

# RHUMBO repositories for Open Access

DELIVERABLE

## 5.10.

**Date:** 30/04/2020

**Prepared by:** UPV

### RHUMBO

**modelling and pRedicting Human decision-making Using  
Measures of subconscious Brain processes through mixed  
reality interfaces and biOmetric signals**

From November 2018 to October 2022

Grant agreement: 813234

[www.rhumbo.eu/](http://www.rhumbo.eu/)



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Dissemination level	
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	PP = Restricted to other programme participants (including the EC)
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*“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 813234.*

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## ABBREVIATIONS

ESR: Early Stage Researcher

WP: Work Package

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## Executive Summary

RHUMBO will take the measures to make it possible for third parties to access, mine, exploit, reproduce and disseminate the data generated by the project, -including the 'underlying data' needed to validate the results presented in scientific publications-, together with their metadata. Institutional servers and Zenodo repositories will be used for this purpose as they meet RHUMBO's main storage and dissemination requirements. They will act as trusted repositories with high quality storage and guaranteed backup and resilience, ensuring RHUMBO's data preservation, while accessibility is guaranteed as it meets interoperability standards.

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## INTRODUCTION

The present document is a deliverable of the RHUMBO project (Grant Agreement # 813234), funded by the European Commission Research Executive Agency (REA), under the Innovative Training Networks Programme of the Marie Skłodowska Curie Actions (H2020-MSCA-ITN2018).

In line with the principles of Open Access to research data and publications generated through H2020 programmes, RHUMBO relies generally on an Open Access Strategy bound to generate the maximum impact of the project's results both for the research and the education communities but also to industry (promoting fast access to cutting-edge RHUMBO's research results) and the general public. To ensure the fulfilment of this strategy, in M6 the Consortium, led by AAU for the preparation of the deliverables, submitted deliverable D5.9., which outlined the initial Data Management Plan (DMP) of the project. As stated before, that document should be periodically updated to support the management life-cycle for all data that will be collected, processed and generated as the project progresses, including the guidelines on how to make them findable, accessible, interoperable and reusable (FAIR). This deliverable (5.10) is focused on the repositories for open access that will be used.

As the initial DMP was, this document is based on the template H2020 Programme Guidelines on FAIR Data Management in Horizon 2020 version 3.0, 26 July 2016 and is structured with inspiration from the questions presented in the template. The current focus is on providing specific information on open access policies and how the RHUMBO partners ensure that the data will comply with FAIR standards.

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## RHUMBO DATA COLLECTION

One important aspect of RHUMBO is the development of an integrated multimodal-sensing platform for characterizing user experience in MRT, which will be used in different experimental designs conducted by the ESRs. This platform will use biomedical signal processing and feature extraction algorithms to decode brain and autonomic nervous system dynamics during immersive affective scenarios. The research efforts will be focused in the development of novel metrics derived from the analysis of three kinds of data (according to its origin):

1. Brain activity signals to assess user's core cognitive processes through non-invasive methods including functional magnetic resonance imaging (fMRI), near-infrared spectroscopy (fNIRS) and electroencephalography (EEG).
2. Autonomic nervous system (ANS) activity on cardiovascular and respiration control in mixed reality as well as other peripheral physiological correlates linked to the so-called central autonomic network, such as electrodermal activity (EDR), respiration dynamics, cardiac heart rate variability and cardio-respiratory coupling.
3. Behavioural patterns based on social signal processing (SSP), eye-tracking, and stealth assessment within mixed reality scenarios, including also facial expression analysis, prosody from speech utterances, gesture/posture recognition and VR engine behavioural metrics.

These data sets will be captured through different sensors and hardware devices, according to the type of signal. Efforts will be made in order to guarantee the compatibility and interoperability of equipment and hardware used for capturing the data in the different lab locations of the ESRs. Additionally, subjective and demographic data will be collected through questionnaires and semi-structure interviews in order to guide the segmentation of the physiological and behavioural data, and for the purpose of maintaining a homogeneous metadata standard throughout the project.

Table 1 summarizes the origins of the data and the sensors and the methods for gathering it.

