University of Antwerp
Faculty of Business and Economics

CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

MKLab
Multimedia Knowledge and Social Media Analytics Laboratory

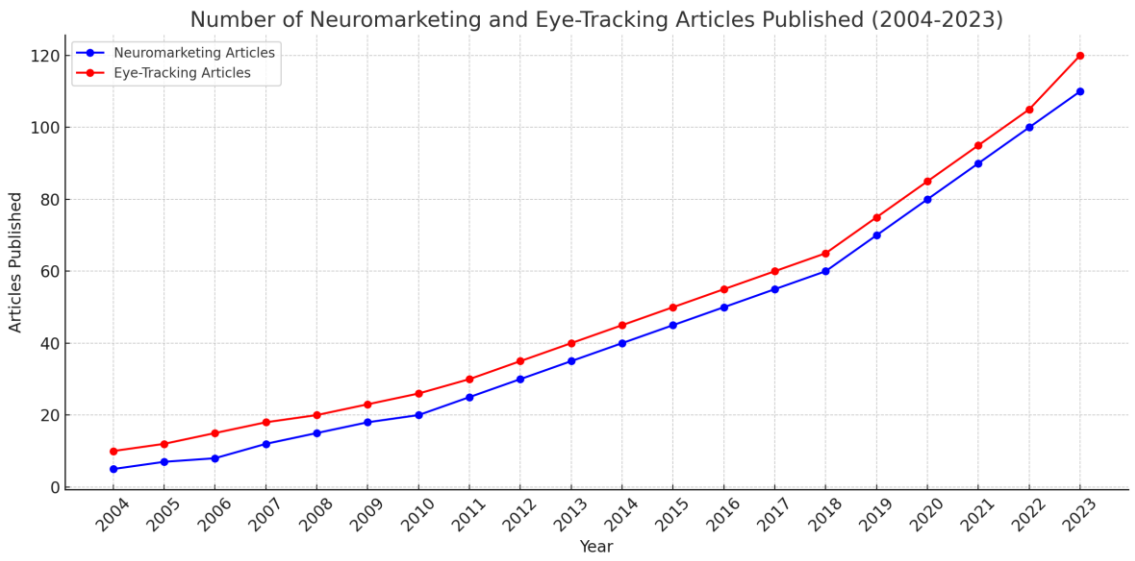
On streamlining data reporting and data sharing practices for promoting research reproducibility in screen-based neuromarketing studies

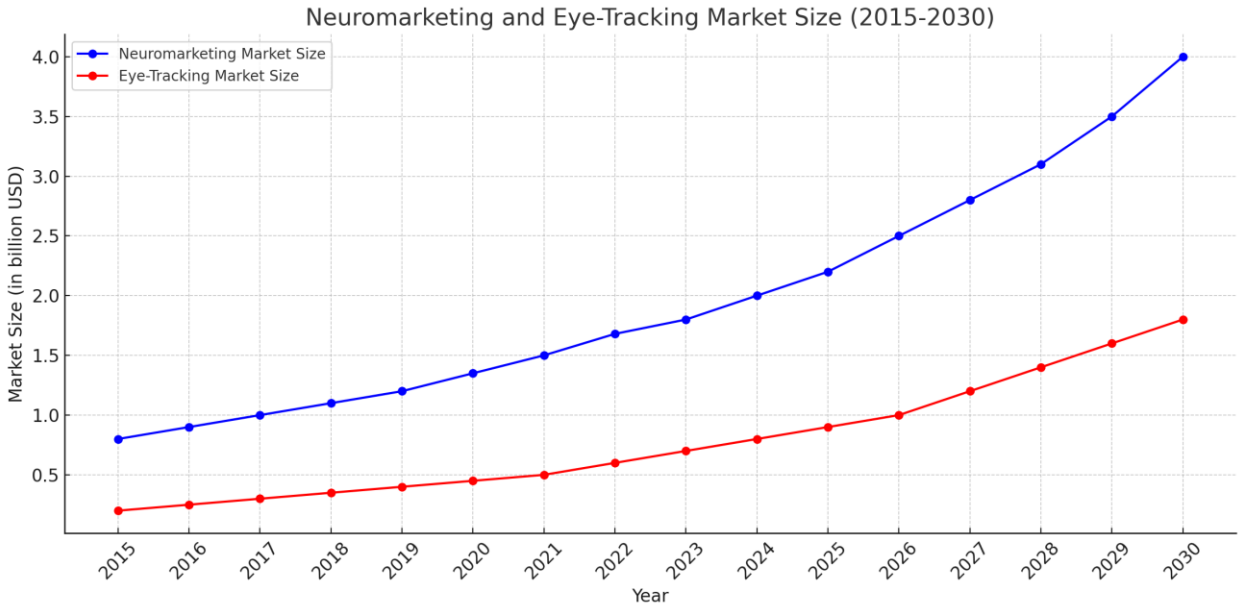
V. Mygdalis, V. P. Oikonomou, K. Georgiadis, F. P. Kalaganis, S. Nikolopoulos, I. Kompatsiaris and N. Dens

