Minimum Information about a Neuroscience Investigation (MINI): Electrophysiology

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Abstract

This module represents the formalised opinion of the authors and the CARMEN consortium, which identifies the minimum information required to report the use of electrophysiology in a neuroscience study, for submission to the CARMEN system (www.carmen.org.uk).

Introduction

Electrophysiology is a technology used to study the electrical properties of biological cells and tissues. Electrophysiology typically involves the measurements of voltage change or electrical current flow on a wide variety of scales from single ion channel proteins to whole tissues.

This document is a single module, as part of the Minimum Information about a Neuroscience investigation (MINI) family of reporting guideline documents, produced by the CARMEN consortium (www.carmen.org.uk). A MINI module represents the minimum information that should be reported about a dataset to facilitate computational access and analysis to allow a reader to interpret and critically evaluate the processes performed and the conclusions reached, and to support their experimental corroboration. In practice a MINI module comprises a checklist of information that should be provided (for example about the protocols employed) when a data set is submitted to the CARMEN system. The MINI modules specify neither the format that

data should be transferred in, nor the structure of the repository. In this respect a MINI module is implementation independent definition of a particular technology and follows the design principles and presentation format of the MAIPE guidelines [**?**].

The requirements specification for the electrophysiology family of techniques is prescriptive in some respects while maintaining flexibility, allowing the description of a wide range of protocols. The principles underlying this specification define the minimum information that should be associated with data generated from a laboratory based electrophysiology study, for submission to the CARMEN system.

The information defined within this document should facilitate the interpretation, dissemination and evaluation of electrophysiology data, in the first instance to meet the consensus requirements within the CARMEN consortium, and ultimately the wider Neuroscience community. The reporting requirements contained within this document should comply with two general criteria; as outlined in Taylor *et al*, 2007 [?];

1. **Sufficiency**. The MINI reporting requirements should require sufficient information about a dataset and its experimental context to allow a reader to understand and critically evaluate the interpretation and conclusions, and to support their experimental corroboration.

2. **Practicability**. Achieving MINI compliance should not be so burdensome as to prohibit data submission or use of the CARMEN system.

These reporting recomendations cover both extracellular and intracellular electrophysiology recordings. Specifically, defining general auditing information, such as date stamps and responsible persons, the subject under study, the subject task or stimulus if appropriate, the recording protocol and the resulting description of time series data. They do not cover optical electrophysiology techniques of the process of time series informatics analysis.

Items falling outside the scope of this module may be captured in complementary modules, which may be developed in due coursecan be. Note that subsequent versions of this document may have altered scope, as will almost certainly be the case for all the MINI modules. The MINI family of guidelines has been registered with the MIBBI registry (http://mibbi.sourceforge.net/) and are currently structured using the FuGE data model [**?**], via SyMBA [**?**].

The following section, detailing the reporting requirements for the use of electrophysiology, is subdivided as follows:

1. Contact and context
2. Study subject
3. Task
4. Stimulus
5. Behavioral event
6. Recording
7. Time series data

The glossary table provides a definition for each checklist item in the MINI guidelines. Examples are given only to facilitate interpretation and are not intended to be a comprehensive list of the technologies that can or cannot be recorded under each section heading.

In this document the key words "MUST," "MUST NOT," "REQUIRED," "SHALL," "SHALL NOT," SHOULD," "SHOULD NOT," "RECOMMENDED," "MAY," and "OPTIONAL" are to be interpreted as described in RFC-2119 [**?**].

Reporting requirement for electrophysiology

1. **Contact and context**
   (a) Date and time
   (b) Responsible person or role
   (c) Experimental context
   (d) Electrophysiology type
2. **Study subject**
   (a) Genus
   (b) Species
   (c) Strain
   (d) Cell line
   (e) Genetic characteristics
   (f) Genetic variation
   (g) Disease state

(h) Clinical information
(i) Sex
(j) Age
(k) Development stage
(l) Subject label
(m) Subject identifier
    i. Type
    ii. Value
(n) Associated subject details
(o) Preparation protocol
(p) Preparation date

