Ysys Denutte, Thomas Reijnders, Wim Janssens, Thierry Troosters &amp; Andreas von Leupoldt</td>
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<td>S5.2</td>
<td>Investigating neural correlates of perceptual habituation to breathlessness</td>
<td>Valentina Jelincic, Diana Torta, Ilse Van Diest &amp; Andreas von Leupoldt</td>
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<td>Invited Address: Prof. Dr. Christina Spengler</td>
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<td>8:00</td>
<td>Welcome coffee</td>
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<td>9:00</td>
<td>Chair: Dr. Sarah Perry and Dr. Karen Wheeler</td>
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<td>9:00</td>
<td>S6.1 Respiratory Strength Training in an Individual with Inclusion Body Myositis</td>
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<td>William W. Connellan, James Wymer, Emily Plowman, Raele Robison &amp; Paul W. Davenport</td>
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<td>9:20</td>
<td>S6.2 The effect of dual tasking on cough reflex sensitivity in people with Parkinson’s disease compared to healthy controls</td>
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<td>S. Perry &amp; M.Troche</td>
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<td>9:40</td>
<td>S6.3 Airway Sensation Following Intensity Modulated Radiotherapy for Head and Neck Cancer</td>
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<td>Fullerton AL, Ruggles RK, Hitchcock K, Silver NL &amp; Hegland KH</td>
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<td>10:00</td>
<td>S6.4 Respiratory Sensation and Its Influence on Respiratory-Swallow Coordination in Parkinson’s Disease</td>
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Symposium 1:
Chair: Dr. Elke Vlemincx

Opening Welcome Presentation

S1.1 Concurrent Patterns of Children’s Controller Medication Adherence and Quick Relief Medication Use and Relationship to Acute Healthcare Utilization

S1.2 Emotional consequences of dyspnea variability
Sarah Froidure, Cecile Chenivesse, Thierry Perez & Nathalie Bautin

S1.3 Everyday cognitive failure in patients suffering from hyperventilation syndrome
Soraya Bordier, David Nunes, Nathalie Bautin, Camille Audousset, Thierry Perez & Cecile Chenivesse

S1.4 Odor-induced placebo/nocebo effects on FeNO in asthma: Exploring potential mediators and moderators
Thomas Janssens, Daniel Vigo, Lieven Dupont, & Omer Van den Bergh
Concurrent Patterns of Children’s Controller Medication Adherence and Quick Relief Medication Use and Relationship to Acute Healthcare Utilization


**Background:** ICS adherence is not stable and adherence patterns (poor; moderate; decreasing adherence; and increasing adherence) are associated with acute healthcare utilization. Inadequate ICS use is posited to lead to over-use of albuterol but little data exist examining this in children. We hypothesized that children in the Poor and Decreasing adherence classes would demonstrate over-utilization of albuterol and have higher acute healthcare visits. We analyzed ICS and albuterol Doser data (collected quarterly) from Latino children (n=123; ages 5-12 years) who participated in a 12 month, non-intervention study.

**Results:** The Moderate adherence class demonstrated stable, low albuterol use over 12 months (17.54-25.81 puffs/month). The Increasing adherence class displayed simultaneous decreases in albuterol (28.92 puffs/month to 12.67 puffs/month) and increases in ICS (30.32 puffs/month to 59.96 puffs/month) use from 6-12 months. The Poor adherence class showed low albuterol use across 12 months (6.4-23.8 puffs/month). The Decreasing adherence class had the highest ICS adherence and albuterol use at M3 (76.48%; 34.33 puffs/month). Interestingly, as ICS adherence declined from M6 to M9, albuterol use remained constant then decreased sharply from M9 to M12 with a concurrent spike in ICS adherence at M12. Acute healthcare visit patterns were less definitive. The Moderate adherence class had the lowest acute visits through M9 but there was an unexplained spike at M12. Acute visits remained stable for the Increasing adherence class. The Decreasing adherence class demonstrated a slight increase in acute visits over time. Contrary to the hypothesis, the Poor adherence class displayed a decline in acute visits through M9 followed by an increase at M12.

**Discussion:** Partial support for our hypotheses was shown leading to inconclusive results for the relationship between poor adherence, albuterol over-utilization, and acute healthcare visits; validating findings from a previous study that concluded albuterol use is not a reliable proxy for ICS adherence.
Emotional consequences of dyspnea variability

Sarah Froïdure, Cécile Chenivesse, Thierry Perez & Nathalie Bautin

Background: Clinical evaluation usually considers dyspnea as a stable symptom or focuses on acute episodes. However, dyspnea variability may have emotional consequences. Patients with chronic lung disease filled in a dyspnea calendar with Borg scale, 5 time a day (morning, noon, afternoon, evening, and night) during a week. We assessed the Borg variation coefficient for each patient and its relationship with Hospital Anxiety and Depression (HAD) scores and sensory and affective components of the worst recent dyspnea episode evaluated by the multidimensional dyspnea profile (MDP) questionnaire. Results are expressed as median [interquartile range].