EUROPEAN ADVERTISING ACADEMY
ICORIA 2024

Introduction

- **Neuromarketing and Eye-tracking academic and business growth**





University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

Motivation

- **Are there devices/sensors** that can directly measure high-level cognitive human emotional responses?
- **The capabilities of Eye-Tracking (ET) and Electroengephalogram (EEG) sensors are sometimes overestimated**
- **Lack of widely accepted conventions across studies in variables and measures**
- **Lack of reproducibility due to limited raw sensor data sharing**

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

Contribution

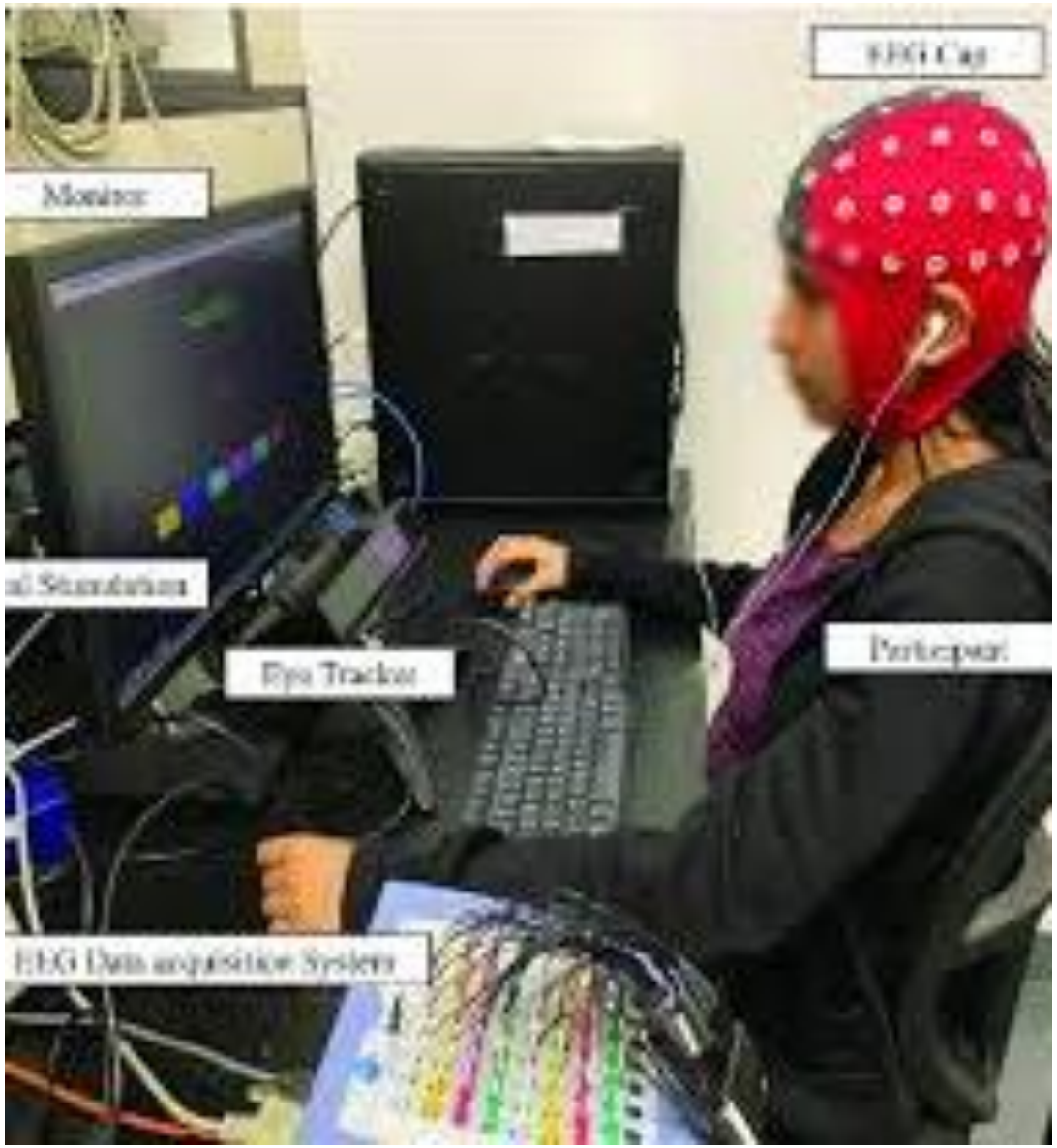
1. **Re-iterate technological limitations of ET and EEG sensors.**

