TEATIME

COST Action CA20135

Manual for the 1st TEATIME Introductory Training School

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

TEATIME

Training School on

The use of homecage technologies to monitor rodents

19th – 23rd September 2022

Venue:

Tecniplast Training Facility

Varese, Italy

SPONSORED BY:

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INTRODUCTION

COST Action CA20135 (TEATIME) is funded by COST (European Cooperation in Science and Technology), which is a funding organisation for research and innovation networks in European Research Area.

The TEATIME is a network of behavioural research and animal welfare scientists, manufacturers of equipment, bioinformaticians and experts in machine learning to form a collaborative, multidisciplinary consortium. Together they are addressing issues such as the diversity of equipment available, complementarity of protocols and common formats for analysis and presentation of results to enable results to be more cross-comparable. They will look what is needed for the development of new bioinformatics tools such as ontologies (a form of controlled vocabulary) to describe behaviours, analysis of large volumes of data and tools such as Machine Learning to automatically describe or quantify behaviours to reduce the need for lengthy time spent watching videos.

The ultimate aim is to be able to describe animal behaviours with a minimum impact on the animals by monitoring them in the homecages where they live, enabling them to exhibit routine behaviours in a familiar environment. The aim is to share protocols and results that are as interpretable as results currently obtained from behavioural observations of animals outside their homecage which are considered the gold standard, but can be affected by animals being in unfamiliar and sometimes variable environments. Homecage monitoring also offers welfare advantages in that animals remain in their own environments, so are not subject to stresses of being moved to testing arenas. Also the 24/7 nature of the monitoring may pick up welfare issues of animals leading to better welfare outcomes.

The **TEATIME introductory training school** was designed for young scientists (M.A., PhD, and post-doctoral students) with background in neuroscience, pharmacology, medicine, and biology, taking their first steps in bio-behavioral work. The aim of the training school was to introduce the field of rodent behavioral assessment from basic methods and tools to more complex systems, with a special emphasis on home cage systems, e.g. how to use, data analysis.

The TEATIME grant awarding committee received more than 50 applications and selected 24 students (based on academic and research background and motivation) to attend the training school. The student participation was fully funded by COST.

TEATIME

PROGRAMME

	19th September	20th September	21st September	22nd September	23rd September
9:00 – 10:00 (Lecture 1)		Importance of the genetic background, the sex and the age of the mice when assessing behavior tests (**Claudia Pitzer**)	Standard tools for motor assessment (**Silvia Mandillo**)	Standard tools for psychiatric assessment (**Michel Tsoory**)	Student presentations
10:00 – 10:30 (Coffee break)		**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
10:30 – 11:30 (Lecture 2)		Advantages and limitations of mouse models (**Sara Wells**)	Motor assessment at the home cage (**Silvia Mandillo**)	Psychiatric assessment at the home cage (**Michel Tsoory**)	Student presentations
11:30 – 12:30 (Lecture 3)		Behaviour 101 – how do we define behaviour? (**Erika Roman;** virtual talk)	Standard tools for cognitive assessment (**Claudia Pitzer**)	Emerging of digital biomarkers in home cage monitoring (**Stefano Gaburro**)	**End of School**
12:30 – 14:00 (Lunch)		**Lunch**	**Lunch**	**Lunch**	
14:00 – 15:00 (Lecture 4)		Three Rs, Ethics and Animal Welfare (**Anna Olsson;** virtual talk)	Using home cage monitoring for assessing the cognition in rodents (**Claudia Pitzer**)	Home cage systems: let's start at the beginning (**Lior Bikovski**)	
15:00 – 18:00 (Hands on session & coffee)	Social dinner @ 8pm	Experimental design (**Nuno Franco**)	Hands on home cage system (**Reinko Roelofs, Giorgio Rosati and Dilip Verma**)	Understanding & maximizing home cage system data (**Mara Rigamonti**)	

TEATIME

TUESDAY 20th September

LECTURE 1 - Importance of the genetic background, the sex and the age of the mice when assessing behavior tests

CLAUDIA PITZER - Heidelberg University, Germany

Biography

I graduated from the University of Heidelberg/Germany and also obtained my PhD in Biology there. I have more than 20 years track record in biomedical research and drug development in Biotech and Academia, with an extensive background in in vivo pharmacology. I am now leading the Interdisciplinary Neurobehavioral Core INBC at the University of Heidelberg, a multidisciplinary in vivo core facility with extensive state-of-the art in vivo application, infrastructure and support for the researchers. My research focuses are translational studies in neurodegenerative diseases, standardization and quality in preclinical animal studies, quality assurance in core facility, animal welfare and 3Rs among others.

