Investigating the Impact of Ecologically Valid Interactions on Rapid Serial Visual Presentation-based Brain-Computer Interface Performance

Muhammad Ahsan Awais, Peter Redmond, Tomas Ward, Graham Healy

Insight SFI Research Centre for Data Analytics, School of Computing, Dublin City University, Dublin, Ireland
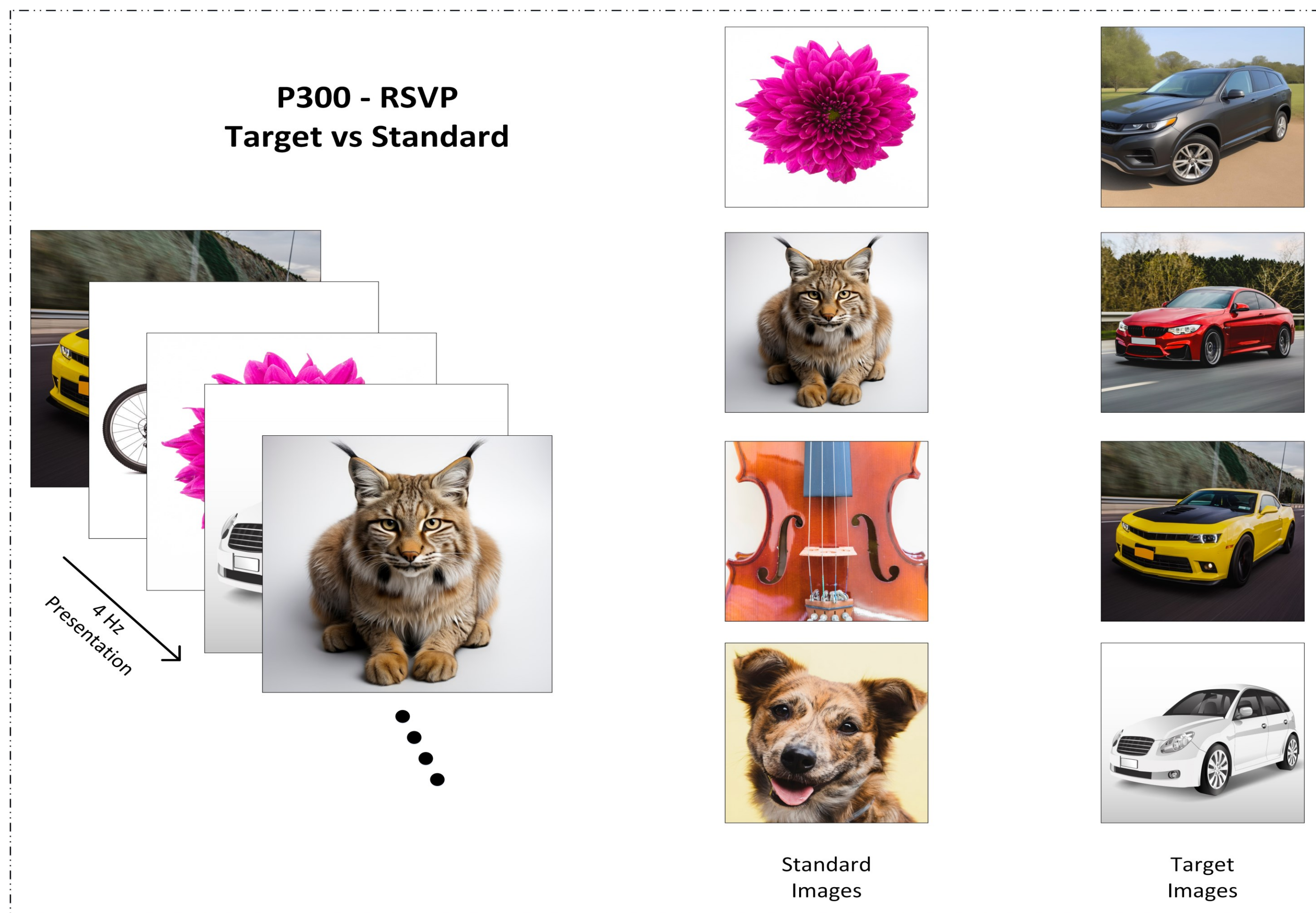
Insight — SFI RESEARCH CENTRE FOR DATA ANALYTICS

A World Leading SFI Research Centre

Science Foundation Ireland For what's next

Introduction

P300 - RSVP
Target vs Standard

4 Hz Presentation

Standard Images

Target Images

The Rapid Serial Visual Presentation (RSVP) is an experimental approach to BCIs in which a series of images are displayed at a high speed. Participants are asked to differentiate between a set of target images and a set of non-target images, where the P300 ERPs are evoked by the target image, but not by the non-target image.

