**7a.\* Identify the 1st individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).**

A/Prof Baumert's most significant contribution to the field of computerized electrocardiography (ECG) is his highly interdisciplinary approach to developing QT interval variability analysis as a non-invasive clinical tool for probing sympathetic outflow to the heart and assessing risk for mortality in cardiac patients. He was one of the first researchers to develop high-fidelity template matching algorithms that enabled the reliable quantification of the subtle yet important beat-to-beat fluctuations in cardiac repolarization duration from ECG. By utilizing two-dimensional warping and free-form deformation approaches, he was able to measure QT interval variability with unprecedented precision, which is crucial for practical clinical applications. Motivated by the lack of non-invasive tools for assessing sympathetic outflow to the heart, which is a critical determinant of health, he was the first to demonstrate that QT variability is directly correlated with cardiac noradrenaline spillover, the current gold standard for measuring sympathetic neural outflow to the heart. By conducting complex experiments in humans and employing modern data modelling approaches, he significantly improved our understanding of QT variability and helped to establish it as an important biomarker in cardiology.

**7b.\* Verifiable evidence of 1st contribution (maximum 400 words).**

[A.1] Baumert, M., Schlaich, M.P., Nalivaiko, E., Lambert, E., Sari, C.I., Kaye, D.M., Elser, M.D., Sanders, P. and Lambert, G., 2011. Relation between QT interval variability and cardiac sympathetic activity in hypertension. American Journal of Physiology-Heart and Circulatory Physiology, 300(4), pp.H1412-H1417. (99 citations/GS)

The first paper to demonstrate the direct link between QT variability in the electrocardiogram and cardiac sympathetic outflow in humans. Thus, it can be used as a simple non-invasive biomarker of autonomous nervous system activity. This work provides critical evidence to the physiological interpretation of QT variability.

[A.2] Baumert, M., Javorka, M., Seeck, A., Faber, R., Sanders, P. and Voss, A., 2012. Multiscale entropy and detrended fluctuation analysis of QT interval and heart rate variability during normal pregnancy. Computers in Biology and Medicine, 42(3), pp.347-352. (70 citations/GS)

The first paper to demonstrate the complexity and fractal properties of QT variability, providing evidence for the presence of nonlinear dynamics that should be considered when assessing beat-to-beat fluctuations.

[A.3] Baumert, M., Starc, V. and Porta, A., 2012. Conventional QT variability measurement vs. template matching techniques: comparison of performance using simulated and real ECG. PloS one, 7(7), p.e41920. (52 citations/GS)

This paper shows that template matching approaches are necessary to quantify QT interval variability reliability, triggering subsequent work on template adaptations.

[A.4] Schmidt, M., Baumert, M., Porta, A., Malberg, H. and Zaunseder, S., 2014. Two-dimensional warping for one-dimensional signals—conceptual framework and application to ECG processing. IEEE Transactions on Signal Processing, 62(21), pp.5577-5588. (45 citations/GS)

This paper introduced two-dimensional signal warping to template adaptation problems and provided the technical framework for highly accurate QT variability measurement in clinical data, where poor signal-to-noise ratios are common. Schmidt was one of Baumert's students. The work was patented (DE 10 2014 100 609 A1).

[A.5] Karisik, F. and Baumert, M., 2019. Inhomogeneous Template Adaptation of Temporal Quasi-Periodic Three-Dimensional Signals. IEEE Transactions on Signal Processing, 67(23), pp.6067-6077.

This paper proposes a novel vectorcardiographic framework for the quantification of QT variability. By using free-form deformations, beat-to-beat fluctuations can be accurately quantified in 3-dimensional projections of the electrocardiogram. Karisik is a PhD student of A/Prof Baumert.

[A.6] Karisik, F. and Baumert, M., 2020. Template Adaptation of 2D Quasi-Periodic Data Using a Soft-Assign Localized Correspondence Matrix. IEEE Transactions on Signal Processing.

This paper expands on the concept proposed in [A.4] and [A.5] by developing a mathematical framework ensuring convergence to locally adapt ECG waveforms.