Results: 58 patients fulfilled a calendar including 28 asthmatics, aged 50 [35-60], FEV1 67% [45-91], 20 patients with COPD, aged 60 [56-68], FEV1 59% [27-90] and 10 patients with interstitial lung disease, aged 73 [62-81], FVC 90% [63-107]. Over one week, the mean Borg score was 1.4 [0.6-2.7], the maximum Borg score 3 [2-4] and the Borg variation coefficient 43% [24-94]. HAD anxiety score was 7/21 [5-10], HAD depression score was 4/21 [2-7], immediate breathing discomfort MDP-A1 was 5/10 [3-7], sensory dimension MDP-QS was 9/50 [2-24] and affective dimension MDP-A2 was 7/50 [2-21]. Patients from the 3 groups mostly reported air hunger, hyperpnoea and anxiety on the MDP questionnaire. Borg variation coefficient was not correlated with HAD, MDP-A1, QS and A2 scores. The maximum Borg score was correlated with A1, QS and A2 (r = 0.52, 0.67 and 0.43, p<0.01) but not with HAD scores.

Discussion: In conclusion, our exploratory results show that dyspnea variability over a week is not associated with symptoms of anxiety disorder or depression nor with sensitive and affective characteristics of the worst recent dyspnea episode.
Everyday cognitive failure in patients suffering from hyperventilation syndrome

Soraya Bordier, David Nunes, Nathalie Bautin, Camille Audousset, Thierry Perez & Cecile Chenivesse

Background: Hyperventilation syndrome (HVS) is a frequent dysfunctional breathing occurring in young adults. HVS severely impacts quality of life, in particular in its physical components. We hypothesized that HVS may also impact cognitive functions by competitive interactions of attentional resources with cortical breathing activation. We aimed to assess everyday cognitive failures in HVS and its correlates with HVS severity.

Methods: In this prospective study, patients with a diagnosis of HVS confirmed by a positive Nijmegen score and evidence of alveolar hyperventilation (hypocapnia or positive hyperventilation provocation test) were included. HVS severity was assessed by the Nijmegen score and everyday cognitive failure by the Cognitive Failure Questionnaire (CFQ). Associations between variables were analyzed using Spearman’s correlation coefficients.

Results: Nineteen patients (women 63%; age 43 ± 13.3 years) were included. Dyspnea intensity evaluated by the Baseline Dyspnea Index was moderate with a median score at 7 (IQR: 6 – 9). The median Nijmegen score was 34 (IQR: 28 – 39). Among the patients, 73.7% presented with symptoms of anxiety (HAD-A > 10) and 21.1% with symptoms of depression (HAD-D > 10). The median CFQ score was 40/100 (IQR: 29 - 65; min: 13 - max: 73). A high CFQ score (≥ 43) was found in 47.4% of the patients. No relationship between the CFQ and Nijmegen scores (r = 0.40; p = 0.08) was found.

Discussion: Cognitive failure is a frequent condition in HVS with half of the patients reporting a significant cognitive deficit. This could be an additional mechanism of social disability in this disorder. However, CFQ score was not related to HVS severity under reserve of a possible lack of statistical power.
Odor-induced placebo/nocebo effects on FeNO in asthma: exploring potential mediators and moderators

Thomas Janssens, Daniel Vigo, Lieven Dupont, Omer Van den Bergh

Background: Participants with asthma often report odors as asthma triggers. Odors can induce placebo and nocebo responses, with a previous study (Jaen & Dalton, 2014) showing that effects on airway inflammation (Fraction of exhaled Nitric Oxide; FeNO) can be present 24h after odor exposure. In this study, we explored the role of odor perception, worry and HRV as potential mediators and moderators of this response.

Methods: Participants (n=39) received information about Phenylethyl Alcohol (PEA) leading to symptom relief or symptom worsening, and were subsequently exposed to PEA. During exposure, we assessed odor qualities (intensity, irritancy, annoyance). Symptoms, FeNO, and worry were assessed at baseline, and after exposure, as well as, 2h and 24h after exposure. HRV was assessed throughout the 24h period.

Results: Participants receiving information about PEA causing symptom worsening had increased FeNO 24h after PEA exposure. Placebo/Nocebo information also had an impact on odor perception and HRV, but not on worry about the odor. Mediation models showed no clear mediation effects. Both perceived odor irritancy and worry about the odor showed additional effects on FeNO, with 24h effects on FeNO being strongest for participants showing sensitization of odor irritancy during exposure or showing high levels of odor-related worry throughout the 24h assessment period.

Discussion: We did not find clear evidence of a mediation pathway linking placebo/nocebo information with changes in FeNO after odor exposure. Effects of odor irritancy and worry suggest changes in FeNO after trigger exposure can result from different psychological processes, which may have important implications for asthma management.
Symposium 2:
Chair: Dr. Thomas Janssens

S2.1 Is breathing always in phase with heart rate variability during resonance frequency breathing?
Paul Lehrer, Vinay Vidali & Evgeny Vaschillo

S2.2 The relaxation effects of slow breathing beyond breathing awareness
Elke Vlemincx, Sabrina Mohammed Nasir & Elsa-Pauline Noelle Du Rietz
Burke

S2.3 Respiratory variability in university music students with low and high levels of music performance anxiety
A. Guyon, R. Cannavò, R.K. Studer, H. Hildebrandt, E. Vlemincx & P.Gomez

S2.4 Using rhythmical sighing to test mechanisms of regulation in the baroreflex system
Evgeny G. Vaschillo, Bronya Vaschillo & Jennifer F. Buckman
Background: For many years it has been an axiom among practitioners of heart rate variability biofeedback that heart rate and breathing vary in phase with each other when people do resonance frequency breathing. When people breathe at the frequency of the baroreflex system, about 0.1 Hz, heart rate and blood pressure have been found to oscillate 180 degrees out of phase, while heart rate and breathing are in phase (zero degree phase). Thus breathing stimulates the baroreflex by augmenting the baroreflex response with each breath, an effect that is magnified by resonance properties in the baroreflex system. All of the original data on these relationships have been found in studies of highly athletic healthy young people. However we have found clinically that heart rate and breathing often are not completely in phase with each other in many individuals when they are breathing at the rate that produces the highest amplitude of heart rate variability.

