VIRTUAL REALITY
JetBall

PHENOSYS
Technology for Behaviour Analysis

BACKGROUND

Virtual reality (VR) systems create experimental environments with unlimited possibilities. They allow to investigate fundamental mechanisms of navigation, cognition, learning, or memory in animals.

The JetBall is an air cushioned spherical treadmill in combination with screens or a projection dome. It allows an animal to navigate and to perform behavioral tests in a virtual space, while it is examined by in-vivo imaging, optogenetic, or electrophysiological methods.

The JetBall enables new applications in neuroscience.

ADVANTAGES

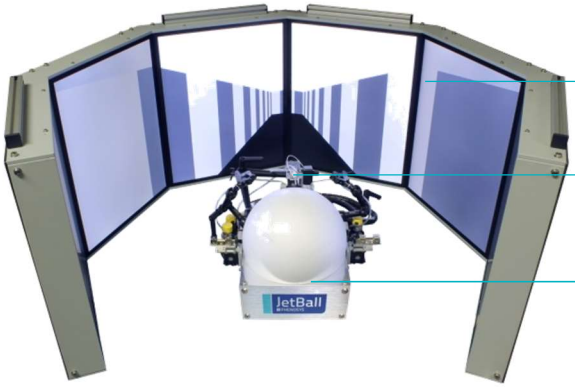
- The VR allows flexible modifications of experimental environments and fast repetitions of simple tasks.
- The animal remains completely stationary while interacting with a virtual world.
- Animal activity can be correlated with external measurement data such as optical imaging or electrophysiology.
- Many different additional stimuli and reward systems may be added to make the VR more realistic and interactive.
- Standard mazes and experiments are provided that can be modified and extended according to specific experimental needs.
- Hardware synchronization and data export allow the easy integration with complex experimental setups

VIRTUAL REALITY VARIANTS

The virtual reality is either displayed on a TFT surround monitor or via a spherical mirror projection to the inner surface of a section of a sphere. A common equipment rack integrates power supplies, control PC, and the air flow regulation system for JetBall and accessories.

JetBall-TFT

- Easy accessibility for external setups, e.g. microscopes and manipulators
- High contrast and luminance.



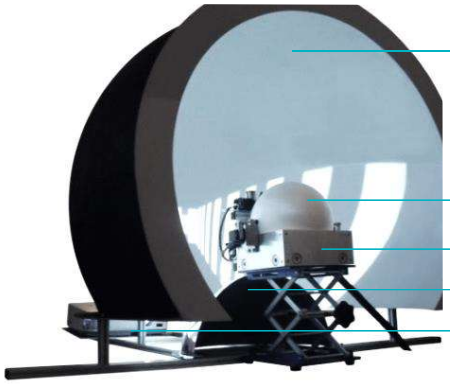
TFT surround monitor with virtual reality scene (270°) with six 19“ sub-units

Air cushioned spherical treadmill

Ball holder

JetBall-Dome

- Larger field-of-view for presenting the virtual reality
- Seamless projection surface.



Dome (1.2m) with spherical mirror projection

Air cushioned spherical treadmill

Ball holder with stand

Spherical mirror

Projector

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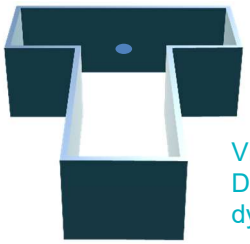
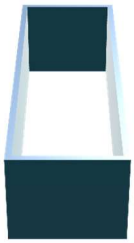
TYPICAL VIRTUAL MAZES & PARADIGMS

Create your own virtual maze with our software, place own landmarks variable in size and shape appearing and disappearing at defined times, create endless mazes, run different mazes as test batteries without moving the animal from the top of the ball, or uncouple the virtual reality and the actual movement of the animal.

