MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES

MindBrainBody Symposium |10th MBB Symposium 2023 | Berlin & Virtual | 14-17 March 2023

Mind, brain, body & environment interaction: the emotionally embedded cognition hypothesis

Anabela Pereira [1] | David Yates [2] | Hugo Alexandre Ferreira [3]

Master in Cognitive Science | University of Lisbon

[1] Cies-Iscte, IUL | [2] LanCog, CFUL | [3] IBEB-FCUL

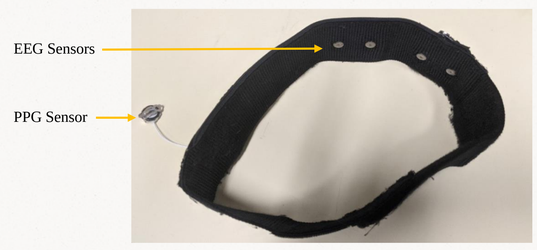
Background: Through *embodied cognition* theory, identity between mind and body contests the idea that mental processes are fundamentally different and separate from physicality. At the same time, *embedded cognition* stresses the interdependence of a mental phenomenon with its environment.

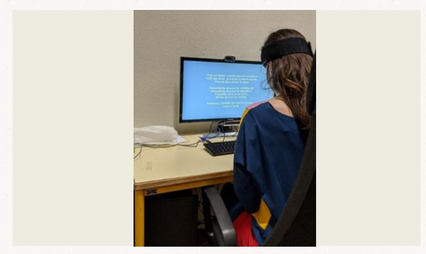
Question: However, how exactly is the emotionally embedded response (to a specific environment) capable of constraining cognition and behaviour, and what factors can be related to it (e.g., age, gender, features or objects from the environment)?

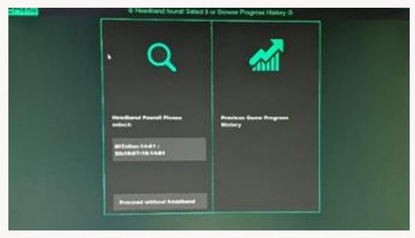
Methods

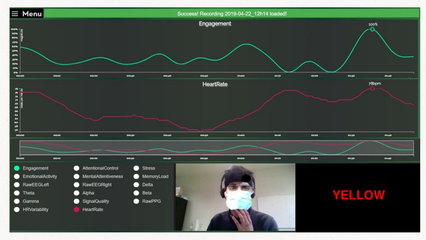
- An **assessment (N=16) of biometrics** associated with cognitive control and emotional response (heart rate and heart rate variability) captured through photoplethysmography (PPG) signals.
- The **Stroop Test** (measuring cognitive interference, time of response, and accuracy in the task.
- Neuropsychological scales: the Maslach Burnout Inventory Students Survey (**MBI-SS**); the Profile of Mood States (**POMS**).
- A Likert scale on the perceptions of **environment characteristics** (light, sounds, objects).
- *Prerequisite*: participants had to attend a class (digital vs presential) before the experiment.

Materials and procedures









Acknowledgements: The headband and platform were partially funded by “CAMELOT-C2 Advanced Multi-domain Environment and Live Observation Technologies”, Project ID: 740736, financed by the European Commission grants H2020-EU3.7.3 – Strengthen security through border management and H2020-Eu 3.7.7. – Enhance standardisation and interoperability of systems, including for emergency purposes.

Results and conclusions*

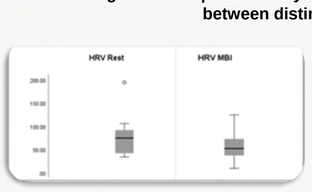
Table 1 | Correlations between physiology and moods

Spearman's rho correlations	HR POMS	HR Content	HR Exit	Tension/ Anxiety	Confusion/ Disorientation
HR MBI-SS	0.742**	0.584*	0.595*		
HRV POMS			-0.575*		
HR POMS		0.903**	0.770**		0.538*
HR Content			0.824**	0.588*	0.710**

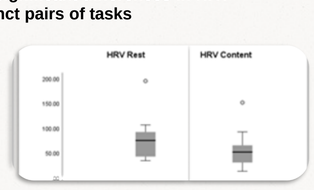
*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Figures 1 & 2 | Statistically significant differences in HRV between distinct pairs of tasks