3. **Recording Location**
   (a) Recording Location structure
   (b) Brain area
   (c) Slice thickness
   (d) Slice orientation
   (e) Cell type
       i. Target cell type
       ii. Confirmed cell type
4. **Task** - *if appropriate*
   (a) Protocol
   (b) Sensory conditions
   (c) Equipment
   (d) Recording
5. **Stimulus** - *if appropriate*
   (a) Protocol
   (b) Sensory conditions
   (c) Solutions
   (d) Equipment
   (e) Recording
6. **Behavioral event** - *if appropriate*
   (a) Event
   (b) Equipment
   (c) Recording
7. **Recording**
   (a) Protocol
   (b) Conditions
   (c) Containing device
   (d) Solutions
   (e) Solution flow speed
   (f) Equipment
       i. Electrode
       ii. Electrode configuration
       iii. Electrode impedance
       iv. Amplifier
       v. Filter
       vi. Filter settings
       vii. Recorder
8. **Time series data**
   (a) Data format
   (b) Sampling Rate
   (c) File location

Summary

The MINI: Electrophysiology minimum reporting requirements for the use of electrophysiology specify that a significant degree of detail be captured about the subject, the task or stimulus, the protocol and equipment used to record the measurements, and a description of the resulting time series data. However, it is clear that providing the information required by this document will enable the effective interpretation and assessment of electrophysiology data and metadata and potentially, support experimental corroboration. Much of the information required herein may already be stored in an electronic format, or exportable from instrumentation; we anticipate further automation of this process. These guidelines will evolve. To contribute, or to track the process of the MINI documents contact the corresponding author or view the CARMEN website www.carmen.org.uk.

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Tables

Table 1 - MINI: Electrophysiology Glossary of required items

Classification	Definition
1. Contact and context	
(a) Date and time	The date and time on which the work described was initiated given in the ISO:8601 representation. YYYY-MM-DDThh:mm:ss
(b) Responsible person or role	The (stable) primary contact person for this data set; this could be the experimenter, lab head, line manager etc. Where responsibility rests with an institutional role (e.g. one of a number of duty officers) rather than a person, give the official name of the role rather than any one person. In all cases give affiliation and stable contact information, which consists of (i) Name, (ii) Postal address and (iii) Email address.
(c) Experimental context	The name of the project, study or wider investigation of which the "experiment" is a part (if appropriate).
(d) Electrophysiology type	The type of electrophysiology recording reported as 'extra cellular' or 'intra cellular'

Classification	Definition
2. Study subject	*(derived from MIAME 1.1 [?])*
(a) Genus	The genus classification of the study subject according to the NCBI taxonomy classification
(b) Species	The species classification of the study subject according to the NCBI taxonomy classification
(c) Strain	The strain, genetic variant classification of the study subject, if appropriate. Note this is not cell line (see x.x)
(d) Cell line	The identifier for the immortalised cell line, if appropritate.
(e) Genetic characteristics	The genotype of the study stubject. Genetics characteristics include polymorphisms, disease alleles and haplotypes.
(f) Genetic variation	The genetic modification introduced in addition to strain, if appropriate.
(g) Disease state	The name of the pathology diagnosed in the subject. The disease state is "normal" if no disease state has been diagnosed.
(h)Clinical information	A link, summary or reference to additional clinical information, if appropriate.
(i) Sex	The sex of the subject, in terms of either male, female or hermaphrodite.
(j) Age	The time period elapsed since an identifiable point in the life cycle of an organism. If a developmental stage is specified the identifiable point would be the beginning of that stage. Otherwise the identifiable point must be specified. For example, 2 hours post surgery.
(k) Development stage	The developmental stage of the study subject's life cycle
(l) Subject label	If the subject has been chemically labeled or stained; state the label name.
(m) Subject identifier	The type and value of the identifier assigned to the subject.
(m)i. Subject identifier type	The type and value of the identifier assigned to the subject. For example, vendor or patient identifier. For patients, the identifier must be approved by an Institutional Review Board or appropriate body.
(m)ii. Subject identifier value	The unique string which corresponds to the identifier type.
(n)Associated subject details	The organisation (e.g vendor) or individual repsonsible for the subject.
(o) Preparation protocol	The surgical procedure or the preparation protocol implmented to obtain the specific sample for recording.
(p) Preparation date	The date the surgical procedure or the preparation protocol was performed to obtain the specific sample for recording. Given in the ISO:8601 representation. YYYY-MM-DDThh:mm:ss

