Self-dissimilarity of respiratory effort across sleep states and time
Long, X.; Haakma, R.; Goelema, M.S.; Weysen, T.E.J.; Ferreira dos santos da Fonseca, P.M.; Foussier, J.; Aarts, R.M.

Published in:
28th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2014), 31 May - 4 June 2014, Minneapolis, Minnesota

Published: 01/01/2014

Document Version
Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

• A submitted manuscript is the author's version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 11. Dec. 2018
Self-Dissimilarity Of Respiratory Effort Across Sleep States And Time

Long X\textsuperscript{1,2}, Haakma R\textsuperscript{2}, Goelema MS\textsuperscript{2,3}, Wysen T\textsuperscript{2}, Fonseca P\textsuperscript{1,2}, Foussier J\textsuperscript{4}, Aarts RM\textsuperscript{1,2}

\textsuperscript{1}Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, The Netherlands, \textsuperscript{2}Philips Group Innovation Research, Eindhoven, The Netherlands, \textsuperscript{3}Department of Industrial Design, Eindhoven University of Technology, Eindhoven, The Netherlands, \textsuperscript{4}Chair for Medical Information Technology, RWTH Aachen University, Aachen, Germany.

\textbf{Introduction:} Respiratory activity strongly associates with sleep states. For instance, respiration is more regular during deep sleep compared with wakefulness. When awake, the respiratory regularity and the measurement of respiratory effort would be influenced by motion artifacts or other external factors. We therefore tested the hypothesis that the self-dissimilarity of respiratory signal morphology within a subject differs between sleep states, which would in turn help separate them. Moreover, the self-dissimilarity between two periods of respiratory signals might be in accordance with their time difference, which was investigated for each state.

\textbf{Methods:} Continuous overnight respiratory effort signals (acquired with respiratory inductance plethysmography) of 48 healthy adults (age 41.3 ± 16.1 years) were analyzed. Sleep states were scored on 30-s epochs using polysomnography according to R&K rules. For each state, we computed the self-dissimilarity $D_s$ between every two epochs of respiratory effort per subject. $D_s$ was measured by a uniform-scaling distance between the subseries with same number of consecutive breaths (normalized to have zero mean and unit variance) of the corresponding two epochs. A larger $D_s$ value ($D_s \geq 0$) indicates a higher self-dissimilarity.

\textbf{Results:} The self-dissimilarity $D_s$ was significantly different (Mann-Whitney test, $p<0.001$) between wake ($1.0 \pm 0.29$), REM sleep ($0.95 \pm 0.27$), light sleep ($0.83 \pm 0.30$) and deep sleep ($0.70 \pm 0.31$) regarding respiratory effort. We also found that the longer time between two epochs the higher $D_s$ between them.

\textbf{Conclusion:} Sleep states can be differentiated using respiratory self-dissimilarity expressing the signal morphology which is usually evoked by the autonomic activity, the alternation of ventilation control or other external factors such as will or body movements. The lower self-dissimilarity score in short term implies the inclusion of nonrandom components of respiration which might be explained by less influence of body movements, presence of consciousness or memory of breathing control.