Abstract

Neurological and neuropsychiatric disorders can be efficiently modeled and assessed in rodents via different sets of behavioral tests. To ensure the quality of the behavioral studies some aspects must be taken in consideration. This includes the role of the genetic background, sex, and experimental settings in the age-dependent regulation of different behaviors related to neurological disorders. In this course some results of our previous behavior studies will be presented to emphasize the crucial importance of the genetic background, the sex and the age of the mice cohorts.

LECTURE 2 - Advantages and limitations of mouse models

SARA WELLS – MLC at MRC Harwell, UK

Biography

I am the Director of the Mary Lyon Centre at Harwell near Oxford UK, which is the Medical Research Council's national facility for mouse genetics. I oversee and coordinate mouse genetics projects and animal welfare in the continually changing field of genetics. I am a member of various national groups and committees and I am keen to promote technological opportunities which promise to be able to reduce and refine the work undertaken in animal research.

Abstract

Since the 1980s, researchers have been altering the genome of laboratory mice in order to interrogate the function of genes and explore the molecular and physiological consequences of mutations. In this seminar we will discuss how genetically altered mice have revolutionised genomic medicine, the advantages and limitations of mouse models and how better phenotypical characterisation will drive improvements in *in vivo* research.

LECTURE 3 - Behaviour 101 – how do we define behaviour?

ERIKA ROMAN (virtual presentation) - Swedish University of Agricultural Sciences (SLU) & Uppsala University, Sweden

Biography

I graduated in Pharmaceutical Sciences and I have a PhD in Pharmaceutical Pharmacology from Uppsala University, Uppsala, Sweden. I am Associate Professor in Behavioural Pharmacology and Neurobiology at Uppsala University and now Professor in Domestic Animal Neurophysiology at the Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden.

I am, among other commitments, a member of the Swedish National Committee for the Protection of Animals used for Scientific Purposes and a representative in the Management Committee for COST Action CA20135 TEATIME.

As a behavioural neuroscientist I have taken part in the development of the multivariate concentric square field™ (MCSF) test for behavioural profiling of mice, rats and zebrafish as well as the establishment of Uppsala University Behavioural Facility (UUBF). Using these tools, my group has studied individual differences for vulnerability for excessive alcohol intake and risky gambling strategies in rats and I have taken an active part in

Abstract

The study of animal behaviour is crucial for the understanding of physiological processes and brain function under normal conditions and well as in pathological processes. The definition of behaviour will be presented together with the use of descriptive behavioural parameters for the interpretation of mental states. The lecture will also demonstrate how a limited number of descriptive parameters can hamper interpretation of mental states as well as how such interpretation can be aided by the score of species-specific behaviours in a behavioural test arena.

LECTURE 4 - Three Rs, Ethics and Animal Welfare

ANNA OLSSON (virtual presentation) - University of Porto, Portugal

Biorgraphy

I am a researcher at i3S – University of Porto where I coordinate the research group Laboratory Animal Science. My background is in animal science (integrated Master, 1994) and applied ethology (PhD, 2001). My main research interests are animal behaviour and welfare and ethics of the use of animals in research and biotechnology. My research experience includes the coordination of several EU projects addressing the 3Rs and ethics: ANIMPACT about legislation regulating animal experimentation and REMODEL about organoids and advanced 3D models in research. I coordinate a FELASA accredited training course for researchers and teach research ethics in several doctoral programs at the University of Porto. I am an editor for Laboratory Animals and PLOS ONE and a founding member of the Portuguese Reproducibility Network.

Abstract
As the human use of animals is increasingly challenged in society, scientists need insight into ethics of animal research. This is crucial not only when engaging with a critical public, but also as scientists deal with the ethical dilemma in planning and carrying out their research, and when reviewing the research of others for funding and publication. In this lecture, I will address the main issues in contemporary animal research ethics, including the ethical dilemma, EU legislation and challenges to it, harm-benefit analysis and communication with the public. I will further talk about the Three Rs, with focus on refinement in housing and handling of laboratory animals. Finally, I will introduce the topics of research integrity and reproducibility that participants will work further on in the hands-on session on experimental design.