**7c.\* Impact of 1st contribution (maximum 200 words).**

At the time A/Prof Baumert started QT variability research in 2006, the prevalent clinical opinion was that it is technically impossible to quantify these beat-to-beat fluctuations in a meaningful way due to critically low signal-to-noise ratios and the limited understanding of pathophysiological underpinnings. Over the subsequent ten years, his laboratory and other teams across the world developed critical technology and collected experimental and clinical evidence to show that QT variability constitutes an important biomarker. Research efforts culminated in the in the establishment of an international committee to define guidelines for QT variability measurement and clinical interpretation. The consensus guidelines were endorsed by two highly influential professional societies of cardiac electrophysiology, paving the way for clinical use. It is now widely accepted that QT variability can be measured reliably on clinical electrocardiogram with template matching techniques, and importantly, it is a clinically validated biomarker of mortality risk in cardiac patients.

**7d. \* Verifiable evidence of impact of 1st contribution (maximum 200 words).**

[A.7] Baumert, M., Porta, A., Vos, M.A., Malik, M., Couderc, J.P., Laguna, P., Piccirillo, G., Smith, G.L., Tereshchenko, L.G. and Volders, P.G., 2016. QT interval variability in body surface ECG: measurement, physiological basis, and clinical value: position statement and consensus guidance endorsed by the European Heart Rhythm Association jointly with the ESC Working Group on Cardiac Cellular Electrophysiology. Europace, 18(6), pp.925-944. (144 citations/GS)

Developed by world-leading experts on computerized electrocardiography and cardiac electrophysiology, this position statement has become the key reference for clinical scientists.

[A.8] El-Hamad, F.J., Bonabi, S.Y., Müller, A., Steger, A., Schmidt, G. and Baumert, M., 2020. Augmented oscillations in QT interval duration predict mortality post myocardial infarction independent of heart rate. Frontiers in Physiology, 11.

Independent clinical investigators demonstrated the predictive value of our QT variability measurement technology in a large cohort of >900 cardiac patients.

[A.7] Baumert, M., Smith, J., Catcheside, P., McEvoy, R.D., Abbott, D., Sanders, P. and Nalivaiko, E., 2008. Variability of QT interval duration in obstructive sleep apnea: an indicator of disease severity. Sleep, 31(7), pp.959-966. (60 citations /GS)

A/Prof Baumert was the first to show that QT variability is critically elevated during respiratory events sleep and may trigger dangerous arrhythmias.

**8a.\* Identify the 2nd individual contribution which qualifies the Nominee for Fellow grade (maximum 200 words).**

A/Prof Baumert contributed significantly to the field of sleep medicine by developing several computer algorithms for analyzing overnight sleep studies (polysomnography) and translating them to clinical research, advancing the diagnostic capabilities. He was one of the first researchers to coduct detailed analysis of overnight oximetry to identify different sources of oxygen desaturation. By using multivariable modelling approaches, he was one of the first to decompose sources of heart rate control during sleep and demonstrate autonomic dysregulation in sleep disorders. He developed he concept of joint symbolic dynamics to quantify the nonlinear interplay between cardiorespiratory control and was one of the first to study phase-locking of cardiac and respiratory rhythms during normal and pathological sleep. He then developed deep learning approaches to quantify the cyclic alternating pattern of non-rapid-eye-movement sleep in EEG and establish the causality of these cortical activation patterns and cardiovascular dynamics using the concept of Granger causality.

**8b.\* Verifiable evidence of 2nd contribution (maximum 400 words).**

[B.1] Baumert, M., Walther, T., Hopfe, J., Stepan, H., Faber, R. and Voss, A., 2002. Joint symbolic dynamic analysis of beat-to-beat interactions of heart rate and systolic blood pressure in normal pregnancy. Medical and Biological Engineering and Computing, 40(2), pp.241-245. (125 citations/GS)

This paper proposes the framework of joint symbolic dynamics for analyzing bivariate cardiovascular time series, demonstrating that it can effectivly capture changes blood pressure control.

[B.2] Kabir, M.M., Saint, D.A., Nalivaiko, E., Abbott, D., Voss, A. and Baumert, M., 2011. Quantification of cardiorespiratory interactions based on joint symbolic dynamics. Annals of Biomedical Engineering, 39(10), p.2604. (45 citations/GS)

This paper expands on [B.1] by developing joint symbolic analysis for detecting cardiorespiratory interactions. Kabir was a PhD student of A/Prof Baumert.