Significance of the median differences: p=0.034



Significance of the median differences: p=0.056

Figure 3 | Medians of the POMS dimensions

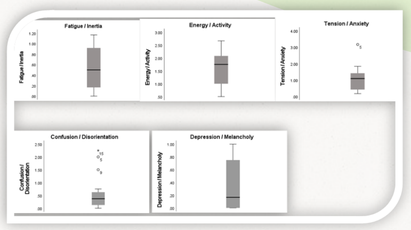


Table 2 | Determining factors of the cognitive performance of the Stroop task

Simple Linear Regression Models	Dependent variables						
Explaining variables	B	R	R^2	F	Sig. F Change	df	Durbin-Watson
SE							
1. Environment engagement	-0.446*	-0.516*	0.266	5.079*	0.041*	1-14	2.534
Stroop (HRV)							
2. Environment engagement	60.765*	0.641*	0.411	9.786	0.007*	1-14	1.971
SE							
3. Depression/Melancholy	-58.508*	0.538*	0.290	5.715*	0.031*	1-14	2.102
Stroop (HR)							
4. Confusion/Disorientation	13.261*	0.547*	0.299	5.976*	0.028*	1-14	2.401

*$p < 0.05$

- The emotionally embedded cognition hypothesis holds in the context of this experiment. Namely, our research outcomes suggest that moods and environmental engagement are essential to cognition, positively and negatively affecting interference during the Stroop task. Respectively:
  - from the POMS scale, depression/melancholy could predict the Stroop effect to decrease, and confusion/disorientation could predict increased heart rate during the task.
  - environmental engagement could predict the Stroop effect to decrease and the heart rate variability to increase during the task.

*** The analysis was made with exploratory goals. The results are not representative.**

Selected references

- Clark, A., & Chalmers, D. (1998). The Extended Mind, *Analysis*, *58*(1): 7–19. https://doi.org/10.1093/analys/58.1.7
- Damásio, A. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transaction: Biological Sciences*, 351, 1413–1420. https://doi.org/10.1098/rstb.1996.0125
- Damásio A. (1998). Emotion in the perspective of an integrated nervous system. *Brain Research Reviews*. *26*(2-3): 83–86. http://doi.org/10.1016/s0165-0173(97)00064-7
- Damásio, A. (2017). *A Estranha Ordem das Coisas. A Vida, os Sentimentos e as Culturas Humanas*. Temas & Debates/Círculo de Leitores (viz. pp. 145-224).
- Dawson, M. (2014). Embedded and situated cognition. In L. Shapiro (Ed.), *The Routledge Handbook of Embodied Cognition* (pp. 59–67). Routledge.
- Ekman, P. (1992) An argument for basic emotions. *Cognition and Emotion*, 6:169–200. https://www.paulekman.com/wp-content/uploads/2013/07/An-Argument-For-Basic-Emotions.pdf
- Eysenck, M. W., & Keane, M.T. (2000). Cognition and Emotion. In M. W. Eysenck, & M.T Keane, *Cognitive Psychology: A Student's Handbook* (pp. 489–512). Psychology Press.
- Gallagher, S. (2005). The Terms of Embodiment. In *How the Body Shapes the Mind* (pp.17-39). Oxford University Press. https://doi.org/10.1093/0199271941.003.0002
- Gray, J. R., Braver, T. S., & Raichle, M. E. (2002). Integration of emotion and cognition in the lateral prefrontal cortex. *Proceedings of the National Academy of Sciences, 99*(6), 4115–4120. www.pnas.org./cgi/doi/10.1073/pnas.062381899
- Korunovska, J., & Spiekermann, S. (2019). The effects of digitalisation on human energy and fatigue: a review. Corporate website [entry] Computer Science/Computers and society/the effects of digitalisation on human energy and fatigue: a review (pp. 1–51). Cornell University. arXiv:1910.01970[cs.CY].
- Pessoa, L. (2013c). Cognitive-Emotional Interactions in Prefrontal Cortex. In *The Cognitive-Emotional Brain: From Interactions to Integration*. (pp. 107-132). The MIT Press.
- Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, *9*(4), 625–636. https://cogsci.ucsd.edu/~coulson/Courses/200/EmbCog_Wilson.pdf