Challenges

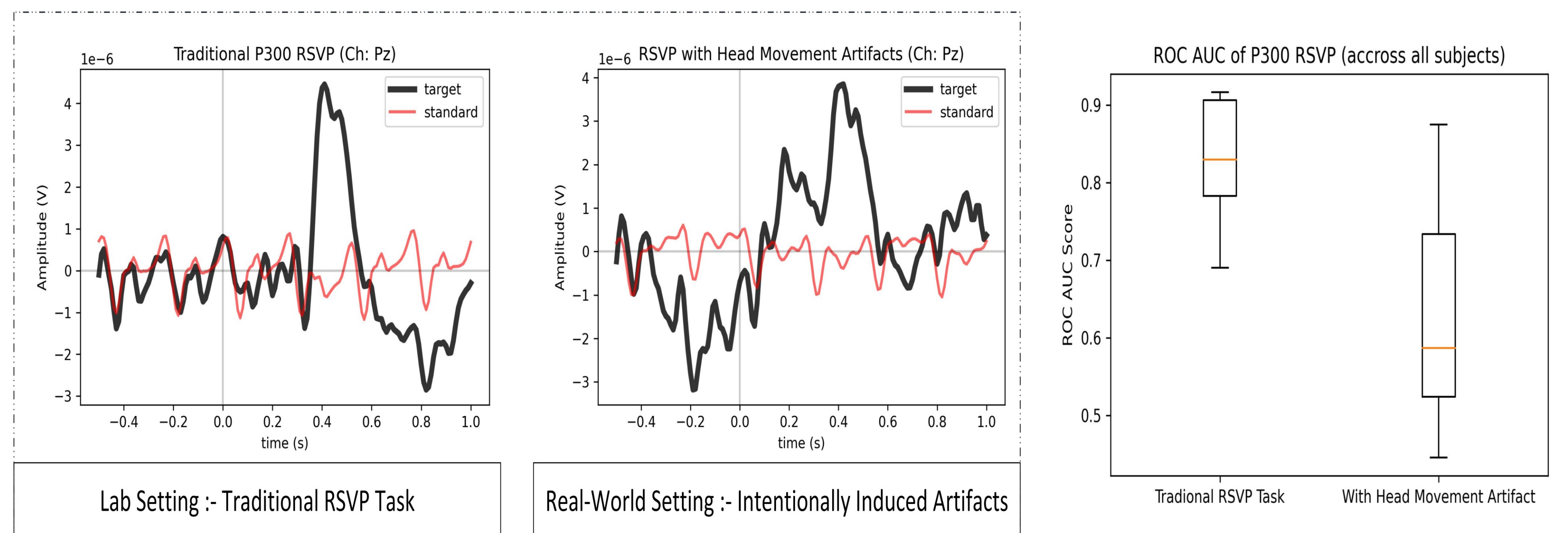Lab Setting

Real-world or MetaVerse

VS
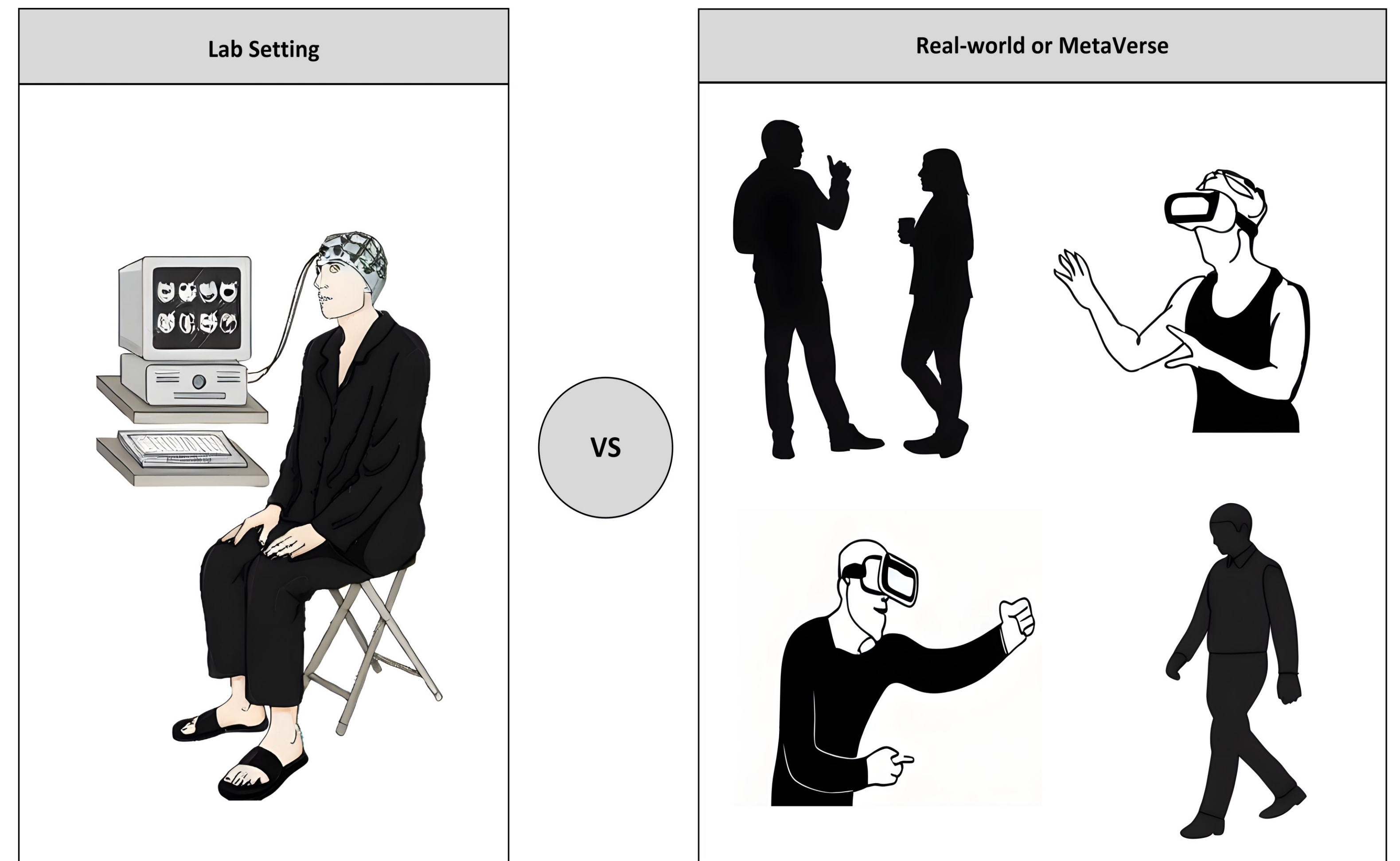
While the RSVP approach produces impressive results in lab-based environments, translation of this technology into consumer contexts requires a better understanding of performance in ecologically valid settings, for example, the use of the BCI to enhance experiences in real/online worlds, metaverse, and gaming contexts.