HANDS ON SESSION - Experimental design

NUNO H. FRANCO – University of Porto, Portugal

Biography
I am a researcher at the i3S (University of Porto) on the topics of laboratory animal welfare, animal ethics and the 3Rs, and scientific quality. He has degrees in both Animal Biology and Science Education, and a PhD in Biomedical Sciences, and I have been teaching experimental design for 10 years, both in Portugal and across Europe. I am a member of the FELASA working group on experimental design education, vice-president of the Portuguese Society for Laboratory Animal Science (SPCAL) and President of the EU Education & Training Platform for Laboratory Animal Science (ETPLAS). I also sit on the i3S Animal Welfare Body and coordinates the Portuguese Network of Animal Welfare Bodies – RedeORBEA.

Abstract
Within the scientific community there has been increasing distrust in regard to the reliability of scientific research, animal-based or otherwise. Lack of awareness to even the most basic requirements of reliable research – adequate sample sizes, blinding, randomization, controlling of common biases – has been identified as a main factor behind the poor reproducibility and translational value of published findings.

This part of the course will be divided into lectures and group exercises on how to apply good principles and practices in research planning and experimental design. The participants will be able to answer such questions as 'How to randomize in an experiment?', 'What is the experimental unit?', “Is my sample size large enough?”. Although it is not expected that within the time-frame allocated for this theme all types of experiments and designs can be covered, this lecture will draw attention to the main caveats to avoid, and to the conditions that must be in place to make animal experiments more reliable, robust and reproducible, while avoiding animal waste and complying with the 3Rs of animal research, with particular emphasis on Reduction and Refinement.

WEDNESDAY 21st September

LECTURE 1 - Standard and Home cage-based tools for motor assessment
LECTURE 2 - Motor assessment at the home cage

SILVIA MANDILLO - Institute of Biochemistry and Cell Biology, Italy

Biography

I graduated in Natural Sciences at Università La Sapienza in Rome and I have a PhD in Psychology from Tufts University, Medford-Boston, USA. I am a Research Scientist at CNR (National Research Council) - Institute of Biochemistry and Cell Biology in Monterotondo, Italy and faculty at Sapienza University in Rome for the Course 'Methods in Behavioural Neurosciences'.

I am also involved in European/World Wide projects and consortia including IMPC, COST Action CA20135 TEATIME and ETPLAS.

My research focuses on the study of motor and cognitive functions as well as social and emotional behaviours by using automated systems and ethologically based direct observations. I am currently conducting in-depth behavioural analysis of inbred and mutant mouse strains to develop genetic models of neurodegenerative and psychiatric diseases.

Abstracts

Most of what we study in mouse behavior derives from the movement of the animal. The assessment of motor functions is crucial to understand mouse physiology and potentially pathological states. Classical/standard and not so common tests designed for the evaluation of motor functions in mouse models of human diseases will be presented with a practical approach on the description of equipment and procedures. Examples of the application of these tests on mouse models of motor neurodegenerative diseases will be discussed, also in comparison with systems to monitor mouse activity in its home cage.

LECTURE 3 - Behavioral tests for assessing the cognition function of mouse disease models

CLAUDIA PITZER – Heidelberg University, Germany

Abstract

The analysis of learning and memory is used to investigate the mechanisms underlying the cognition in rodents and humans and to model their dysfunction in neuropsychiatric and neurodegenerative disorders (stroke, Alzheimer's disease, Parkinson's disease, autism…). In this course the participants will be learning the experimental approaches and standard behavioral tests that are being used for assessing the learning and memory in rodents. Questions concerning the choice of the appropriate behavior tests and the interaction between them will be treated. Participants will be learning to design a high-quality cognition study and to learn about the limitations and bias of the tests.

LECTURE 4 - Using home cage monitoring for assessing the cognition function in rodents

CLAUDIA PITZER – Heidelberg University, Germany

Abstract

This course is a continuation of the morning session about the 'behavioral tests for assessing the cognition function of mouse disease models '. Participants will be learning how to assess the cognition functions by using the different features and paradigms offered by different home cage observation systems like the IntelliCage, the Laboras and the Phenotyper. Limitations and bias of the systems will be presented.

HANDS ON SESSION - IntelliCage: For measuring rodent cognitive behavior & challenges in an automated home cage system

DILIP VERMA, REIKNO ROELOFS and GIORIO ROSATI

Biography (Dilip Verma) – TSE Systems, Germany

As a behavioural neuroscientist, Dr. Verma completed his doctoral degree from Medical University Innsbruck, Austria and completed 9 years of Post-Doctoral research, working on Neuropeptides to prevent fear and anxiety-like disorder. Recently he joined TSE as product manager behaviour for IntelliCage.