Origin of the data	Sensor/hardware/method	Raw data format	Processing scripts
Brain activity data	Electroencephalogram (EEG)	csv/tsv	(Matlab/Python/R)
	Functional MRI (fMRI)	Dicom / Nifti	
	Near-infrared spectroscopy (fNIRS)	.oxy4/.oxy5	

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<b>Cardiac activity</b>	Electrocardiogram Heart rate variability/pulse	csv/tsv	(Matlab/Python/R)
<b>Respiration rate</b>	Respiration rate sensor	csv/tsv	(Matlab/Python/R)
<b>Arousal</b>	Electro dermal response (EDR)	csv/tsv	(Matlab/Python/R)
<b>Behavioral data</b>	VR Engine behavioral metrics Eye-tracking Facial expression analysis Speech prosody Gesture/posture recognition	csv/tsv	(Matlab/Python/R)
<b>Subjective ratings</b>	Questionnaires Interviews	csv/tsv	(Matlab/Python/R/ standard statistical packages, such as SPSS)
<b>Metadata</b>	Demographics/contextual info	csv/tsv	(Matlab/Python/R)

Table 1. Origin of the data and the sensors and the methods for gathering it

## Data treatment

Raw data captured through the different sensors and methods will be subjected to a series of treatments and analysis protocols that include complex combinations of signals in order to derive innovative metrics to meet the objectives of the project. First, the data will be cleaned of all known artefacts and systemic factors, like for example eye and head movement artefacts in the case of fNIRS and EEG signals. Besides standard signal processing techniques yielding canonical markers, novel complex metrics will be derived from the application of the theory of nonlinear dynamical systems. This could be for example the coupling of brain and heart signals. Bayesian/multivariate statistics and ad-hoc machine learning algorithms will be employed to obtain reliable representations of multimodal signals combining neural correlates with peripheral physiological signals such as electrocardiogram (and derived heart rate variability series), respiration, and electrodermal activity. The processing platform will integrate subjects' individual differences, psychometrics, and behavioural patterns while interacting with virtual situations using MRT. The platform will be shared by the different ESRs responsible for collecting, processing and analysing the data of their respective experiments.

## Data types

In the context of this DMP, we apply the definition used by Corti et al. (2014) who 'define research data as any research materials resulting from primary data generation or collection, qualitative or quantitative, or derived from existing sources intended to be analysed in the course of a research project. The scope covers numerical data, textual data, digitized materials,

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images, recordings or modelling scripts.’ In RHUMBO there will be 5 types of data with their respective formats:

1. Rawdata (csv/tsv, oxy5 and oxy5,)
2. Processing scripts (Matlab/Python/R)
3. Post processed data (csv/tsv)
4. Analysis scripts (Matlab/Python/R)
5. Results data (graphs and tables)

All consortium partners will be involved in data collection, processing and management, especially with respect to their specific ESRs and therefore have been involved in discussions regarding the choice of data repository and considerations relating to data treatment and management.

The primary users of the data will be the ESRs that collect and analyse it in order to accomplish the objectives of RHUMBO, but there will be also extensive internal re-use of data within the consortium in order to try out new signal processing methods, new derived metrics, and validation and comparison of results. Besides this, the data is expected to be useful for other researchers and projects in the fields of behavioural/cognitive neuroscience, biomedical signal processing, psychophysiology, consumer behaviour, and users and developers of sensing technologies (e.g. fNIRS and EEG) and Mixed Reality Technologies.

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Corti, L., Van den Eynden, V., Bishop, L., & Woollard, M. (2014). Managing and sharing research data: a guide to good practice: Sage.

## Data volume

It is hard to estimate the expected size of the data until the final ESR plans and experimental designs are in place. The size of the raw data files will depend on different factors inherent to the experimental paradigms in question, e.g. the length of the measurements, the number of channels and sensors applied, the kind of signals and devices synchronized, etc. The total volume generated per ESR will also depend on how many subjects the particular experimental design requires.

## FAIR DATA

### Making the data findable

The primary responsibility for storage, management and findability of the data generated by each ESR project over the course of RHUMBO lies within the institution hosting the ESR. Each

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partner agrees to comply with the common standards and guidelines agreed by the consortium in order to assure the sharing and interoperability of the data both, internal to the development of RHUMBO and for the general compliance of the FAIR principles.