Results: We therefore analyzed phase relationship data between heart rate and breathing during 5-min periods of resonance frequency breathing among 26 adults from a recent study of heart rate variability biofeedback to treat adults with mild to moderate currently symptomatic asthma, ages between 18 and 75. We analyzed coherence, transfer function, and phase between cardiac interbeat interval measured from the electrocardiogram and the respiration curve using the WinCPRS program for all frequencies in the low frequency range (0.05-0.15 Hz). Among records with coherence . 0.8, for frequencies corresponding to the highest amplitude of heart rate variability, we found a phase relationship of 166 degrees with cardiac interbeat interval, or about 64 degrees with heart rate, with heart rate preceding breathing.

Discussion: Thus, among these individuals, breathing stimulates the baroreflex in the middle of its swing in each direction, but not at the extremes of each swing. Implications are discussed for treatment of lung diseases, as well as for HRV biofeedback training protocols.
The relaxation effects of slow breathing beyond breathing awareness

Elke Vlemincx, Sabrina Mohammed Nasir & Elsa-Pauline Noelle Du Rietz Burke

**Background:** Slow breathing has been shown to increase relaxation and reduce negative emotional states. However, existing studies show important caveats. First, no randomized control trials exist. Second, no studies have investigated the effects of slow breathing beyond the effects of breathing awareness. Therefore, the present randomized control trial aims to investigate whether slow breathing increases relaxation while controlling for effects of breathing awareness.

**Method:** Participants were invited to a study investigating the role of breathing in relaxation. After a 10-min baseline recording, participants were exposed to a 15-min worry induction, after which they engaged in a 15-min breathing exercise. Participants were randomly assigned to one of two breathing exercises: a slow breathing biofeedback (SB) exercise or a breathing awareness (BA) exercise. Both exercises involved the measurement and feedback of the participant’s breathing pattern. The BA group was instructed to focus on the sensation of every inhalation and exhalation. The SB group was given the same instructions, but, additionally, was instructed to reduce respiratory rate to eight breaths per minute. The Smith Relaxation States Inventory was used to assess self-reported relaxation and mindfulness after the baseline and after the breathing exercise. Throughout the study, respiration, the electrocardiogram, skin conductance and skin temperature were recorded.

**Results:** The slow breathing manipulation was successful; the average breathing rate in the SB group was 8 breaths per minute, significantly lower than the average breathing rate in the BA group. Although mindfulness increased significantly from baseline to breathing intervention, no significant group changes were found. Similarly, no group changes in self-reported or physiological relaxation were found.

**Discussion:** The present study shows that, while controlling for the effects of breathing awareness, slow breathing in itself may not significantly contribute to relaxation. Previous relaxation effects of slow breathing could be explained by differences in expectations and/or breathing awareness.
Respiratory variability in university music students with low and high levels of music performance anxiety

A. Guyon, R. Cannavò, R.K. Studer, H. Hildebrandt, E. Vlemincx & P. Gomez

Background: Music performance anxiety (MPA) is a major issue for many music students. Whether low- and high-anxious musicians differ in their respiratory responses to performance situations is largely unknown. A healthy respiratory system balances random variability warranting flexibility in response to internal and external changes and nonrandom variability ensuring stability. We aim to determine whether low- and high-anxious music students differ in their respiratory variability prior to and after a private performance and a public performance.

Methods: Sixty-five university music students varying in their self-rated MPA level from low to high performed privately and publicly one week apart, while their respiration was recorded with the LifeShirt system. For the 10 minutes before and after each performance, we computed coefficients of variation (CVs) as indices of total variability (sum of random and nonrandom variability) and autocorrelations at one breath lag (ARs(1)) as indices of nonrandom variability of minute ventilation ($V'_e$), tidal volume ($V_t$), inspiration time ($T_i$), expiration time ($T_e$), and duty cycle ($T_i/T_{TOT}$ (%)). We tested the effects of MPA and performance situation.

Results: Increasing levels of MPA were associated with lower CVs of $V'_e$, $V_t$, $T_e$ and $T_i/T_{TOT}$, whereas MPA was unrelated to ARs(1). Compared to the private performance, the public performance was associated with higher CVs of $V_t$, $T_i$, $T_e$ and $T_i/T_{TOT}$, and more so among high-anxious than low-anxious participants. AR(1) of $V'_e$ and $T_i/T_{TOT}$ were lower in the public performance situation than in the private performance situation.

Discussion: The present study has shown that in the context of music performance situations, measures of respiratory variability are sensitive to situational factors (presence of audience) and personal factors (MPA level). Breathing is a powerful regulator of homeostatic balance. Breathing modification might be part of interventions aiming at promoting adaptive psychophysiological states in musicians and other performers.
Using rhythmical sighing to test mechanisms of regulation in the baroreflex system

Evgeny G. Vaschillo, Bronya Vaschillo & Jennifer F. Buckman

**Background:** We consider the baroreflex as a complex of closed loop control systems that coordinates oscillations across cardiovascular (CV) processes. Respiratory manipulation is a convenient approach for investigating the mechanisms by which the baroreflex system (BRS) functionally regulates CV oscillations. Paced breathing at different frequencies is commonly used, but such manipulations are limited by the range that individuals can sustain breathing (0.08-0.4 Hz). We developed a paced sighing manipulation to study BRS regulation in the range of 0.02-0.08 Hz.