Abstract

Classical phenotyping of rodent models is traditionally assessed with several time-consuming test batteries in which animals are tested individually and experimental procedures are often difficult to standardize. TSE Systems IntelliCage is the system on the market that combines automated testing under close-to-natural conditions "group housing" with a high degree of experimental standardization. This combination significantly improves inter-and intra-lab-reproducibility (Lipp, 2005; Puscian et al., 2014), which is a major shortcoming in all commonly used behavioral tests (Wahlsten et al, 2003, 2006; Prinz et al, 2011). IntelliCage comprises 4 operant conditioning corners which are equipped with sensors, allowing continuous 24x7-recording of behavioral events, and actors, allowing the system to feedback on animal behavior in a pre-defined way.

In this COST action "TEATIME training school in the use of homecage technologies to monitor rodents" I will drive you on "How to use an IntelliCage and the science behind it", important tips and tricks, and troubleshooting of your IntelliCage experiments.

THURSDAY 22nd September

LECTURE 1 - Standard tools for psychiatric assessment
LECTURE 2 - Psychiatric assessment at the home cage

MICHAEL M. TSOORY – Weizmann Institute of Science, Israel

Dr. Tsoory is an associate staff scientist, heading the Behavioral and Physiological Phenotyping Unit at the Department of Veterinary Resources, Weizmann Institute of Science. He did his B.A., M.A. and PhD in Psychology at the University of Haifa, Haifa, Israel. He got his training and research experience in behavioral neuroscience combining different biological assays with behavioral assessments. For his M.A. he assessed the involvement of central monoamines in a rat model of social cooperation and for a PhD he established a novel early life stress rat model of exposure to stress during juvenility. During his Post-Doc at the Department of Neurobiology, Weizmann Institute of Science (Rehovot, Israel) he assessed the involvement of the CRF/Urocortin systems in modulating stress responses and learning faculties- developing models of stress induced psychopathologies.

He is also active as a stakeholder in the EQIPD initiative: an European Union's Horizon 2020 consortium aimed at Enhancing Quality In Preclinical Data.

Abstract

Assessment of Mental Dysfunctions in Mouse Models of Psychiatric Disorders:
The talks focus on one hand (Lecture 1, Day 3: Assessment of Mental Dysfunctions in Mouse Models of Psychiatric Disorders) on the prevailing methods to assess behaviors in mice that are analogous of symptoms of mental dysfunctions that relate to social behaviors, anxiety (and or stress responses), post-traumatic stress disorder (memory of fear and its extinction), schizophrenia and depression (learned helplessness/ despair, anhedonia). While on the other hand (Lecture 2: Home-Cage Based Assessment of Mental Dysfunctions in Mouse Models of Psychiatric Disorders), present indices collected in different home cage-based monitoring systems that may be used for phenotyping of mouse models of the above noted mental dysfunctions.

The lectures discuss in a critical manner issues of validity, reliability, scientific rigor and animal well fare.

LECTURE 3 - Emerging of digital biomarkers in home cage monitoring

STEFANO GABURRO - Tecniplast, Germany

Dr. Gaburro has a strong academic background in preclinical research (mainly neuroscience). In his former role at DSI and now at Tecniplast, Dr. Gaburro has helped researchers refine their scientific approaches to improve their methodologies and use of lab products. Aside of his primary role, he has also served as Steering Committee member for the American Physiological Society (Neuroscience and Physiology in Industry) for many years.

Abstract
In drug discovery and development, traditional assessment of human patients and preclinical subjects occurs at limited time points in potentially stressful surroundings (i.e., the clinic or a test arena), which can impact data quality and welfare. However, recent advances in remote digital monitoring technologies enable the assessment of human patients and preclinical subjects across multiple time points in familiar surroundings. The ability to monitor a patient throughout disease progression provides an opportunity for more relevant and efficient diagnosis as well as improved assessment of drug efficacy and safety. In preclinical in vivo animal models, these digital technologies allow for continuous, longitudinal, and non-invasive monitoring in the home environment. This presentation will provide an overview of digital monitoring technologies for use in preclinical studies including their history and evolution, current engagement through use cases, and the impact of digital biomarkers (DBs) on drug discovery and the 3Rs. It will also discuss barriers to implementation and strategies to overcome them. Finally, it will address data consistency and technology standards from the perspective of technology providers, end-users, and subject matter experts. Overall, this review establishes an improved understanding of the value and implementation of digital biomarker (DB) technologies in preclinical research.

