

Wearable-derived digital phenotypes of emotion regulation reveal markers of resilience and vulnerability relevant to dementia risk

Marta Alvarez-Ambrosio ^{1 2}, Gabriele Cattaneo ^{3 4}, Paloma Chausa ^{1 2}, Diego Moreno-Blanco ^{1 2}, Gemma Albi-Villuendas ^{3 4}, Ignacio Oropesa ^{1 2}, Patricia Sánchez-González ^{1 2 5}, Javier Solana-Sanchez ^{3 4}, Enrique J Gómez ^{1 2 5}

1 Biomedical Engineering and Telemedicine Centre, ETSI Telecomunicación, Center for Biomedical Technology, Universidad Politécnica de Madrid, Madrid, Spain 2 Instituto de Investigación Hospital 12 de Octubre (imas12), Hospital Universitario 12 de Octubre, Madrid, Spain 3 Institut Guttmann, Institut Universitari de Neurorehabilitació adscrit a la UAB, Barcelona, Spain 4 Institut d'Investigació en Ciències de la Salut Germans Trias i Pujol, Badalona, Spain 5 Centro de Investigación Biomédica en Red de Bioingeniería, Biomateriales y Nanomedicina, Instituto de Salud Carlos III, Madrid, Spain

Wearable-derived sleep, autonomic, activity and respiratory phenotypes were associated with differences in emotion regulation, suggesting potential digital biomarkers relevant to brain health and dementia risk.

INTRODUCTION

Emotion regulation and dementias: Difficulties in emotion regulation (ER) are prominent across neuropsychiatric disorders. In dementia research, neuropsychiatric symptoms (NPS) may emerge before cognitive impairment and are closely linked to ER processes. Emotion regulation may therefore provide a useful framework for understanding early neurobehavioral changes associated with neurodegeneration.

The digital phenotyping opportunity: Digital phenotyping offers an objective, ecologically valid complement to self-report measures. Consumer wearables continuously capture physiological and behavioral signals, enabling the identification of digital biomarkers relevant to brain health.

Aims:To identify wearable-derived digital phenotypes and examine their associations with ER outcomes, including strategy use, regulation difficulties, and latent ER profiles, as candidate digital biomarkers of cognitive aging and brain health.

METHODS

Participants: 65 middle-aged adults monitored for 8 weeks using consumer-grade wearables capturing sleep, activity, HR, HRV, and respiration.