**Methods:** Young healthy participants (n=71) performed three 5-6-minute paced sighing tasks at frequencies of 0.02, 0.033, and 0.066 Hz. These tasks produced sighs with periods of 50, 30, and 15 s respectively. Respiration, ECG, and beat-to-beat blood pressure (BP) were collected. Oscillatory reaction in BP, hear rate (HR), vascular tone (VT), and stroke volume (SV) was evaluated for each task and transfer functions (TFs) were computed.

**Results:** HR and SV responses to 0.033 Hz task were significantly lower than to 0.02 and 0.066 Hz tasks. BP and VT responses to both 0.033 and 0.066 Hz tasks were significantly lower than the response to 0.02 Hz task. TF(HR→BP) where HR was an input and BP was an output showed that the phase between BP and HR was close to 0 degrees at frequency of 0.033 Hz.

**Discussion:** Our previous study found that the phase between BP and HR was 180 degrees at ~0.1 Hz, potentially explaining how resonance develops in the BRS. The current study suggests that BP and HR processes at ~0.033 Hz were in-phase, and oscillations in CV processes were clearly suppressed. Resonance properties of BRS are proven to be useful for health state; the possibility of an “anti-resonance” effect at ~0.033 Hz may be physiologically important and should be further investigated.
Symposium 3:

Chair: Dr. Matthew P. Davenport

S3.1 Unpredictability increases dyspnea unpleasantness, anxiety and interoceptive error processing
Yafei Tan, Omer Van den Bergh, Jiang Qiu & Andreas von Leupoldt

S3.2 Brain activation patterns during symptom induction through negative picture viewing in patients with somatic symptom disorder
Omer Van den Bergh, Daniëlle Jongen, Maaike Van Den Houte, Katleen Bogaerts & Lukas Van Oudenhove
Background: Dyspnea is an aversive interoceptive sensation and common in cardiopulmonary as well as mental disorders. Particularly the unpredictability of upcoming dyspnea episodes has been reported to be highly anxiety provoking for affected patients. Furthermore, previous studies showed that unpredictable exteroceptive stimuli amplified ratings and electroencephalographic (EEG) responses of anxiety, for example the startle probe N100, as well as increased the processing of errors as mirrored by greater error-related negativity (ERN). However, studies directly testing the influence of unpredictability on interoceptive dyspnea perception, anxiety and error processing are widely missing. Using high-density EEG, we examined whether unpredictable compared to predictable dyspnea increases the perception of dyspnea, anxiety and interoceptive error processing.

Methods: Healthy volunteers underwent a respiratory forced choice reaction time task to evoke an interoceptive ERN in two experimental conditions: an unpredictable and a predictable inspiratory resistive load-induced dyspnea condition. The (un)predictability was varied by pairing (predictable) or not pairing (unpredictable) dyspnea with an acoustic startle tone probe. Ratings of dyspnea and affective state as well as the interoceptive ERN and startle probe N100 were recorded.

Results: We observed higher dyspnea unpleasantness ratings in the unpredictable compared to the predictable condition. Post-hoc analyses showed that this was paralleled by higher anxiety ratings, and greater amplitudes for the interoceptive ERN and the startle probe N100 during the unpredictable compared to the predictable condition, but only when the unpredictable condition occurred in the first experimental block. Moreover, higher trait-like anxiety sensitivity was correlated with greater ratings for dyspnea unpleasantness and experimental state anxiety.

Discussion: The current results suggest that unpredictability increases dyspnea perception. This seems associated with increased state and trait anxiety and interoceptive error processing, particularly when upcoming dyspnea is especially unpredictable, such as in early experimental blocks.
Brain activation patterns during symptom induction through negative picture viewing in patients with somatic symptom disorder

Omer Van den Bergh, Daniëlle Jongen, Maaike Van Den Houte, Katleen Bogaerts & Lukas Van Oudenhove

Background: Induction of negative affective states can induce bodily symptoms in high habitual symptom reporters among healthy persons and in patients with functional disorders (DSM-5: somatic symptom disorders, SSD). In this study, we investigated brain activation patterns in patients with SSD during experimental induction of elevated symptom reports unrelated to physiological dysfunction.

Methods: Patients with SSD (N=29: 16 fibromyalgia (FM); 7 irritable bowel syndrome (IBS), 6 FM+IBS) and healthy controls (N= 25, matched for age, BMI and SES) viewed series of neutral (Neu), positive (Pos), and negative affective (Neg) pictures while in a scanner (3T Philips Achieva Dstream; 32-channel headcoil; standard echo planar imaging). Six pictures per emotion block (7 s presentation time) were presented in 6 runs per subject; order was counterbalanced. BOLD-responses were measured in ROI’s defined by a relevant mask (Kober et al., Neuroimage, 2008). After every picture series, participants filled out a somatic symptom checklist and rated emotions experienced during the picture series on valence, arousal, and perceived control.

Results: Patients reported stronger negative affect and more somatic symptoms after viewing negative pictures compared with neutral or positive pictures, whereas somatic symptom ratings of HCs after viewing negative picture series did not differ from ratings after viewing neutral or positive pictures. Two clusters in brain activation emerged for the contrast Neg-Neu when contrasting patients and HC: cluster 1 involves the right insula, right putamen and superior temporal lobe; cluster 2 involves (left) mid-cingulate cortex and bilateral supplementary motor area (SMA).