LECTURE 4 - Home cage-systems: let's start at the beginning

LIOR BIKOVSKI – Tel-Aviv University, Israel

Biography
I finished my PhD in Psychology at Tel-Aviv University (TAU) and I have been running the Neuro-behavioral core facility of the Medical school at TAU since then.

My main interest is standardization of the work process in and between labs for a higher replicability of results. For that aim I work a with different TAU lab teaching them how to standardize and calibrate a behavioral method. In addition work on different scientific platforms that work directly (EQIPD) or indirectly (TEATIME COST Action) on improving pre-clinical bio-medical research process.

Abstract
Attempts to reduce human interference and to measure more "natural" behaviors in subjects has led to the development of automated home-cage monitoring systems. These systems enable prolonged and longitudinal recordings, and provide large continuous measures of spontaneous behavior that can be analyzed across multiple time scales. Selecting the right system for the scientific work it is meant for, requires knowing the different systems available commercially, and understanding what features are needed. In this talk, I will review the basic features of a "home cage" and present some of the systems available today.

HANDS ON SESSION - Understanding and maximizing home cage system data

MARA RIGAMONTI – Tecniplast, Italy

Biography

I have a Master's Degree in Statistical Sciences at Università degli Studi Milano-Bicocca in Milan and with a Master's Degree in Statistics at Università Alma Mater Studiorum in Bologna, Italy. I am Data Scientist in Tecniplast and I lead the Digilab Data Science team, where we develop machine-learning algorithms for DVC® and collaborate with researchers and clients to analyze and publish data from their scientific studies with home-cage monitoring systems.

Abstract

Novel technologies allow 24/7 collection of mice behavioral data, directly in their familiar environment. Home-cage monitoring is extremely powerful, but requires careful experimental design and analysis to maximize the usage of data as well as guaranteeing maximum reliability. One of the main advantages of these systems is the possibility of observing animals for a long period, so it's important to appropriately choose the time aggregation and time scale of analysis. Missing data can occur more likely during long experiments, and outliers may be more frequent, due to human procedures (like cage-change) or environmental factors that can affect mice behavior. Moreover, this kind of longitudinal studies needs proper statistical testing for repeated measures, that can be parametric or non-parametric. Finally, due to the large amount of data generated, specific data science tools and coding languages, like R or Python, could be very helpful to get the most from these technologies

FACULTY

Firstname	Lastname	Organisation	Country
Lior	Bikovski	Tel Aviv University	Israel
Nuno	Franco	Institute for Molecular and Cellular Biology	Portugal
Stefano	Gaburro	Tecniplast	Italy
Silvia	Mandillo	IBBC-CNR	Italy
Anna	Olsson	Institute for Molecular and Cellular Biology	Portugal
Claudia	Pitzer	University of Heidelberg	Germany
Mara	Rigamonti	Tecniplast	Italy
Reinko	Roelofs	Noldus Information Technology	The Netherlands
Erika	Roman	SLU - Swedish University of Agricultural Sciences	Sweden
Giorgio	Rosati	Tecniplast	Italy
Michel	Tsoory	Weizmann Institute of Science	Israel
Dilip	Verma	TSE-Systems	Germany
Sara	Wells	Mary Lyon Centre at Harwell	UK

STUDENTS

Firstname	Lastname	Organisation	Country
Maílis	Carrilho	University of Lisbon	Portugal
Özge Selin	Çevik	Mersin University	Turkey
Angelos	Didachos	Radboud University	The Netherlands
Daniela	Domingues	Paris Brain Institute	France
Mahvish	Faisal	University of Tartu	Estonia
Pia	Kahnau	Freie Universität Berlin	Germany
Jenice	Linde	RWTH, Aachen University	Germany
Francesca	Marsili	Sapienza Università di Roma	Italy
Alice	Melloni	IIT - University of Padova	Italy
Karin	Müller	Medical University Vienna	Austria
Dmytro	Nesterenko	DZNE Berlin	Germany
Liya	Niv	The Hebrew University of Jerusalem	Israel
Anaïs	Notario Reinoso	University of Amsterdam	The Netherlands
Ceyda	Özler	Koç University	Turkey
Daniela	Petrinec	University of Zagreb School of Medicine	Croatia
Edoardo	Pisa	Istituto Superiore di Sanità	Italy
Héloïse	Policet-Bétend	University of Geneva	Switzerland
Patrick	Reinhardt	Ruhr-University Bochum	Germany
Freya	Shepherd	Cardiff University	UK
Pegah	Taheri	Nencki Institute of Experimental Biology	Poland
Katharina	Tillmann	Medical University of Vienna	Austria
Rita	Varga	University of Debrecen	Hungary
Jane	Varul	University of Tartu	Estonia
Davor	Virag	University of Zagreb School of Medicine	Croatia

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SUPPLEMENTARY INFORMATION:

Lectures

See attachments for pdfs of lectures.