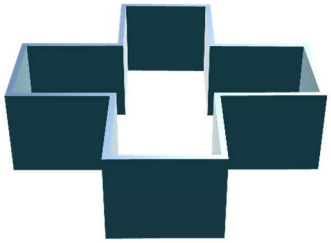


Virtual T-maze
Decision making using dynamic landmarks

Virtual Open Field
Exploratory behavior using elevated 3D landmarks



Virtual Corridor
Training task with frequent rewards and reinforcement



Virtual Plus Maze
Light-Dark-Discrimination
Reaction to olfactory cues

BALL HOLDER & OPERANT MODULES

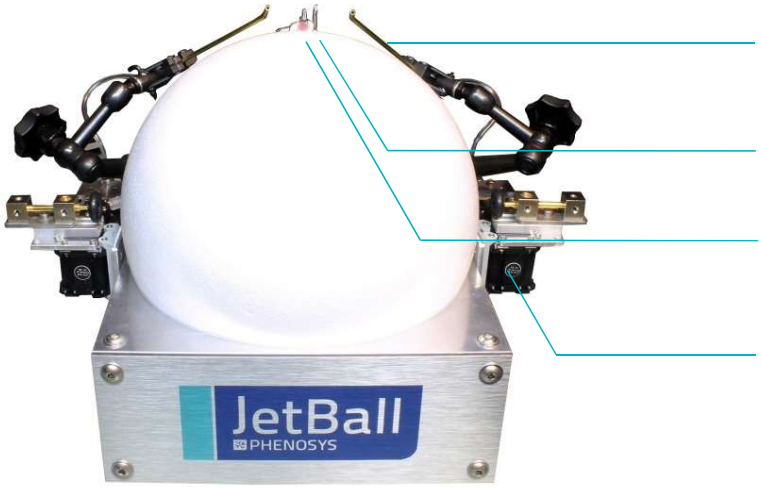
The heart of a JetBall system is the ball holder made of solid aluminum. An air-cushion is generated by compressed air on which a custom made ball can float with minimal friction. The aerodynamically optimized inner surface guarantees a laminar flow and stable, quiet motion. Two XY-motion sensors pick up any movement of the ball and translate it into VR coordinates.

The stimulation is not purely visual but can be extended to sound, odor, whisker stimulation, negative reward by air puff, positive reward by liquids and a brake system.

Ball Holder System
- 20 cm ball holder system: for mice
- 30 cm ball holder system: for rats < 300g

Stereo sound (optional)
Our 3D acoustic system consists of two active monitor speakers, audio-interface, and software.

Odor (optional)
Our multi-channel Olfactometer provides fast-response olfactory stimulation.



Whisker stimulation (optional)
Air flow is presented to left or right whiskers whenever the animal touches the boundary of a virtual wall.

Air puff system (optional)
Negative reward by frontal air puff. Retractable.

Liquid reward system (optional)
Equipped with a lick sensor and a peristaltic pump for positive reward. Retractable.

Brake system (optional)
One frontal and two lateral brakes stop the ball, e.g. at the end of a virtual corridor.

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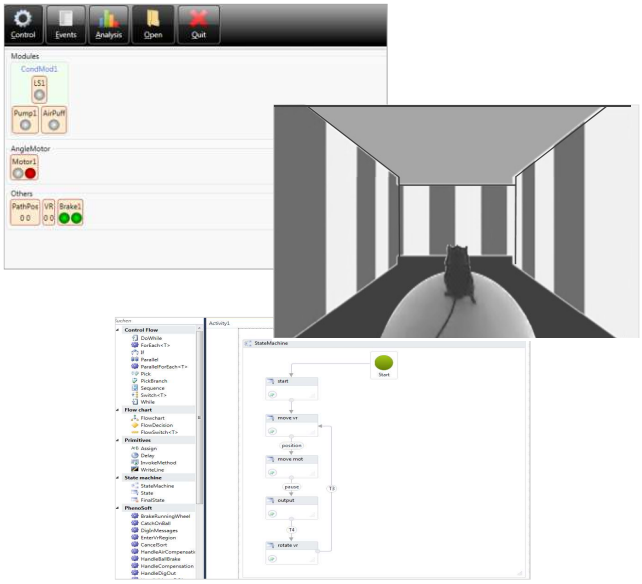
FLEXIBLE AND POWERFUL SOFTWARE

The JetBall system includes the following modules:



PhenoSoft Control
For experimental control and data acquisition. Graphical user interface with visual indicators and extensive data logging of all relevant events.

PhenoSoft VR
To display all kinds of virtual mazes with full flexibility regarding size, shape, walls, sky, floor, textures, landmarks, colors, and images.

PhenoSoft Schedule
For designing complex experimental schedules. A graphic programming environment combines flexibility and complexity.

EXPORT OF DATA

Data transfer and synchronization

The current VR position and all related events of operant units can be transmitted by the JetBall to external devices in real time. TTL trigger signals can be received and sent to wait for or start external equipment.

Coordinates

Two sets of coordinates are registered by the JetBall system:

- XY position: the actually recorded raw data of the xy-motion sensors (independent of the VR).
- VR position: the corresponding position of the animal within the virtual reality.

Both sets of coordinates can be transferred to external hard- and software by:

- Analog data transfer:
  The optional analog output board (8-Channel analog data 12-bit) provides access to position data via four outputs with +-10V output range.
- Digital data transfer:
  Coordinates can also be transferred via TCP/IP (Ethernet) to an external computer.

Events

Accessible events of operant units include:

- Lick sensor activation (liquid reward)
- Pump (liquid reward)
- Air puff (negative reward)
- Whisker stimulation left/right
- Brake activation
- Olfactory stimuli presentation
- Virtual reality events
- External TTL-trigger signals

Operant units are controlled by a PCI interface board. The corresponding I/O-signals (24 lines) are directly available as TTL signals at the Interface Connector Box mounted to the ball holder.

PhenoSys provides several ways to access this data:

- BNC cable connectors for TTL-In and TTL-Out
- Use of a PCI-board (NI PCI-6503) in an external computer directly connected to the Interface Connector Box

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