Classification	Definition
3. Recording Location	
(a) Location structure	The anatomical part or structure of the subject under investigation or recorded from. For example brain or cell culture.
(b) Brain area	If the anatomical structure under study from 3.(a) is the brain then state the location. If the anatomical structure under study is the mammalian brain then state the location using Neuronames. (http://braininfo.rprc.washington.edu/aboutfolder/aboutbi.html).
(c) Slice thickness	The thickness of the recording slice in milimeters.
(d) Slice orientation	State the planes of the slice, in terms of either i) coronal (width ways), ii) saggital (lengthways parallel to midline) or iii) tangential (lengthways perpendicular to midline).
(e) Cell type	.
(e)i. Target cell type	The cell type of the anatomical structure given in 3.(a) under investigation if non mixed. If mixed the target cell type should be provided
(e)ii. Confirmed cell type	The method of coordinate assignment given in 2.3.1. Reported as 'anatomy confirmation','estimation' or chemical label (this includes antibodies and staining). The label used should be reported in section 2.(l). Additional information such as recodings or image files which also confirm the location can be referenced here.
4. Task	(*if appropriate*)
(a) Protocol	A description of the task protocol undertaken by the subject
(b) Sensory conditions	The sensory conditions during the task protocol
(c) Equipment	The Model Name, Model Number and Manufacturer for equipment used in the task protocol
(d) Recording	If the task is recorded state how and what data types are being recorded
5. Stimulus	*(if appropriate)*
(a) Protocol	A description of the stimulus protocol undertaken by the subject
(b) Sensory conditions	The sensory conditions during the stimulus protocol
(c) Solutions	Description of the solutions used in terms of name, components with concentrations,(if appropriate).
(d) Equipment	The Model Name, Model Number and Manufacturer for specialised equipment used during the stimulus protocol. If electrode(s) are used then they should be described following the structure presented in ref x.x
(e) Recording	If the stimulus is recorded state how and what data types are being recorded

Classification	Definition
6. Behavioural event	- *if appropriate*
(a) Event	A description of the behavioural event observed
(b) Equipment	The equipment use to record the behavioural event, if recorded in terms of The Model Name, Model Number and Manufacturer.
(c) Behavioural event recording	The type of recording of the behavioural event, the file format and the format encoding.
7. Recording	
(a) Protocol	A description of the recording protocol
(b) Conditions	The subject conditions during the recording. Invivo or invitro preparation If invivo was it anethesitised or awake? If awake what was the stimulus condition
(c) Containing device	Containing device temperature of the subject or sample (for example, a bath): Include temperature if appropriate.
(d) Solutions	Description of the solutions used in terms of name, components with concentrations,(if appropriate).
(e) Solution flow speed	The flow speed of the solution described in (ref x.x) in terms of ml/min.
(f) Recording Equipment	
(f)i. Electrode	The type of electrode and the Model Name, Model Number and Manufacturer for specialised equipment
(f)ii. Electrode configuration	The configuration or arrangement of the electrode. For example, a 2-dimensional array. Also state the distance between each electrode. If the study uses voltage clamp in a patch configuration, state the access resistance (the resistance of the cell membrane, which is in series with the electrode resistance).
(f)iii. Electrode impedance	The electrode range or impedance of the electrode
(f)iv. Amplifier	The Model Name, Model Number and Manufacturer of the amplifier
(f)v. Filter (if appropriate)	The Model Name, Model Number and Manufacturer of the filter
(f)vi. Filter settings (if appropriate)	The settings or the parameters of the filter
(f)vii. Recorder	The Model Name, Model Number and Manufacturer of the recorder
8. Time series data	
(a) Data format	The name of the data format of the time series data and specific encoding. For example, ASCII or binary encoding.
(b) Sampling Rate	The sampling rate of the recording
(c) File location	The time series file location should be made available when the experiment is published, for example, using a Uniform Resource Identifier (URI) or a Digital Object Identifier (DOI). (Note this will be achieved automatically via submission to the CARMEN system).