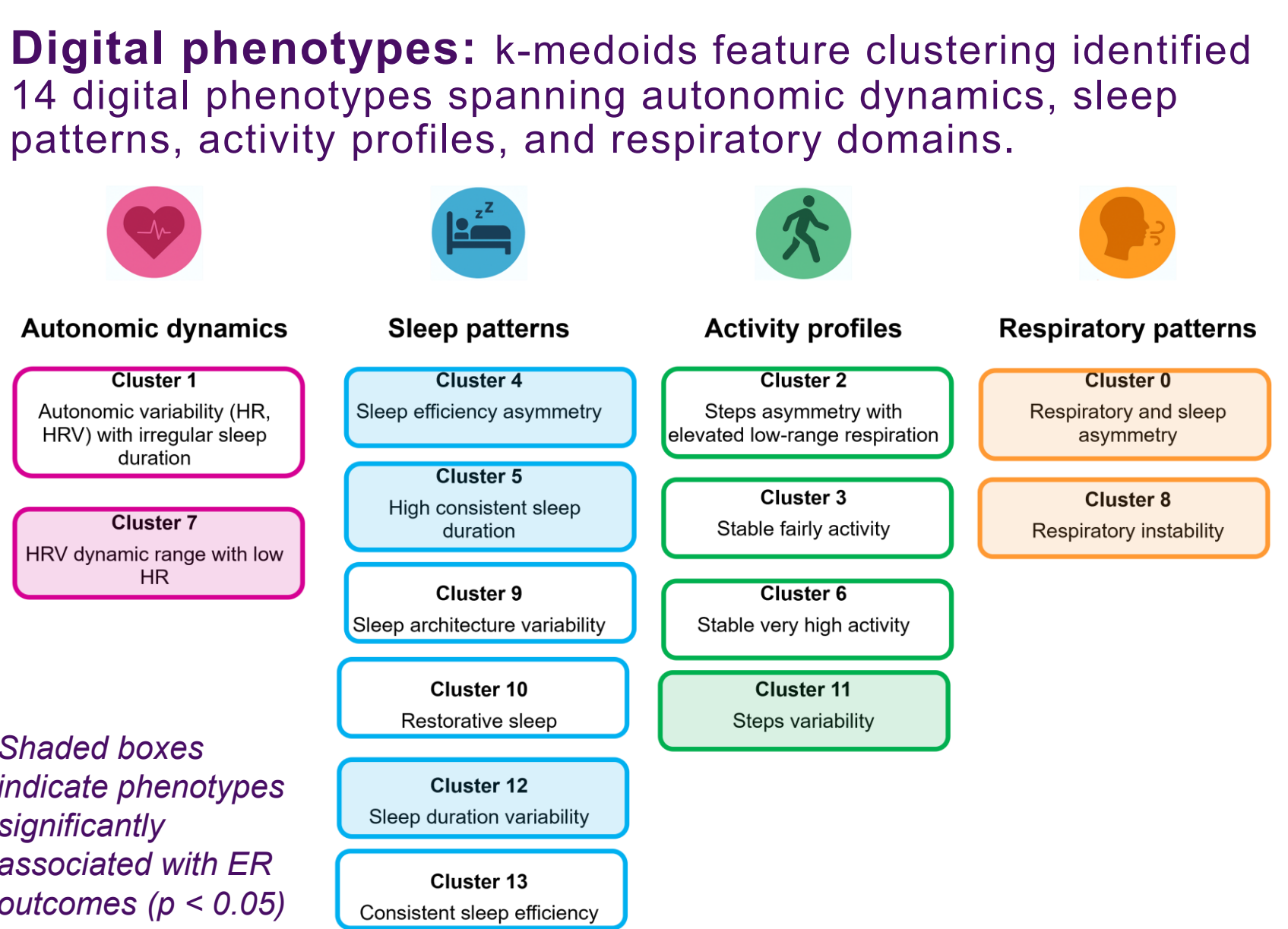
Baseline assessment: ER difficulties (DERS-16), strategy use (E-ERQ), interoceptive sensibility (MAIA-2, BPQ-SF_ANS), and perceived stress (PSS-10).

Data analysis

1. Statistical features extracted from daily wearable time series.
2. Hierarchical clustering and k-medoids feature clustering identified 14 digital phenotypes.
3. Latent Profile Analysis (LPA) identified 3 ER strategy-use profiles.
4. Regression models tested associations between digital phenotypes and ER outcomes, adjusting for age, sex, and education.

Digital phenotypes significantly associated with ER outcomes were proposed as candidate digital biomarkers of emotion regulation.