Background and additional information, as suggested by speakers

Speaker	Suggested literature
Anna Olsson	Barkus C, Bergmann C, Branco T, Carandini M, Chadderton PT, Galiñanes GL, Gilmour G, Huber D, Huxter JR, Khan AG, King AJ, Maravall M, O'Mahony T, Ragan CI, Robinson ESJ, Schaefer AT, Schultz SR, Sengpiel F, Prescott MJ. Refinements to rodent head fixation and fluid/food control for neuroscience. J Neurosci Methods. 2022 Nov 1;381:109705. doi: 10.1016/j.jneumeth.2022.109705. Epub 2022 Sep 9. PMID: 36096238. Anna S Olsson and Peter Sandøe. 2021. Animal research ethics. In: Hau J and Schapiro S (eds) Handbook of Laboratory Animal Science 4th edition. CRC Press. Cait, J., Cait, A., Scott, R.W. *et al.* Conventional laboratory housing increases morbidity and mortality in research rodents: results of a meta-analysis. *BMC Biol* **20**, 15 (2022). https://doi.org/10.1186/s12915-021-01184-0
Stefano Gaburro	Home Cage-based Phenotyping in Rodents: Innovation, Standardization, Reproducibility and Translational Improvement, a special Research Topic in Frontiers in Neuroscience
Nuno H. Franco	Quick notes on effect size and sample size calculation using G-power (see attachments for a pdf)
Dilip Verma	Morello F, Voikar V, Parkkinen P, Panhelainen A, Rosenholm M, Makkonen A, Rantamäki T, Piepponen P, Aitta-Aho T, Partanen J. ADHD-like behaviors caused by inactivation of a transcription factor controlling the balance of inhibitory and excitatory neuron development in the mouse anterior brainstem. Transl Psychiatry. 2020 Oct 21;10(1):357. doi: 10.1038/s41398-020-01033-8. PMID: 33087695; PMCID: PMC7578792.
Mara Rigamonti	Fuochi S, Rigamonti M, Iannello F, Raspa M, Scavizzi F, de Girolamo P, D'Angelo L. Phenotyping spontaneous locomotor activity in inbred and outbred mouse strains by using Digital Ventilated Cages. Lab Anim (NY). 2021 Aug;50(8):215-223. doi: 10.1038/s41684-021-00793-0. Epub 2021 Jun 21. PMID: 34155410. Golini E, Rigamonti M, Iannello F, De Rosa C, Scavizzi F, Raspa M and Mandillo S (2020) A Non-invasive Digital Biomarker for the Detection of Rest Disturbances in the SOD1G93A Mouse Model of ALS. *Front. Neurosci.* 14:896. doi: 10.3389/fnins.2020.00896

	Noguchi, K., Gel, Y. R., Brunner, E., & Konietschke, F. (2012). nparLD: An R Software Package for the Nonparametric Analysis of Longitudinal Data in Factorial Experiments. *Journal of Statistical Software*, *50*(12), 1–23. https://doi.org/10.18637/jss.v050.i12 Pernold K, Iannello F, Low BE, Rigamonti M, Rosati G, Scavizzi F, Wang J, Raspa M, Wiles MV, Ulfhake B. Towards large scale automated cage monitoring - Diurnal rhythm and impact of interventions on in-cage activity of C57BL/6J mice recorded 24/7 with a non-disrupting capacitive-based technique. PLoS One. 2019 Feb 4;14(2):e0211063. doi: 10.1371/journal.pone.0211063. PMID: 30716111; PMCID: PMC6361443. Pernold K, Rullman E, Ulfhake B. Major oscillations in spontaneous home-cage activity in C57BL/6 mice housed under constant conditions. Sci Rep. 2021 Mar 2;11(1):4961. doi: 10.1038/s41598-021-84141-9. PMID: 33654141; PMCID: PMC7925671.

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Tecniplast
https://www.tecniplast.it/

TSE-Systems
https://www.tse-systems.com/

Noldus
https://www.noldus.com/

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COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

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