2. **Pinpoint underdiscussed reasons** for cross-study inconsistencies, that hinder research reproducibility.

3. **Highlight the importance of standardization** in data reporting and **provide** further **incentives** for raw data sharing.

4. **Propose a set of good data reporting practices** that may be adopted in ET and EEG marketing studies by researchers.
   - Or be used as a “checklist” by reviewers and journal editors.

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union’s HE research and innovation programme under the g.a.n. 101103256



Limitations of ET and EEG sensors

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

1. Technological limitations of ET sensors

- **ET sensors work optimally under the manufacturer-defined conditions:**
  - And it varies across different participants (age, ophthalmic conditions, wearing glasses etc.), light conditions, across different participant distances from the screen.
  - There is no guarantee that they work under different conditions.
- **ET sensors cannot calculate attention. They can only estimate the gaze direction over time, i.e.,**
  - 4D signal over time estimating the relative/normalized (0-1) X, Y gaze direction, and can also be 6D if the sensor can also output the pupil diameter
- **All other variables such as fixations, saccades, gaze paths, attention maps etc. are extracted by algorithmic processing of the raw data.**

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

1. EEG signals

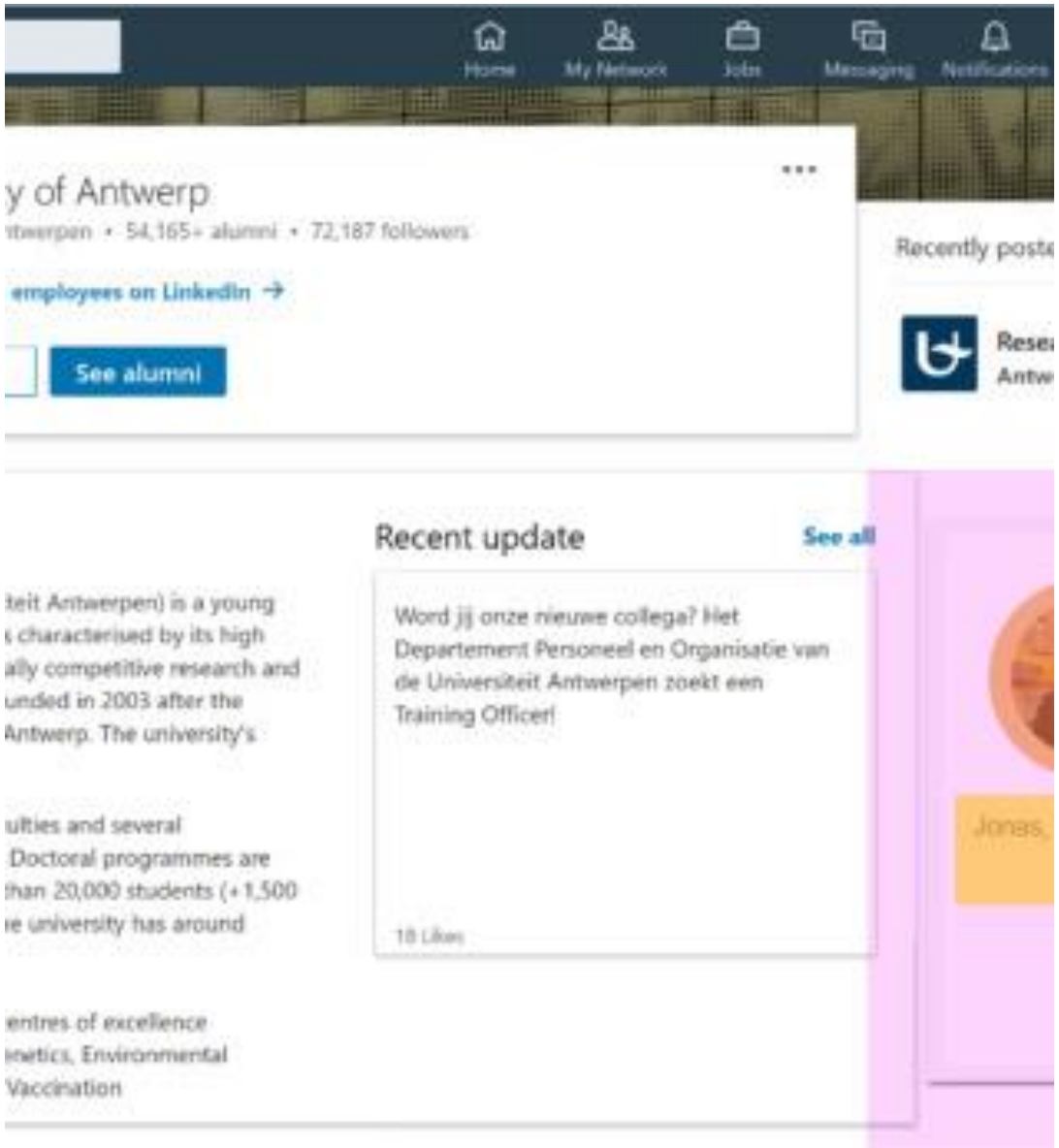
- **EEGs measure the brain's electrical activity:**
  - through non-invasive scalp electrodes.
- **EEG analysis includes:**
  - spectral analysis to examine signal frequencies
  - hemispheric asymmetry to compare brain hemispheres
  - and calculation of statistical indices correlated to some given marketing stimuli
- **The most widely used brain activity metrics are:**
  - Approach-Withdrawal index
  - the Global Field Power
  - the Memorization Index
  - the Pleasantness Index

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

1. EEG limitations

- **EEG signals are susceptible to noise**
  - electrical interference from the environment, artifacts from muscle movements (e.g., eye blinks, jaw clenches), and even heartbeats.
- **EEG signals are non-stationary, i.e., their statistical properties are changing over time.**
  - This variability can occur even within a session due to fatigue, boredom, or varying levels of engagement.
- **There can be significant variability in EEG responses both within a single session, across different sessions, and between different subjects.**
  - stemming from individual differences in brain anatomy, psychological states, and other factors.
- **The quality and relevance of the EEG data depend significantly on the precise placement of electrodes on the scalp.**
  - Incorrect placement can lead to poor signal quality or the misinterpretation of where brain activity is originating.
- **Standardized electrode placement protocols like the 10-20 system are used to ensure consistency and comparability of data across studies.**