Discussion: besides differences in area’s involved in visuospatial exploration, multisensory control of eye and head and working memory, the results point to a critical role of the (right) insula in interoception, underlying both negative affective states and elevated symptom reporting. The results will be discussed within a predictive coding perspective.
Symposium 4:
Chairs: Dr. Andreas von Leupoldt

S4.1 The occlusion differentiation task: a new measure of accuracy of respiratory Sensations
Maaike Van Den Houte, Elke Vlemincx, Omer Van den Bergh, Lukas Van Oudenhove, Ilse Van Diest & Olivier Luminet

S4.2 Categorical interoception and the role of threat in healthy women
Nadia Zacharioudakis, Elke Vlemincx & Omer Van den Bergh

S4.3 Relationship between Perception, Inspiratory Work, Power, Drive and Load Compensation Index During Multiple Breath Extrinsic Resistive Loading in Healthy Adults
Matthew Davenport, Justin Feinstein, Sahib Khalsa, Andreas von Leupoldt & Paul Davenport

S4.4 Functional Near-Infrared Spectroscopy (fNIRS) modulation by Inspiratory Resistive (R) and Pressure Threshold (PT) Load Perception
Paul W. Davenport, Matthew P. Davenport & Joseph F. Welch

S4.5 Brain rhythms related to awareness of breathing: a pilot study with intracranial EEG
Edwin Alexander Cerquera S., Giridhar Kalamangalam and Paul W. Davenport
The occlusion differentiation task: a new measure of accuracy of respiratory Sensations

Maaike Van Den Houte, Elke Vlemincx, Omer Van den Bergh, Lukas Van Oudenhove, Ilse Van Diest & Olivier Luminet

Background: Interoceptive accuracy (the ability to sense interoceptive signals) is most often measured with the heartbeat counting task (HBCT). However, the HBCT only measures the accuracy of cardiac sensations. The goal of this project was to develop a new task measuring interoceptive accuracy of respiratory sensations.

Methods: The occlusion differentiation task (ODT) measures respiratory interoceptive accuracy as the just noticeable difference (JND) in lengths of respiratory occlusions. A two-down, one-up adaptive staircase paradigm with a two-alternative forced choice task was used to determine the JND. Each trial, participants received two short respiratory occlusions (within one inspiration) and were asked to determine which of the two was the longest. The difficulty of the trial depended on the participant's last answer: after two consecutive correct answers, the difference between the two presented occlusions would become smaller, while after one incorrect answer, the difference between the two presented occlusions would become larger. The initial step size of the staircase was 30ms, and was reduced with 5ms after each reversal (change in direction of the staircase). The staircase ended after 10 reversals. A pilot study was conducted to test the efficiency of these parameters.

Results: 25 participants completed the pilot study. None of the participants rated the occlusions as unpleasant, and the timing of two occlusions in one inspiration was feasible for all participants. The pilot study indicated that the preset step size rule was efficient, but that an end rule of six reversals was sufficient. The average JND was 58.3 ms (SD = 33.9).

Discussion: The ODT is a promising new task to measure accuracy of respiratory sensations. We are currently collecting data (N = 100) to determine performance distribution, internal consistency, test-retest reliability, and discriminant validity (by comparing ODT performance with performance on the HBCT and performance on an auditory discrimination paradigm).
54.2
Categorical interoception and the role of threat in healthy women

Nadia Zacharioudakis, Elke Vlemincx & Omer Van den Bergh

Background: Interoceptive fears and biased interoception are important characteristics of somatic symptom disorders. It has been shown that categorization of interoceptive sensations impacts perception of their intensity and unpleasantness. In this study we investigated whether making interoceptive categories threat-relevant further biases interoception of individual sensations compared to safe categories.

Methods: Healthy women (N=80) learned category membership of eight respiratory stimuli that were equidistant in intensity by allocating them to a low- or high-intensity category. Subsequently, participants classified these stimuli as ‘low’ or ‘high’, and rated fear, intensity, and unpleasantness in both a safe and threat condition. Either the ‘low’ or ‘high’ category was made threat-relevant by instructing (and occasionally experiencing) that interoceptive sensations could be followed by an unpredictable electrocutaneous stimulus.

Results: Stimuli within categories were perceived as more similar (in fear, intensity, and unpleasantness) than equidistant stimuli at the category border. Threat-relevance decreased perceived within-category differences in intensity when category ‘high’ was threat-relevant, and in fear and, on trend level, in unpleasantness when category ‘low’ was threat-relevant. However, threat did not induce better between-category discrimination, nor an altered categorization threshold.

Discussion: We replicated that categories have a profound effect on respiratory perception and found partial evidence for the effect of threat-relevance of categories on the strength of this effect. Threat did, however, not impact outcomes that may be more relevant to behaviour.
Background: Extrinsic resistive loads (R) increase the work of breathing, require load compensation and are perceived as effortful. The work (W) of breathing during inspiration is defined as: \( W = P_{aw} \times V_i \). The power (J) is defined as: \( J_{aw} = W_{aw} \times T_i \). With increasing R, the Waw and Jaw for ventilation (VE) increases. The pressure-time-product, \( PtP = \int P_{aw} \times dt \), is a measure of the inspiratory drive over the inspiratory duration (Ti) an individual provides to generate force to move the air. We predicted that as the magnitude of the R increases, the extrinsic load dependent Jaw elicits an increase in PtP to maintain VE. We reasoned that individuals will modulate breathing pattern during sustained breathing against increased R’s resulting in increasing PtP to compensate for the R-dependent Jaw. We hypothesized during a 10-breath R loading trial, the PtP for Breath 10 will be greater than Breath 1. We further hypothesized that the perception of breathing effort (ME_{int}) and unpleasantness (ME_{un}) are directly proportional to the PtP and Jaw.