Methodology

RSVP Task

Talking

Body Movement

Head Movement

Lab Setting

Real-World
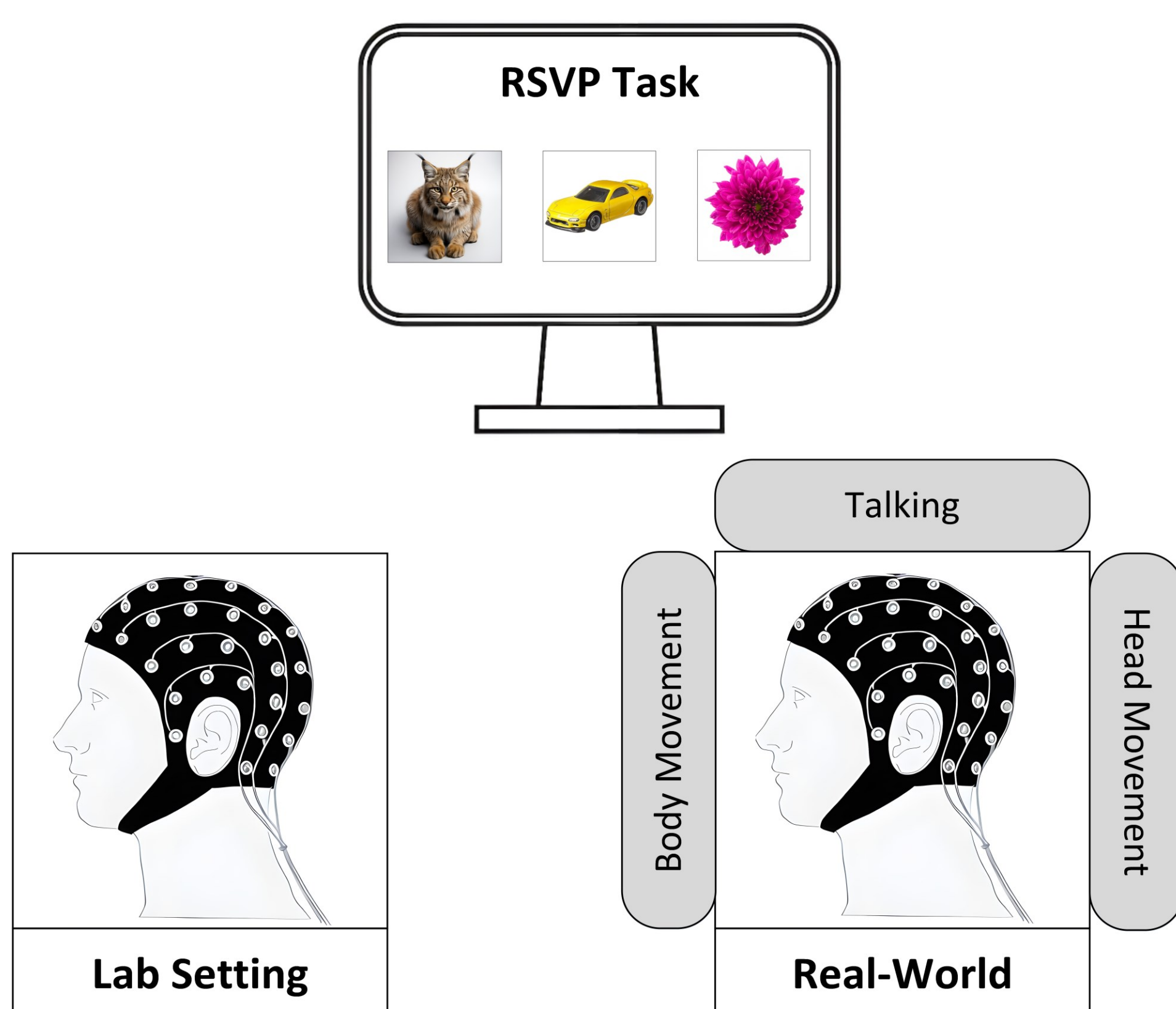
To emulate realistic scenarios and assess their impact on EEG-based RSVP, different artifacts were intentionally introduced.

Results

Lab Setting :- Traditional RSVP Task

Real-World Setting :- Intentionally Induced Artifacts

ROC AUC of P300 RSVP (accross all subjects)

These P300 waveforms were extracted from a single subject utilizing the Pz channel. In contrast to the controlled lab setting, the second plot vividly showcases the adverse impact of noise in real-world scenarios, particularly evident in the pre-stimulus desynchronization. This impact is further corroborated by ROC AUC.

Discussion & Conclusion

- To explore the impact of noise on result accuracy in controlled laboratory environments versus real-world scenarios.
- Head movements have been utilized to demonstrate the impact of various artifacts (traditional vs noisy).
- The results are based on data from a single subject out of a total of 10 subjects.
- The ROC-AUC score of P300 RSVP with head movement is significantly lower compared to the traditional 'target vs standard' identification task, indicating a need to enhance algorithms to achieve better results in real-world settings.