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

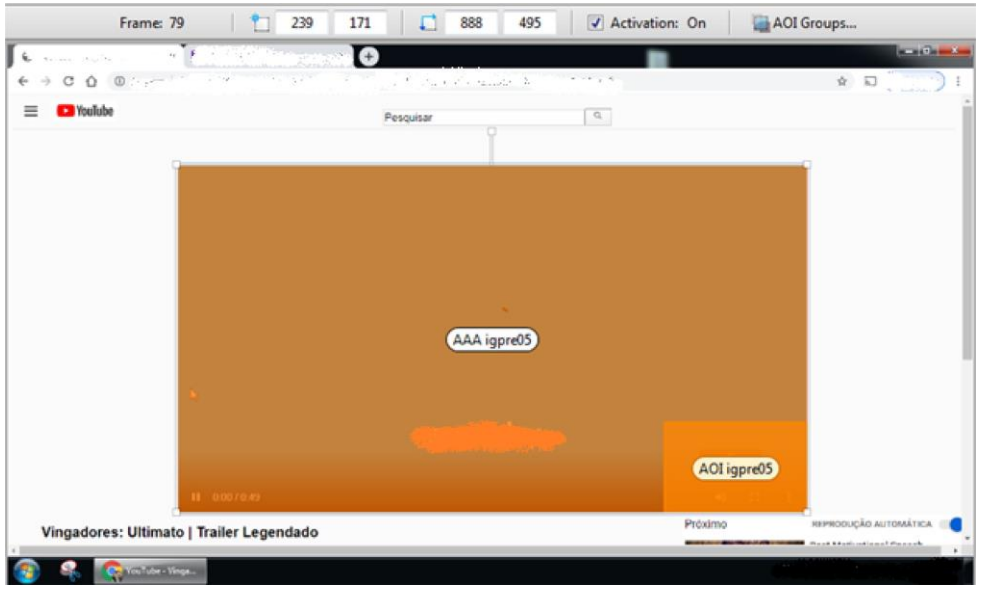


Examples of studies

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

2. Eye-tracking studies in marketing

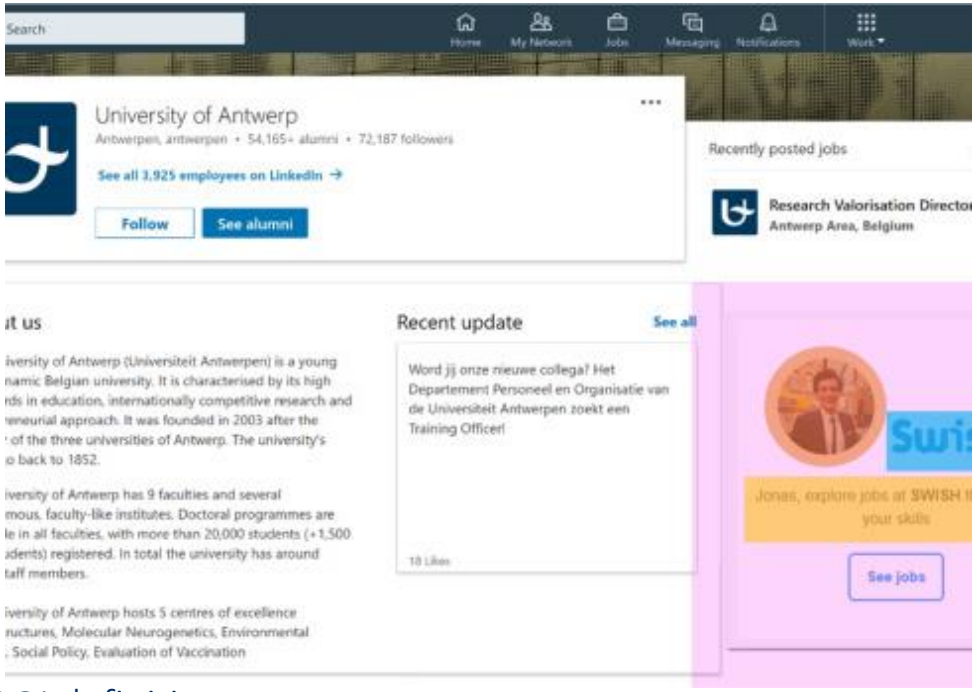
Study 1



- AOI definition:
  The AOI defined on the bottom right, is a lot larger than the actual button

Frade et. al (2022). Skippable or non-skippable? Pre-roll or mid-roll? Visual attention and effectiveness of in-stream ads. *IJA*, 42(8), 1242–1266.