Results: Healthy participants were tested while breathing through a non-rebreathing circuit with inspiratory flow-resistive loads (R=0-100 cmH2O/L/s). The subjects inspired for 10 consecutive breaths for each load magnitude. Subjects estimated load intensity ME_{int} and unpleasantness ME_{un} for breaths 1, 5 and 10. VE was unchanged for all 10 breaths with all R loads. The Waw and Jaw increased with increasing R. The PtP and Jaw significantly increased with increasing R. The ME_{int} and ME_{un} increased with increasing R, PtP and Jaw.

Discussion: The results demonstrate that the increased Waw associated with breathing against extrinsic R loads increases the Jaw required to sustain VE, and that PtP (drive) increases proportionately to the Jaw. Increases in perceived breathing effort and negative affective valence correlates with the increased load dependent PtP and Jaw.
S4.4

Functional Near-Infrared Spectroscopy (fNIRS) modulation by Inspiratory Resistive (R) and Pressure Threshold (PT) Load Perception

Paul W. Davenport, Matthew P. Davenport & Joseph F. Welch

**Background:** fNIRS applies near-infrared (NIR) light to the skin at 700-900 nm wavelengths, strongly absorbed by oxyhemoglobin and deoxyhemoglobin. The differences in absorption by oxyhemoglobin and deoxyhemoglobin allows the estimation of changes in HB oxygen (HB-Oxy) concentration. The optodes sensing the reflection of the NIR light are positioned on the forehead to record HB-Oxy differences at a depth for the prefrontal cortex. Changes in brain activity modulate the HB-Oxy difference allowing estimation of prefrontal cortical activity response to a stimulus. We hypothesized that perception of R and PT loads will modulate the HB-Oxy as a function of the perceived load intensity (MEInt) and unpleasantness (MEUn).

**Results:** Healthy individuals were tested breathing through a non-rebreathing circuit with R (5-50 cmH2O/L/s) and PT (5-30 cmH2O) loads, each load applied for 10 consecutive breaths. fNIRS was recorded bilaterally on the forehead. Subjects estimated MEInt and MEUn for breaths 1, 5 and 10. Each load presentation was separated by 1 min unloaded breathing. The HB-Oxy was determined for each load magnitude. MEInt and MEUn increased with increasing load magnitude, inspiratory pressure and work. MEInt and MEUn were greater for the PT loads. For equivalent maximum pressure and work, PT loads were estimated as more unpleasant than R loads. fNIRS HB-Oxy difference was greater for large magnitude loads. Time dependent changes in HB-Oxy of the prefrontal cortex over the 10-breath loading were imaged by fNIRS.

**Discussion:** These results demonstrate that PT loads may be more aversive than R loads. R loads allow air to flow throughout the breath while PT loads only allow air to flow when the pressure threshold is reached for the inspiratory effort. The inspiratory occlusion that occurs prior to PT valve opening may explain the greater perceived unpleasantness. fNIRS HB-Oxy changes suggest prefrontal cortical responses are increased with increasing load magnitude and ME.

S4.5

**Brain rhythms related to awareness of breathing: a pilot study with intracranial EEG**

Edwin Alexander Cerquera S., Giridhar Kalamangalam and Paul W. Davenport
Symposium 5:
Chairs: Dr. Paul W. Davenport

SS.1 The effect of dyspnea-specific fear on breathing patterns and dyspnea perception in COPD patients
Ysys Denutte, Thomas Reijnders, Wim Janssens, Thierry Troosters & Andreas von Leupoldt

SS.2 Investigating neural correlates of perceptual habituation to breathlessness
Valentina Jelincic, Diana Torta, Ilse Van Diest & Andreas von Leupoldt
The effect of dyspnea-specific fear on breathing patterns and dyspnea perception in COPD patients

Ysys Denutte, Thomas Reijnders, Wim Janssens, Thierry Troosters & Andreas von Leupoldt

Background: It is well known that high levels of non-specific fear and anxiety are prevalent in patients with COPD and related to worse outcomes including dyspnea. Considerably less is known about respective effects of dyspnea-specific fear. Moreover, previous studies demonstrated that non-specific anxiety can influence breathing patterns, but respective studies on dyspnea-specific fear (DSF) as well as in patients with COPD are widely absent. Therefore, the aim of this study was to investigate whether DSF would be related to differences in dyspnea perception and breathing patterns in patients with COPD.

Methods: Thirty-two COPD patients underwent two experimental blocks during which brief inspiratory occlusions were repeatedly presented. Breathing patterns were continuously recorded and perceived intensity and unpleasantness of dyspnea and occlusions was rated after each block on a Borg scale. Levels of DSF were measured with the Breathlessness Beliefs Questionnaire.

Results: Multiple regression analyses showed that patients who reported higher levels of DSF demonstrated higher breathing frequency (p=0.049) and lower tidal volume (p=0.03). Furthermore, higher DSF was significantly associated with higher occlusion intensity (p=0.035) and unpleasantness (p=0.004). Most associations remained significant after controlling for age, sex, lung function, smoking status, and general anxiety. No association was found between DSF and dyspnea intensity and unpleasantness.