Why This Research Matters

- Brain-computer interfaces bridge the gap between the human brain and technology. In clinical applications, BCIs offer innovative solutions for individuals with neurological disorders, while for society, they represent a transformative avenue, enabling seamless communication and control through direct brain interactions.
- To implement a BCI system in real-world scenarios, data gathering beyond controlled environments is essential.
- My research aims to eliminate brain signal noise, which will revolutionize applications in clinical and non-clinical settings through more efficient brain-computer interfaces.
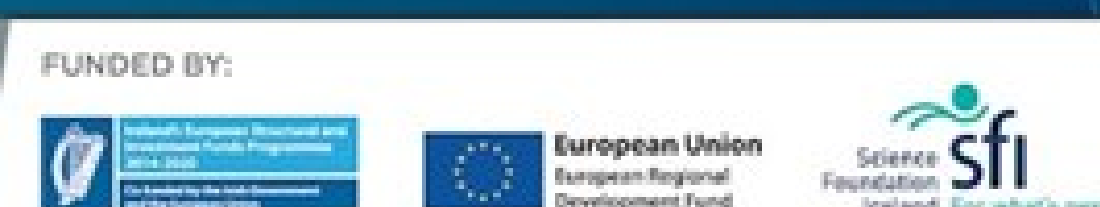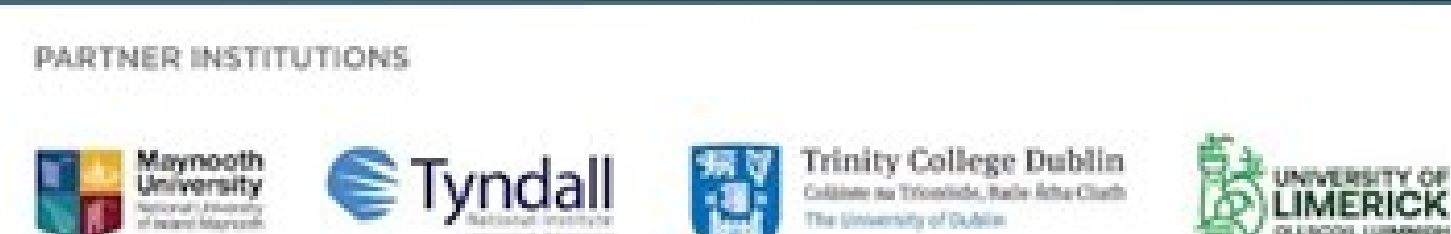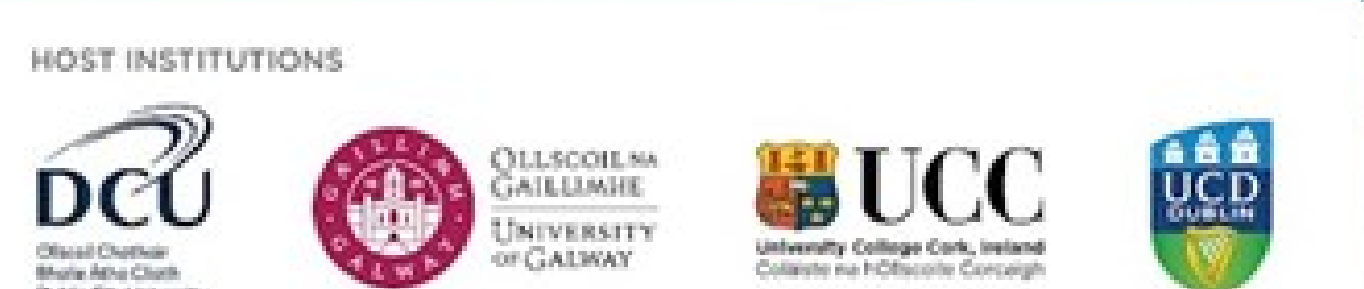
Want to Know More ?

A comprehensive dataset named AMBER has been made available to facilitate further exploration by researchers.

Research Paper

Email Me