Study 2



- AOI definition:
  Here AOI sizes were defined at the 115% of the actual stimuli size (reported)

J. Pfiffelmann et al (2020). Personalized advertisements with integration of names and photographs: An eye-tracking experiment. *JBR*, 111,196–207

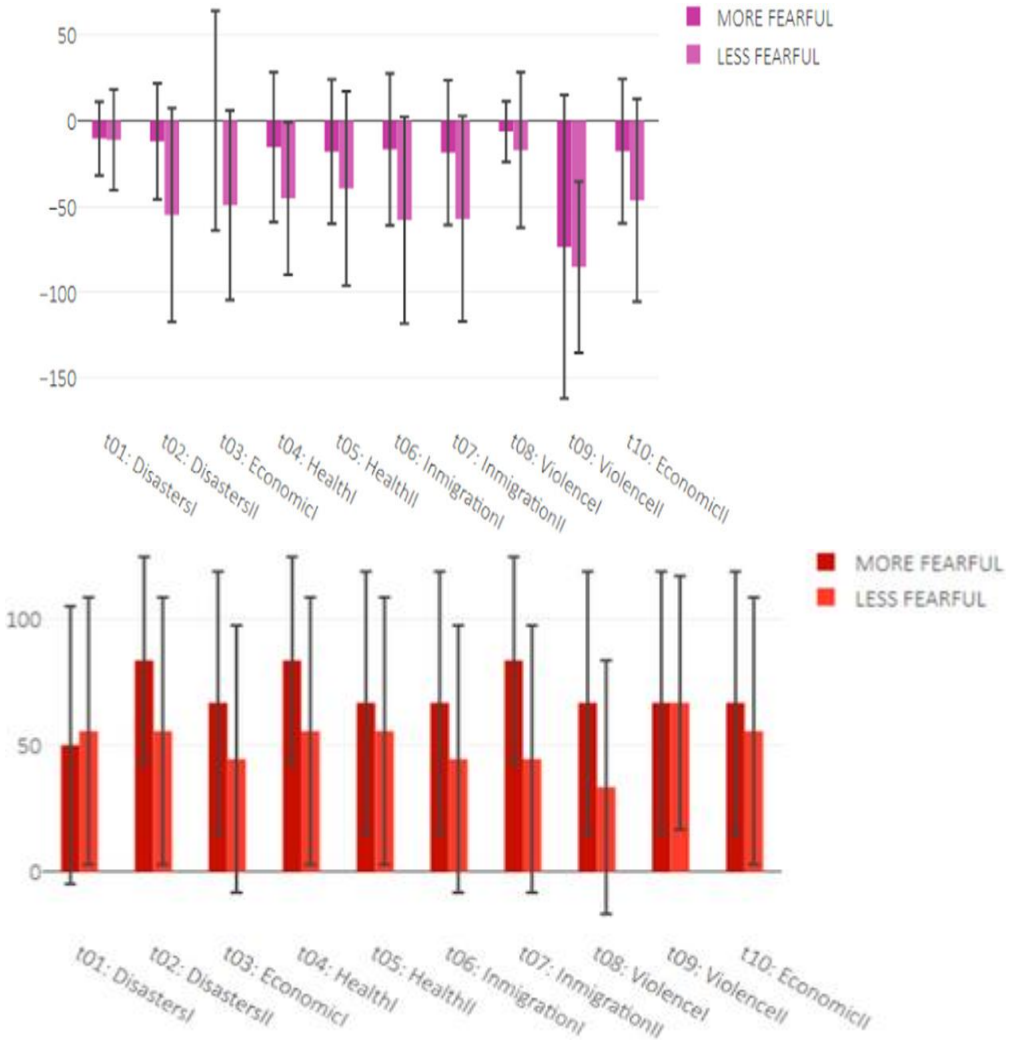
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

2. Multisensor Neuromarketing study

Study 3

- EEG, EDA, BVP
- Reported variables:
- “Percentages (0-100%)” of:
- Fear, attention, valence, memorization

- Are some values exceeding the variable range (0-100)?
- Are percentages >100% or negative?