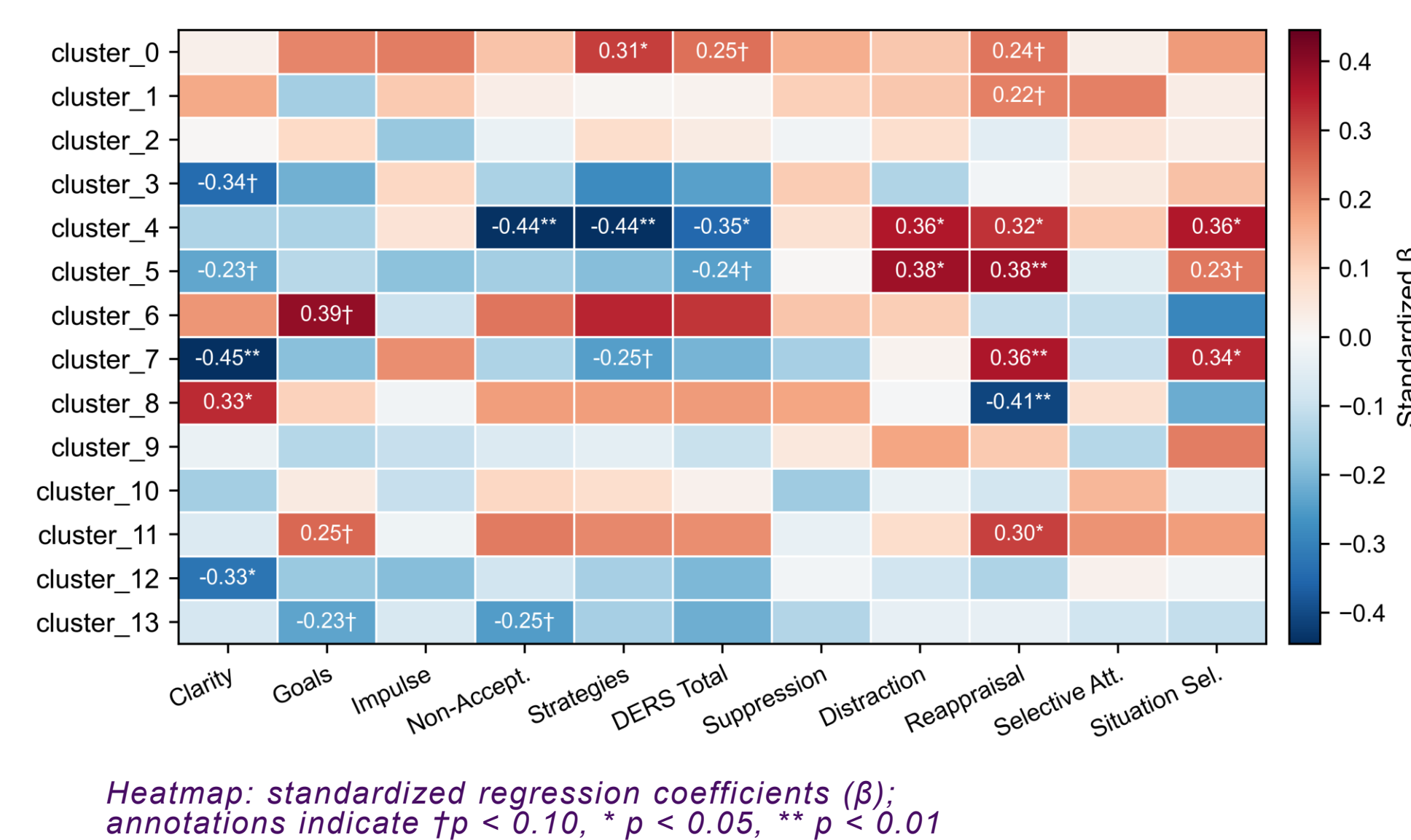
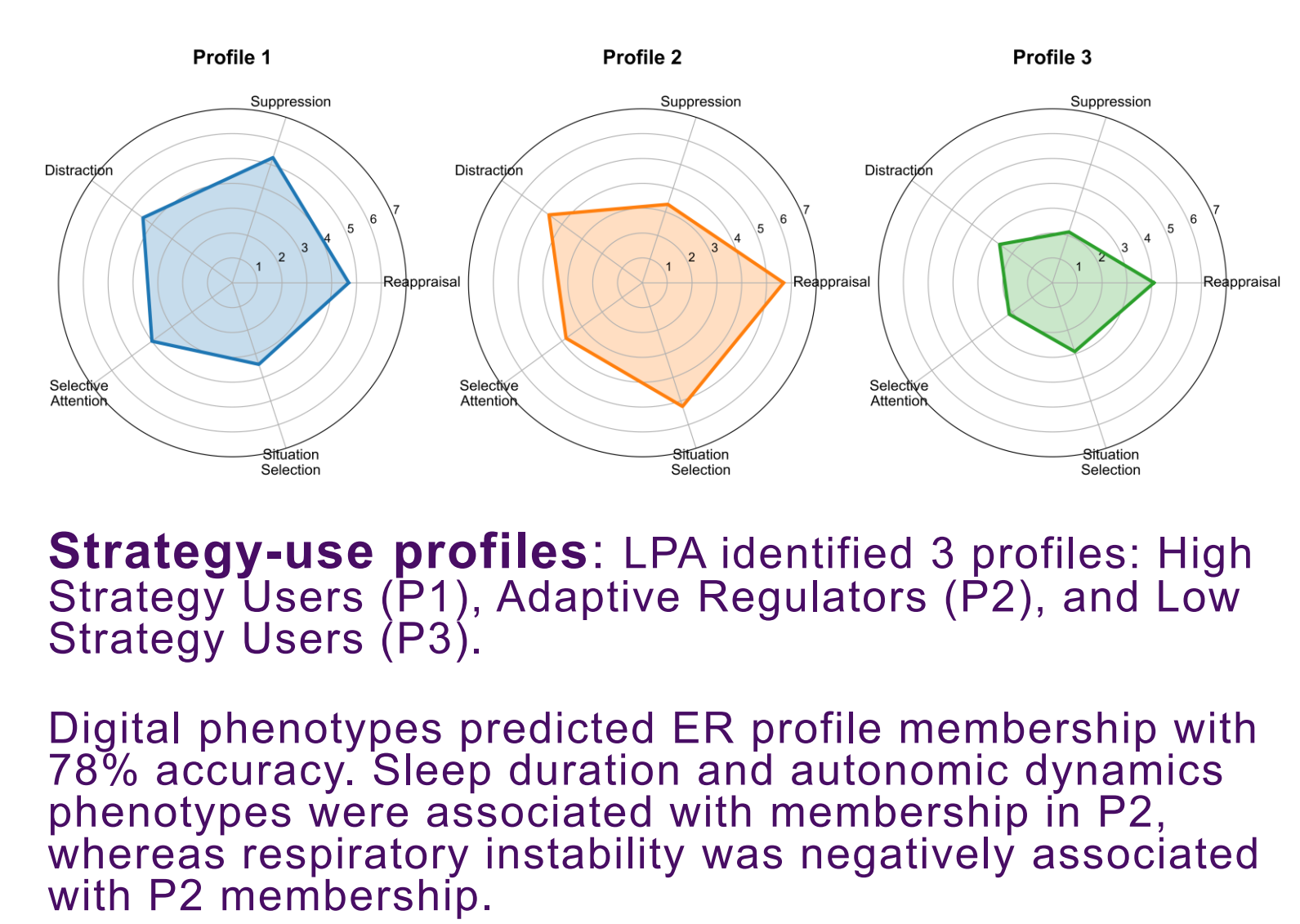
RESULTS



