Using Basal Attributes to Identify Key Properties of Emerging Technologies for Responsible Innovation

Julius Fenn[1,2], Paul Sölder[1,2] , Lukas Königs[3] , Lisa Reuter[2], Michael Gorki[1,2], Stefan Conrad[4], Olga Speck[1], Louisa Estadieu[1] , Philipp Höfele[1], Martin Möller[5], Andrea Kiesel[1,2]

[1] Cluster of Excellence *liv*MatS, University of Freiburg, [2] Institute of Psychology, University of Freiburg, [3] Institute of Medical Biometry and Statistics, University of Freiburg, [4] Plant Biomechanics Group, University of Freiburg, [5] Öko-Institut e.V. – Institute for Applied Ecology, Germany

Motivation

- **Collingridge Dilemma** in Technology Assessment: Evaluating technologies at later stages provides more accurate impact information but makes modifications difficult, while early-stage assessment allows easier modifications but with less predictable impacts.
- Technology assessment should provide information on the probable impacts of emerging technologies to facilitate informed societal deliberation and responsible innovation.

Our **proposed methodology** combines expert interviews, Cognitive-Affective Maps (CAMs) for assessing layperson attitudes, and Large Language Models (LLMs) for predicting acceptance to integrate societal and ethical considerations into technology development from the beginning based solely on adjectives lists* of technologies.

Basal Attributes*

- **Definition and Origin**: Basal attributes are fundamental properties and functionalities of technologies, conveyed through commonly used adjectives or phrases such as sustainable, self-repairing, energy-generating, and bio-inspired. These terms are used to describe the core characteristics that define the new material systems, which are currently developed in the Cluster of Excellence ”Living, Adaptive and Energy-autonomous Materials Systems” (*liv*MatS).
- Attitude Formation: Basal attributes are stored in semantic memory, which includes explicit knowledge about the world and the meanings of words. Attitudes towards these basal attributes are formed through associations between the attributes and prior experiences, emotional responses, or initial perceptions.
- Emotional and Cognitive Evaluation: Evaluations of basal attributes involve both cognitive and affective components. Individuals draw associations and assign emotional evaluations (positive, negative, neutral, or ambivalent) to these attributes using CAMs.

Outcomes

Part I

- Refinement of Basal Attributes List: An **initial list of 435 basal attributes** was derived from expert interviews and refined through multiple steps, including independent reviews, expert evaluations in a world café format, and automated scans of existing publications.
- Expert Rating and Final List: The attributes were rated by two independent raters, leading to a **final list of 32 basal attributes** after further expert evaluation. The most significant attributes included "adaptive" "sustainable" and "environmentally friendly" while less relevant attributes included "anisotropic" and "soft".
- Literature Scan and Additional Attributes: An automated scan of 200 livMatS publications identified additional relevant adjectives, adding "energy storage," "harvest energy," "responsive," and "long-lasting“.

Part II

Laypersons were tasked with connecting 32 basal attributes to each other (see Fig. 1) and to the central concept of "Acceptance of a new material system", whereby free to change the valence and add comments (Fig. 2). Cluster of densely interconnected basal attributes, using various algorithms and robustness checks, were identified over 169 aggregated CAMs.

Figure 1 Default CAM with user interface.

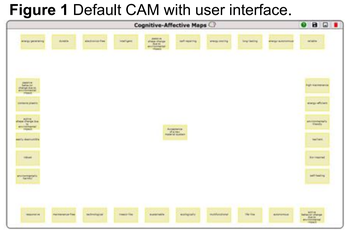


Figure 2 Example CAM.

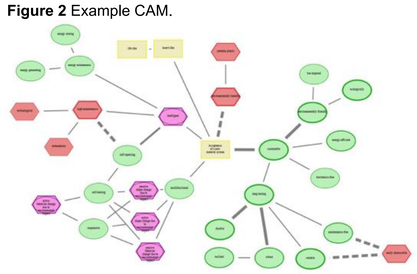
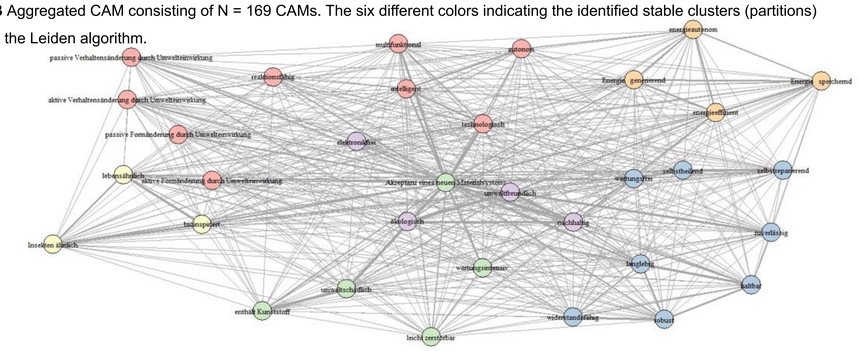
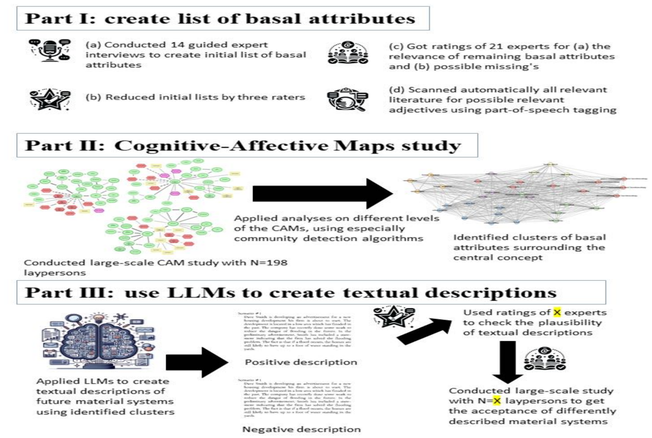


Figure 3 Aggregated CAM consisting of N = 169 CAMs. The six different colors indicating the identified stable clusters (partitions) applying the Leiden algorithm.



Study Design

Figure 4 Overview of the study design



References

Reuter, L. (2019). Collection and evaluation of basal attributes of living materials systems [University of Freiburg]. https://doi.org/10.13140/RG.2.2.27832.90889

Speck, T., Schulz, M. E., Fischer, A., & Rühe, J. (2023). Cluster of Excellence Living, Adaptive and Energy-Autonomous Materials Systems (livMatS). In K. Dröder & T. Vietor (Eds.), Future Automotive Production Conference 2022 (pp. 239–252). Springer Fachmedien. https://doi.org/10.1007/978-3-658-39928-3_18

Traag, V. A., Waltman, L., & van Eck, N. J. (2019). From Louvain to Leiden: Guaranteeing well-connected communities. Scientific Reports, 9(1), 5233. https://doi.org/10.1038/s41598-019-41695-z

Further information

central webpage

https://drawyourminds.de/

link poster

Acknowledgements

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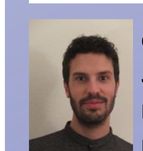

Contact

Julius Fenn, Dr.

E-Mail: julius.fenn@psychologie.uni-freiburg.de

Phone: +49 761 203 9153

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FIT

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