All the data will be stored in local servers (of each institution). Besides their institutional servers, all partners will have the optional possibility to mirror and back up their individual data sets in the **open access repository Zenodo**.

**ZENODO will be a voluntary database for RHUMBO partners.** The following table shows the open Access policies that the partners will follow:

Partner	Open Access policies
UPV	UPV is interested to work in the frame of FAIR and to make the project's data sets public. As RHUMBO is adopting Zenodo, UPV will also use this repository. UPV will use the repository CLAAUDIA provided by AAU, as part of its cooperation with the Augmented Cognition lab at AAU.
AAU	AAU is interested to work in the frame of FAIR and to make the project's data sets public. As RHUMBO is adopting Zenodo, AAU will also use this repository. Moreover, at the Individual level, AAU will made its data sets available through <b>VBN, Aalborg University's research portal</b> . This research portal is publicly available and supports the aim to aid the accessibility to research carried out at or in cooperation with AAU. Internally, AAU will also rely on CLAAUDIA, its own data management infrastructure.
UKB	UKB is interested to examine neural correlates of risk-taking behaviours. fMRI data will be submitted as region-specific timecourses and activation magnitude estimates instead of whole-brain raw data, as the latter would require too much storage space.
UVEG	UVEG is interested to work in the frame of FAIR and to make the project's data sets publicly available upon request. The criteria for the distribution of the data will follow the requirements and regulations of the local institution. For joint projects with other Rhumbo partners, the data will be uploaded to the platform adopted by Rhumbo (Zenodo).
UPISA	UPISA is committed to work in the frame of FAIR and to make the project's data sets publicly available upon request. Data collected at UPISA will be provided to researchers who meet the ethics requirements detailed by the local institutional review board.
AMS	For Open Access journals, AMS will also use the snirf dataformat apart from Zenodo, which is an attempt of the fNIRS community to standardize and to facilitate data sharing. More information can be found here: <a href="https://fnirs.org/resources/software/snirf/">https://fnirs.org/resources/software/snirf/</a> <a href="https://github.com/fNIRS/snirf">https://github.com/fNIRS/snirf</a>

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GTEC	GTEC is working on hardware and software development for the experiment platform, rather than experiments for data collection. There will be no open data sets from us, since no experiment is planned at GTEC.
NEUR	NEUR will follow the FAIR principles regarding raw data sharing (eye-tracking and EEG, including video recordings and EEG format) and processed data (e.g., as csv files). NEUR will use Zenodo as this is the open access repository selected for RHUMBO project. Sharing of scripts for handling the data will be analysed in each particular case due to IP reasons.

In any case, the location and nature of the different data sets and their relation to the integral experimental design of RHUMBO as a whole, will be made explicit in the project's website to provide overview. This does not preclude additional use of European and international repositories as the project advances in order to maximize the findability and potential of the datasets.

All datasets will include metadata, i.e.: discovery and technical metadata that defines the what, where, when, why and how of the data. Where appropriate and possible, the data creators will assign Digital Object Identifiers (DOIs) or a Persistent URL (PURL) to their datasets. Search keywords related with the specific objectives of each ESR will be provided in order to optimize the possibilities for re-use.

The approaches for storing, finding, and accessing the data generated within each ESR project is still under discussion. The expectations on FAIR data will be made clear to each ESR and will be included in their respective research plans. The final responsibility to comply with EU regulations will be the responsibility of the hosting institution. The full process will be drawn up once the ESR experimental designs are ready for implementation.).

## Metadata

The use of common data and metadata standards and formats are a key aspect for technological and semantic data operability, allowing the data to be discoverable and hence promoting international and interdisciplinary access to, and use of, research data. Standard dictionaries of metadata will be used for all data types produced by the ESRs. A technical quality control will ensure that all required information is included and all the ESRs will be instructed on a common metadata standard decided by the consortium. Different communities and disciplines develop and adopt various metadata standards and/or practices for the management of their research data and materials. The experimental paradigms that will be used in RHUMBO are of an interdisciplinary nature between applied neuroscience, computer science and immersive media technology in which the characterization of human cognition and affective states are central.