[B.3] Kabir, M.M., Saint, D.A., Nalivaiko, E., Abbott, D. and Baumert, M., 2011. Time delay correction of the synchrogram for optimized detection of cardiorespiratory coordination. Medical & biological engineering & computing, 49(11), pp.1249-1259. (20/GS)

This paper proposes an improved detection method for cardiorespiratory synchronization. The journal's editors named it a journal highlight of the year.

[B.4] Hartmann, S. and Baumert, M., 2019. Automatic a-phase detection of cyclic alternating patterns in sleep using dynamic temporal information. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 27(9), pp.1695-1703. (14 citations/GS)

This paper is the first to use recurrent neural networks to detect the cyclic alternating pattern in EEG. Cyclic alternating patterns are closely linked to cardiovascular changes in sleep, linking A/Prof Baumert's previous work on cardiovascular control to cortical activity. Hartmann is a PD student of A/Prof Baumert

[B.5] Baumert, M., Immanuel, S.A., Stone, K.L., Litwack Harrison, S., Redline, S., Mariani, S., Sanders, P., McEvoy, R.D. and Linz, D., 2020. Composition of nocturnal hypoxaemic burden and its prognostic value for cardiovascular mortality in older community-dwelling men. European Heart Journal, 41(4), pp.533-541. (22 citations/GS, 5 media reports)

Published in the leading journal of cardiology and publicized in the general media, this paper proposes a novel algorithm for processing overnight oximetry signals and detecting apneas, demonstrating predictive value for cardiac mortality in a large cohort study.

**8c.\* Impact of 2nd contribution (maximum 200 words).**

Joint symbolic analysis of biomedical time series demonstrated to be a powerful tool for quantifying cardiovascular and respiratory control and is used by various research laboratories across the world, including Prof. Porta (University Milan), Prof. Javorka (Comenius University), Prof. Caminal (Polytechnic University Catalonia), Prof. Aljama-Corrales (Autonomous University Mexico).

The novel oximetry processing technology proposed in [B.5] is applied internationally by several research teams to some significant, large clinical sleep studies, including A/Prof. Linz (University of Maastricht), Prof. McEvoy (Flinders University), Prof. Arzt (University Regensburg). It has generated critical evidence for clinical decision making on sleep disorders.

The system for automated cyclic alternating pattern scoring in EEG [B.6] is used internationally by several eminent sleep research groups, including Prof. DeRosso (Seattle Children's Hospital), Prof. Bruni (University of Rome), Prof. Ferri (Oasi Research Institute, Italy), Prof. Parrino (University of Parma), Prof. O'Hara (Stanford University). It has been featured on the National Sleep Research Resource (sleepdata.org), the key repository for sleep research managed by Harvard University.

**8d. \* Verifiable evidence of impact of 2nd contribution (maximum 200 words).**

References [B.6] and [B.7] exemplify notable clinical applications of A/Prof Baumert's oximetry computer software.

[B.6] Linz, D., Loffler, K.A., Sanders, P., Catcheside, P., Anderson, C.S., Zheng, D., Quan, W., Barnes, M., Redline, S., McEvoy, R.D. and Baumert, M., 2020. Low Prognostic Value of Novel Nocturnal Metrics in Patients With OSA and High Cardiovascular Event Risk: Post Hoc Analyses of the SAVE Study. Chest, 158(6), pp.2621-2631. (3 citations/GS)

[B.7] Linz, D., Malfertheiner, M.V., Werner, N., Lerzer, C., Gfüllner, F., Linz, B., Zeman, F., McEvoy, R.D., Arzt, M. and Baumert, M., Nocturnal hypoxemic burden during positive airway pressure treatment across different central sleep apnea etiologies. Sleep Medicine.

Reference [B.7] and [B.8] exemplify applications of A/Baumert's sleep EEG signal processing contributions to clinical studies on brain activity during sleep in children improving our understanding of normal sleep and pathological conditions.

[B.8] DelRosso, L.M., Hartmann, S., Baumert, M., Bruni, O., Ruth, C. and Ferri, R., 2020. Non-REM sleep instability in children with restless sleep disorder. Sleep Medicine, 75, pp.276-281. (2 citations/GS)

[B.9] Chatburn, A., Coussens, S., Lushington, K., Kennedy, D., Baumert, M. and Kohler, M., 2013. Sleep spindle activity and cognitive performance in healthy children. Sleep, 36(2), pp.237-243. (85 citations/GS, 3 media reports)