Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA24123

Grantee name: Hendrik Knoche

Details of the STSM

Title: **Standardizing Eye-Tracking Data in XR: Enabling Cross-Site Interoperability**

Host: Eye Tracking Research Center, SWPS University, Warsaw, Poland. Dates: 26 to 31 October 2026.

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

The STSM took place at the Eye Tracking Research Center at SWPS University in Warsaw from 26 to 31 October 2026. I worked with Dr Izabela Krejtz and Dr Krzysztof Krejtz in a series of joint working sessions that followed the five steps of the working plan.

Knowledge exchange. We reviewed how the host lab and my group calibrate and validate eye tracking in XR, which coordinate systems we use, how we preprocess data and how fixation detection is reported (velocity-based I-VT and dispersion-based I-DT algorithms, with the minimum and maximum duration thresholds that must be stated). A recurring issue was the loss of accuracy for targets near the edges of the HMD field of view. This is critical for spatial neglect research, where targets are deliberately placed in the periphery and where a wide-field calibration may be hard to complete on the neglected side.

Cross-device data mapping. We collected data on both labs' headsets (HTC VIVE Focus Vision and HTC VIVE XR Elite) with both the Whack-A-Mole (WAM) platform and the host's software, including a 3×3 target validation test, and compared the outputs. We began mapping gaze origin, gaze direction, timestamps and reference frames to a common representation. Deviation from the plan: the mapping could not be completed during the week. The host's application was built by an external technical partner who was not available, so it remained unclear which coordinate space (HMD-local, head-local or world) the host's logs use.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the Grant Holder Manager to verify the grant documents compliance and proceed with the payment.

Core data elements. We defined a three-tier structure. Tier 1 covers recorded signals and their context: the participant (eyes with gaze, pupil and eye openness; head pose; hands; controllers; body posture), the world (objects and targets with position, rotation, dimensions and state; environment and world coordinates; events and interactions), and metadata and quality (device, sampling rate, field of view and how it was measured, corrective lenses, software stack and versions, calibration and post-calibration validation). Tier 2 covers derived features. Tier 3 covers the constructs inferred from them, such as fatigue, vigilance and cognitive load.

Feature descriptions. We started harmonized descriptions of Tier 2 features, among them fixation duration and frequency, saccade amplitude, blink rate, PERCLOS, task-evoked pupil responses and the Index of Pupillary Activity. We also assessed which pupil measures can be compared across sites. Baseline-corrected, within-subject and task-evoked responses are the most transferable; absolute pupil diameter, and clinical thresholds based on it, do not transfer across devices or labs. This step is not yet complete.

Interoperability schema. During the visit we identified the Brain Imaging Data Structure (BIDS), with its eye-tracking and motion conventions, together with Hierarchical Event Descriptors (HED), as a suitable existing basis for the schema. We built a worked example that traces one cancellation-task event from OpenXR values through Lab Streaming Layer (LSL/XDF) recordings to BIDS files with HED annotations, and links it to pseudonymised clinical data expressed in FHIR and the OMOP Common Data Model. The example was prepared for the WG4 workshops at the Action meeting in Izmir.

Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

The STSM achieved most of its planned goals. The knowledge exchange, the definition of core data elements and the choice of an interoperability framework were completed. The cross-device mapping and the standardized feature descriptions were started and will be finished after the visit.

Minimum dataset. The three-tier structure (signals and context, derived features, constructs) forms the first draft of the minimum interoperable dataset promised in the application, including the metadata and quality fields needed to interpret eye-tracking data from different devices and sites.

Reporting checklist. We formulated the questions every XR eye-tracking dataset should answer: how gaze is represented (eye origin and direction, gaze point or both), which coordinate system and origin are used, how accuracy varies across the visual field and depth, which confidence measures exist, how pupil size is computed and in which units, whether off-axis effects are corrected, how eye openness is represented, and which calibration information is stored. Because vendor calibrations are often black boxes, we recommend a short post-calibration validation with known targets, such as the 3×3 test we ran.

Practical recommendations. Seat participants at the world origin (0,0,0) and report their position; report the fixation algorithm class and its thresholds; report how the field of view was measured; and treat absolute pupil diameter as comparable only within the same headset and participant, after baseline correction, with controlled illumination and reported gaze eccentricity.

Data and examples. A paired dataset recorded on two headsets with two software stacks now serves as a test case for the mapping. The BIDS/HED example linking XR sensor data to clinical records was used as material for the WG4 workshops in Izmir.

Contribution to the Action. These results serve WG4’s objectives on research data infrastructure and

harmonized data collection and reporting, and its capacity-building activities through the workshop material. They also lay the groundwork for multi-site studies in WG5, where the specification can act as a shared data collection protocol.

Follow-up. Agreed next steps with the SWPS team are: (1) completing the coordinate mapping once the host's technical partner can document the logging; (2) finishing the feature descriptions and turning the results into a WG4 guidance document; and (3) joint research on calibration suited to neglect patients (narrow-field, 360° circle or funnel layouts, smooth-pursuit calibration), visualizing calibration error, off-axis correction, vergence error as an indicator of neglect in 3D, eye input, and embodiment in prism-adaptation tasks. Joint publications are planned, with the COGAIN symposium, KES and ECEM as candidate venues.