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Given the nature of the experiments and the data generated, the consortium will adopt a metadata model compatible with neuroscientific standards. Besides facilitating findability, the adopted model will aid the interpretation and understanding of the data by providing all the relevant information about the experimental paradigms and conditions, as well as contextual information (i.e. subject's demographics, experimental protocol, hardware and measurement devices, calibration and settings, lab conditions, etc.)

### File naming

A structured data storage is essential for proper and secure storage of data files and records. For any file-based storage, this includes clear and unambiguous file naming, the use of proper versioning, clear and intuitive folder structure. RHUMBO has defined a file naming convention per data type with a clear versioning system. Though each ESR hosting institution will be responsible for storing the data generated by the project, in order to assure reuse and interoperability among partners, the consortium has agreed to adopt the following naming convention to identify the data files generated by each of the 11 ESRs:

RHUMBO\_EsrID\_ExperimentID\_ SubjectID -Date\_Time

This general denomination includes the ID of the ESR conducting the experiment, the experiment ID (followed by the letter R if rawdata or P if processed data), the participant subject ID and the date and time of the recording (the format of date and time will be further specified). This convention will be adapted to the different data types in a consistent manner. The final convention per each type of data will be agreed after the ESR plans are finalized and prior to the generation of any data.

### Making data openly accessible

In the beginning of the project, data is being shared exclusively between members of the RHUMBO project. As previously mentioned, all the data will be stored in local servers (of each institution), while some processing and analytical scripts will be available in a version control open repository like GitHub or similar, to be agreed by the consortium. Besides the partners' institutional servers, RHUMBO is adopting Zenodo as international repository of the project in order to maximize the findability and potential of the datasets. However not all partners have manifested the possibility of making their individual data sets available in the open access repository Zenodo (see table XXXX above). If proprietary software or algorithms are necessary (as in the case of some post- processed data), this will be clearly stated in the metadata. Each partner will make public their access-policy to their respective data sets by providing a reliable

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contact where the data can be obtained upon request. RHUMBO participates on a voluntary basis in the Open Research Data Pilot. However, particular ESRs can opt out at any stage and free themselves retroactively from the obligations associated with the conditions, if:

- Participation is incompatible with the obligation to protect results that can reasonably be expected to be commercially or industrially exploited,
- Participation is incompatible with the need for confidentiality in connection with security issues,
- Participation is incompatible with rules on protecting personal data,
- Participation would mean that the project's main aim might not be achieved,
- The project will not generate / collect any research data, or
- Other legitimate reasons.

ESR projects can also choose to keep selected datasets or even all data closed for any of the reasons above, via their individual Data Management Plan.

The RHUMBO Supervisory Board will make decisions on the publication of the data. In case of publishing our findings in scientific journals, data will be available to the public. In this case, the data sets will get a persistent identifier.

External researchers will be able to apply for access to the RHUMBO data before the general release to the public. In this case an application form needs to be filled detailing a research plan, ethical approval etc.. The application form will be available on the RHUMBO project website together with information on approval process and data content of the RHUMBO database. The Supervisory Board can grant access to the entire database or restrict access to selected data sets.

### Making data interoperable

RHUMBO recognizes that common data and metadata standards and formats are a key aspect for technological and semantic data operability. Standardisation makes the data not only discoverable but also re-usable for different purposes (e.g. assessing the results and analysis procedures, proposing novel ways of analysis, etc.). In order to ensure correct and proper use and interpretation of the RHUMBO data by consortium members and other potential re-users, standardized formats will be used for the different kinds of data (e.g. csv/tsv for rawdata and post processed data; Matlab/Python/R for processing and analysis scripts). In cases in which it will be unavoidable to use non-standard or uncommon specific ontologies or vocabularies, mappings to standardized ontologies will be provided. Vocabularies and conventions in the research domains that converge in RHUMBO (neuroscience, computer science and immersive media technology) will be rigorously applied.