Discussion: The present study shows that dyspnea-related fear is related to a faster and shallower breathing pattern in patients with COPD which converges with previous studies relating general anxiety and breathing patterns in healthy subjects. Furthermore, it seems that COPD patients with higher levels of dyspnea-related fear perceived the occlusions as a more intense and unpleasant respiratory sensation which might be related to the more aversive and motivationally relevant character of these sensations for these patients.
Investigating neural correlates of perceptual habituation to breathlessness

Valentina Jelincic, Diana Torta, Ilse Van Diest & Andreas von Leupoldt

Background: Repeated exposure to breathlessness, for example in chronic respiratory diseases, can result in decreases (habituation) or increases (sensitization) in its perception, however individual differences and potential neural correlates are still poorly understood. Therefore, this study investigated the link between perceptual habituation to breathlessness and respiratory neural gating, a measure of sensory filtering in the brain. We expected to observe decreases in intensity/unpleasantness of breathlessness over time and that reduced respiratory neural gating would relate to smaller decreases.

Method: To assess the relationships between respiratory neural gating and perceptual habituation, we used a 5-session protocol. During Session 1, high-density EEG was used to measure the peak amplitudes of the N1 component of respiratory-related evoked potentials in 44 healthy adults, elicited by paired inspiratory occlusions. Individual N1 amplitude ratios of second/first occlusion were taken as gating scores. Participants also rated the intensity and unpleasantness of breathlessness after 10 consecutive breaths through a 50 cmH2O/L/s inspiratory resistive load. During Sessions 2-4, participants returned to the lab (with 1-3 days between sessions) to again provide ratings of intensity and unpleasantness of breathlessness after 10 loaded breaths. During Session 5, participants completed the same procedures as in Session 1. Throughout the experiment, inspiratory flow and pressure were monitored. To assess perceptual habituation to breathlessness, individual ratios of intensity/unpleasantness ratings and maximum inspiratory mouth pressure were compared between Sessions 1 and 5.

Results: A significant decrease in unpleasantness of breathlessness between Sessions 1 and 5 was found, with an insignificant decrease in breathlessness intensity. No significant relationships between habituation and respiratory neural gating were found.

Discussion: The results underscore that intensity and unpleasantness represent different dimensions of breathlessness with more pronounced habituation for unpleasantness. However, the current data do not support the notion that respiratory neural gating predicts perceptual habituation to breathlessness over 5 days.
Symposium 6:
Chair: Dr. Sarah Perry and Dr. Karen Wheeler

S6.1  Respiratory Strength Training in an Individual with Inclusion Body Myositis
       William W. Connellan, James Wymer, Emily Plowman, Raele Robison &
       Paul W. Davenport

S6.2  The effect of dual tasking on cough reflex sensitivity in people with
       Parkinson’s disease compared to healthy controls
       S. Perry & M. Troche

S6.3  Airway Sensation Following Intensity Modulated Radiotherapy for Head and
       Neck Cancer
       Fullerton AL, Ruggles RK, Hitchcock K, Silver NL & Hegland KH

S6.4  Respiratory Sensation and Its Influence on Respiratory-Swallow Coordination
       in Parkinson’s Disease
       James A. Curtis & M. Troche
Respiratory Strength Training in an Individual with Inclusion Body Myositis

William W. Connellan, James Wymer, Emily Plowman, Raele Robison & Paul W. Davenport

Background: A 72 year old patient was diagnosed in 2017 with Inclusion Body Myositis (IBM). IBM has cellular material that accumulates in muscle tissues and is characterized by progressive muscle degeneration with gradual onset of slowly progressive weakness in the limb muscles. As IBM progresses, there is an increased muscle inflammation, skeletal muscle weakness, atrophy and impairments in swallowing and breathing functions.

Methods: The patient’s limb muscle strength was assessed every 3 months. Medical treatment consisted of physical therapy and dietary. For one year, the quarterly visits documented slow progression in limb muscle strength decline, increased dyspnea with exercise and decreased vital capacity. The patient was referred to the Center for Neuromotor Speech and Swallowing Restoration (NSSR). The patient had reduced vital capacity 85% predicted, maximum inspiratory pressure (MIP) 54% and maximum expiratory pressure (MEP) 57% predicted. The patient enrolled in a respiratory muscle strength training (RMST) program with combined inspiratory (IMST) and expiratory (EMST) muscle strength training for 16 months. The IMST and EMST consisted of 25 training breaths per day at about 75% MIP and MEP, respectively.

Results: The patient significantly increased MIP by 32% to 72% predicted. The MEP significantly increased 78% to 101% predicted. There was also a 15% improvement in peak cough airflow and a 24% increase in forced vital capacity. Importantly, for all but MIP, the patient reached 100% age and gender predicted values. The patient’s limb muscle strength showed slight increases.

Discussion: The IMST and EMST training period resulted in an improvement in respiratory and non-respiratory muscle strength, contrary to the expected progression for an individual with IBM. Ventilatory capacity and cough strength were normalized by the RMST, suggesting RMST is an effective addition to rehabilitation protocols for individuals with IBM.
The effect of dual tasking on cough reflex sensitivity in people with Parkinson’s disease compared to healthy controls

S. Perry & M. Troche

Background: Reflex cough is an essential airway protective mechanism. Evidence suggests that increasing cognitive demands alters cough function. We tested the effects of performing concurrent cognitive and coughing tasks on measures of cough in people with Parkinson’s disease (PWPD), age-matched controls (HOAs) and younger controls (HYAs).