Associations with ER outcomes: Regression models were globally significant for cognitive reappraisal use ($R^2 = 0.47$, $p = 0.001$) and emotional clarity difficulties ($R^2 = 0.35$, $p = 0.044$).

Several phenotypes emerged as candidate digital biomarkers of emotion regulation.

- **Associated with more adaptive ER**
 - Sleep efficiency asymmetry
 - High, consistent sleep duration
 - HRV dynamic range with low HR
 - Sleep duration variability
 - Daily steps variability
- **Associated with less adaptive ER**
 - Respiratory instability
 - Respiratory and sleep asymmetry



CONCLUSIONS

Wearable-derived digital phenotypes captured meaningful individual differences in ER and identified candidate digital biomarkers linked to sleep, autonomic, activity and respiratory domains.

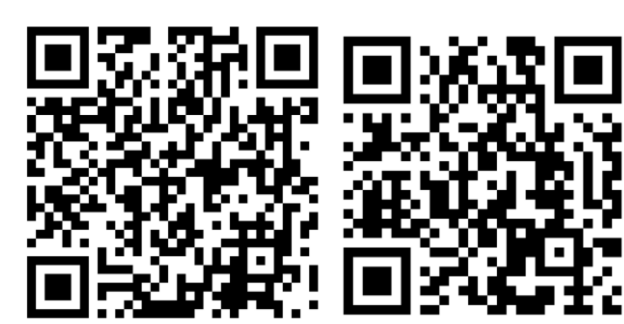
These findings highlight the potential of digital phenotyping to characterize ER in real-world settings and support the development of scalable biomarkers relevant to brain health and dementia research.

Digital biomarkers of ER may offer a promising approach for studying early neurobehavioral changes relevant to cognitive aging and dementia.

Further validation in larger and more diverse cohorts is warranted.

CONTACT & FUNDING

Marta Alvarez Ambrosio
marta.alvareza@alumnos.upm.es



This research work was partially funded by the PID2022-139298OB-C21 and PID-2022-139298OA-C22 projects, Spanish Ministry of Science and Innovation/Agencia Estatal de Investigación, European FEDER program (MCIN/AEI/10.13039/501100011033/FEDER, UE)