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## Making data re-useable

### Quality control

For RHUMBO, measures for quality control of the data collection will be in place throughout the life cycle of the collection. First, rigorous measures will be enforced during the collection process, given the sensitivity of the measurements to a myriad of intrinsic and extrinsic sources of noise and artefacts. Additional controls will take place during the processing and analysis of the raw data, and during storage and management of the data sets in their life-cycle. There will also be paid particular attention to quality control of the metadata at the moment of storing the datasets in the respective repositories. The initial quality control of the data, during data collection, is the primary responsibility of each ESR, who must ensure that the recorded data reflect the actual facts, responses, observations and events. The quality of the data capturing methods utilized strongly influences data quality. Therefore, the ESRs will be instructed to document in detail the collecting protocols with accurate annotations of noticeable factors that may influence the data. Such rigorous documentation provides evidence of quality.

Some relevant recommendations from the UK Data Archive to be included in the RHUMBO protocols for data collection are:

- calibration of instruments to check the precision, bias and/or scale of measurement;
- using standardized methods and protocols for capturing the data, alongside recording forms with clear instructions;
- accompanying notes and documentation about the data;
- checking the truth of the record with an expert;

For RHUMBO, additional quality control is necessary when the data are submitted to processing and filtering procedures, moment in which the data can be edited, cleaned, verified, cross-checked and validated. Checking typically involves both automated and manual procedures. In this direction, relevant recommendations from the UK Data Archive include:

- Double-checking coding of observations or responses and out-of-range values;
- Checking data completeness;
- Adding variable and value labels where appropriate;
- Statistical analyses such as frequencies, means, ranges or clustering to detect errors and anomalous values;

Errors can also occur during data entry or transfer. For this, it is also recommended to ensure standardised and consistent procedures for data entry with clear instructions; using data entry screens; using controlled vocabularies, code lists and choice lists to minimize manual data entry; detailed labelling of variable and record names to avoid confusion; designing a purpose-built database structure to organize data and data files (UK Data Archive).

The quality assurance procedures will be reflected in the metadata, and when possible and pertinent certification available in the partners' institutions will be seek (e.g. ISO 9001 seal).

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### Long-term re-use

By supporting the concept of FAIR data, RHUMBO will strive to make its research data sets available for as long as possible, with the goal of at least 10 years. The final decision about long-term provision will be taken once the data are stored and once individual arrangements have been made between the partners and their respective institutions. Any necessary discussion and decisions for particular datasets (for example, particularly large datasets, IPR-sensitive datasets) and other logistic limitations will involve the RHUMBO Supervisory Board.

With the exceptions already mentioned in this document and the embargo or opt-outs implied by voluntary adherence to open access, most of the research data from RHUMBO will be made open access as soon as the protocols have been developed and the research been completed and published.

## OPEN ACCESS TO SCIENTIFIC PUBLICATIONS

RHUMBO will ensure open, free-of-charge access to the peer-reviewed scientific publications generated by the project's partners. The most relevant outputs will follow the **Gold Open Access** route to assure maximum impact of the project's results. The rest of the research papers will support **Green Open Access**. A machine-readable electronic copy of the published or final peer-reviewed manuscript accepted for publication will be uploaded once available together with the corresponding underlying data via the publisher and/or via OpenAIRE.

All project research results with public dissemination level are available in the project website in <http://rhumbo.eu/webs/rhumbo/results/>

Each beneficiary will ensure open access to all peer-reviewed scientific publications relating to its results.

## ALLOCATION OF RESOURCES

### Costs for making data FAIR

The costs for storing data in the institutional servers of each partner will be born locally.

### Responsibilities

The RHUMBO coordinator and the Best Scientific Practice and Quality Management Committee will oversee the implementation of the DMP by all ESRs, but the ultimate responsibility lies in the individual ESRs and their supervisors. The latter will ensure that the DMP is implemented at the local level.

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RHUMBO's Best Scientific Practice and Quality Management Committee will provide the ESRs with:

- Advise and training in organising and structuring the data storage
- Advice and training on quality assurance processes during data collection, processing, analysis and storage for the various types of data
- Data and metadata standards

The primary responsibility for ensuring adequate storage capacity lies with the individual RHUMBO partners. The primary responsibility for back-up and recovery of the data, as well as the measures to protect the data against unauthorised use also lies with the individual RHUMBO partners.

Each of the partners will follow their national and institutional procedures for data management, in addition to the RHUMBO DMP.