Method: PWPD ($n = 13$, 10 males, age 43 – 87 y, Hoehn & Yahr stage 2), age-matched controls ($n = 13$), and younger controls ($n = 13$, age 23 – 35 y) underwent four blocks of capsaicin-induced cough challenges. Within each block, six concentrations of capsaicin were presented in a randomized order, ranging from 0 – 200 μM. Two blocks consisted of cough testing only (single task). During the other two blocks, participants counted tones whilst undergoing cough testing (dual task). Cough motor response, urge-to-cough (UTC), cough frequency and cough airflow were measured.

Results: Whilst all participants coughed less when dual-tasking, the magnitude of this change was greatest for HYAs [$p = .02$, $d = .94$], followed by HOAs [$p = .26$, $d = .88$], and PWPD [$p = .13$, $d = .41$]. All participants’ cough motor thresholds increased during dual-tasking; the magnitude of change was greatest for HYAs [$p = .03$, $d = -.98$], and was similar for HOAs [$p = .48$, $d = -.38$] and PWPD [$p = .04$, $d = -.44$]. UTC ratings did not change for HYAs, decreased for HOAs [$p = .03$, $d = .92$] and PWPD [$p = .13$, $d = .49$] when dual-tasking. No differences in cough peak expiratory flow rates were observed.

Discussion: Somatosensation of tussive stimuli changes with cognitive load. In PWPD, the influence of dual-tasking on cough sensorimotor outcomes is less pronounced than in healthy controls. Future research should explore the potential underlying mechanisms for this difference.
**Background:** Disordered swallow, or dysphagia, is prevalent among those with head and neck cancer (HNC), and this diagnosis and incidence only increases following intensity-modulated radiotherapy (IMRT). Of those with dysphagia following IMRT, one-third will experience silent aspiration or ingestion of material below the glottis without an appreciable attempt to eject or a cough response, suggestive of reduced airway sensation.

**Introduction:** The objective of this proposal was to characterize dystussia in HNC survivors compared to healthy controls. This was achieved through reflex cough analysis of 91 individuals stratified into three groups: healthy older, healthy younger adults and those status post IMRT.

**Method(s):** Data were collected from three groups of 91 adults (44 male), 30 of whom were healthy, young adults (HYA) aged 19-34 years (mean 23); 28 were healthy older adults (HOA) aged 56-81 (mean 70) and 33 were status post IMRT (mean age 64 and time since treatment ranged from 5-60 months; mean 21 months). Cough was elicited with nebulized capsaicin at three levels (50µM, 100µM and 200µM) and urge to cough (UTC) was reported. Univariate ANOVA was used to detect significant differences between groups for median urge to cough, cough sensitivity slope and cough volume acceleration.

**Results:** Omnibus test showed that the HYA differed significantly from the HOA and IMRT groups for median UTC \(F(86,2)=15.75, p<0.05\), cough volume acceleration \(F(85,2)=13.3, p<0.05\) and sensitivity slope \(F(66,2)=187, p<0.05\).

**Discussion:** These findings suggest that the effects of IMRT on airway sensation may be equivalent to the known desensitization that occurs with normal healthy aging given the homogeneity of both motor and sensory cough variables among healthy older adults and those status post IMRT.
Respiratory Sensation and Its Influence on Respiratory-Swallow Coordination Parkinson’s Disease

James A. Curtis, Michelle S. Troche

**Background:** Suboptimal respiratory-swallow coordination (RSC) is associated with aspiration and dysphagia – a leading cause of death in Parkinson’s disease (PD); however, the pathophysiology underlying suboptimal RSC is not well understood. Blunted respiratory sensation contributes to dysphagia in PD, but its relation to RSC has not been examined. The aim of this study was to evaluate the influence of respiratory sensation on RSC in PD.

**Methods:** A secondary analysis was completed in PD. RSC was assessed using respiratory inductive plethysmography, and respiratory sensation was assessed using magnitude estimation (ME) of perceived inspiratory exertion during six resistive loads: 0, 2.5, 5, 10, 20, and 40 cmH2O. A Borg Scale was used to quantify ME and served as a proxy measure for respiratory sensation. Ordinal regressions were performed to assess the influence of median ME scores on: (1) lung volume during swallowing (‘LV’); (2) duration of respiratory-swallow apnea; and (3) frequency of exhale-swallow-exhale respiratory-swallow patterns.

**Results:** Thirteen people with PD (average age = 73.4 years; average disease duration = 81.4 months) were included for analysis. They had a median ME of 11.5, an average LV of 47.8% vital capacity (± 23.0% VC), an average respiratory-swallow apnea duration of 2.3 seconds (± 1.3), and demonstrated exhale-swallow-exhale on 50.8% of swallows. Regressions revealed ME significantly influenced LV ($p < .0005, r^2 = .185$) and duration of respiratory-swallow apnea ($p = .016, r^2 = .111$). There was no influence of ME on respiratory-swallow patterning ($p = .068, r^2 = .165$).

**Discussion:** This study evaluated the influence of respiratory sensation as measured by inspiratory resistive loading on RSC in PD. Results revealed that reduced ME during resistive inspiratory loading is related to key aspects of RSC. Further work is necessary to understand the extent of these relationships in a prospective sample of people with PD.