Mas et al. (2024). Emotions in fear communication: A cross-cultural neuromarketing approach. *Psychology & Marketing*, 41, 697–718.

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

CONVISE project has received funding from the European Union’s HE research and innovation programme under the g.a.n. 101103256

Experimental protocol Checklist

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

3. ET experimental protocol reporting checklist

- **Equipment and software**
  - Device name, configuration, sampling rate
  - Software for acquiring and processing the data
- **Scene geometry and experimental conditions:**
  - Screen size and resolution
  - Stimuli size in pixels
  - Distance of participants from the screen/sensor
  - Light conditions
- **Core variables and data quality:**
  - What is the definition of a fixation in this study? 80ms, 150ms, 250ms?
  - Was calibration performed per subject? What was the average error?
  - Further data quality checks (as in saturation, variance across participants, etc.)
- **AOI definition:**
  - If square, it should be reported in coordinates respective to the visual material:
    - AOI center (x,y), height, width
  - Intersection over Union (IoU) ,metric (0-100) of the defined AOI area with the stimuli

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

3. EEG experimental protocol reporting checklist

- **Equipment**
  - Device type and model number
  - Number of EEG channels
  - Configuration (montage: bipolar, or referential)
  - Type of EEG electrodes (dry or wet)
  - EEG reference selection, sampling frequency, filtering
  - Recording of supplementary data such as electrooculograms (EOG) signals and eye tracking data
- It is common to **pre-process** the signals to remove artifacts and noise
  - the **adopted specialized software** must be reported together with its configuration.
  - The **algorithms** used for data pre-processing

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

Data sharing incentives and best practices

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

4. Good data sharing practices

- **The most trivial way is to share the raw sensor data, publicly and openly**
  - When enough raw data are shared, open and free tools to analyse them will emerge and become more popular (EEG Lab, Pygaze, etc.)
- **How to share?**
  - OSF, Zenodo, University repositories or Open-research Europe all feature DOI assignment, and fulfill all data management prerequisites
  - Github should also be considered for sharing codes
- **When raw data sharing is not possible:**
  - We incentivize to share as many extracted variables as possible, even if they are not related to the study, in open data formats (most sensors allow it)
  - They can be in some appendix or a separate file, attached with the study

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

4. Incentives for data sharing

- **Data and code sharing can significantly increase article impact (and citation count)**
- **Stimulates further studies within the domain**
  - A meta-analysis study might use them and reference this paper
- **Enables studies outside the domain**
    - Attention heatmaps can be used in computer vision for saliency detection problems (1000+ citations for an article that did it in 2020).
- **Promotes the development of new and existing open-source tools**
- **Long-term benefits**
  - Reduces complexity and costs for conducting experiments
- **There are no real ethics constraints!!!**
  - Sensor data are not personal data, if they are (pseudo-)anonymized
  - Even in the case of facial images/videos, significant effort is needed for re-identification

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

Conclusion

- We **discussed** the **technical details** that ET and EEG works in marketing should take into consideration.
- We proposed a set of minimum reporting protocol that should be followed in order to **promote and facilitate cross study coherence and research reproducibility**.
- Adopting our proposal as a baseline checklist can **facilitate the work of the reviewers by requesting specific details in the experimental settings.**
- **These practices can enhance the quality of the articles and their impact to the domain and outside**, without significant additional workload to the researchers.

University of Antwerp | Faculty of Business and Economics
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256

University of Antwerp
Faculty of Business and Economics

Thank you!

Q & A

Vasileios.mygdalis@uantwerpen.be

CONVISE project has received funding from the European Union's HE research and innovation programme under the g.a.n. 101103256