

Automated Home-cage System User Manual

The Automated Home-cage System is a fully autonomous mouse behavioral and optogenetic experiment system. This manual will guide you through the initial check and installation of your system. It also describes operation, maintenance, and diagnostic procedures of your system.

1. Hardware Checklist

- The Automated Home-cage System is a fully enclosed system as shown in Fig.1.1.

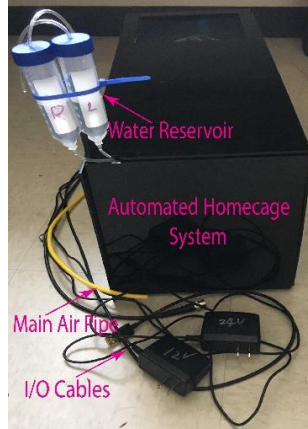


Fig.1.1

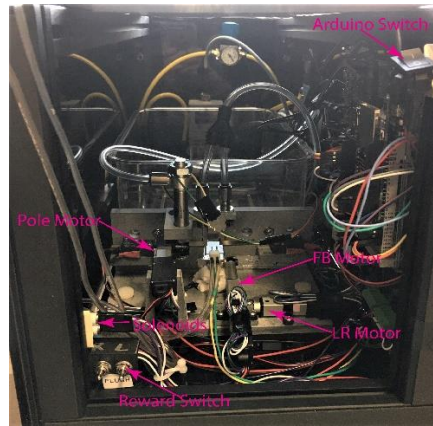


Fig.1.2

- There are four electric cables and one plastic tube come out from the left side of the enclosure. Refer to table1 for their specifications.

Table1. Home-cage I/O

	Item Name	Function
Input	12v AC/DC wall mount Adapter	Provide 12v power for Arduinos, motors and Lee solenoids
	24v AC/DC wall mount Adapter	Provide 24v power for 3/2-way solenoid valve and analog pressure regulator
	USB 2.0 to Micro B Cable	Connect Arduino_Master to PC
	Plastic tube	Provide Air supply (4-bar) to Home-cage
Output	BNC Cable	Send voltages (0-5 V) to control Laser

- The water reservoir, the Arduino switch, the reward switches, and the solenoids are located at the front frame of the enclosure (Fig.1.2).
- All the circuit boards are mounted on the right side of the enclosure (Fig.1.3).

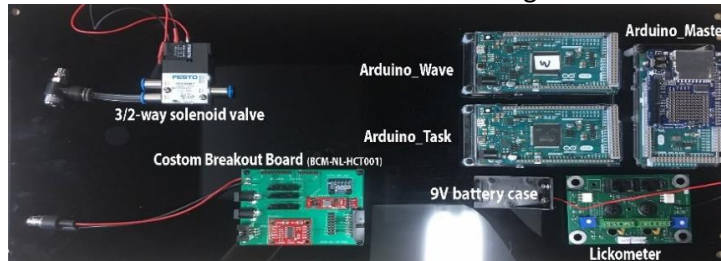


Fig.1.3

- The Home-cage and the Headport are fixed on the floor of the enclosure (Fig.1.4).

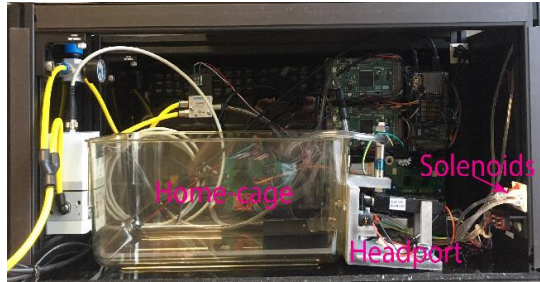


Fig.1.4

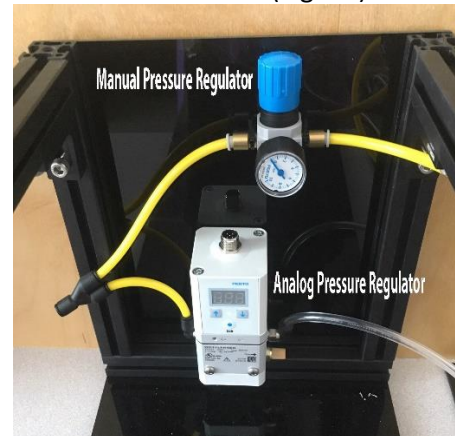


Fig.1.5

- Two pressure regulators are mounted on the back side of the enclosure (Fig.1.5).

2. Software installation

- Download the latest version of **MATLAB** from <https://www.mathworks.com>.
- Download the latest version of the **Arduino IDE** from <https://www.arduino.cc>. After installed it, with the Arduino plugged into a USB port, start up the IDE and make sure that the correct board name/version and COM port appears under the **Tools** menu.
 - The COM port can be seen in the Windows Device Manager.
 - A support package for Arduino DUE needs to be downloaded via the IDE:
 - Click the menu item **Tools → Board → Boards Manager**.
 - Search 'due' and find Arduino Due package.
 - Click on the **Install** button that appears.
 - Copy all the files in the folder "\\Arduino programs\\Library\\" to the PC folder: "\\Program Files (x86)\\Arduino\\libraries\\".
 - To upload an Arduino program to Arduino board via the IDE, do the following steps:
 - Connect a USB cable from PC to the Native USB Port of the Arduino board
 - Click the menu item **File → Open**, select the program.
 - Click the menu item **Tools → Board**, select the Native USB port.
 - Click the menu item **Tools → Port**, select the correct COM port.
 - Click the button **Upload**.
- Upload Arduino program to Arduino board:
 - Upload "\\Arduino programs\\Arduino_Wave\\Arduino_Wave.ino" to the Arduino_Wave board.
 - Upload "\\Arduino programs\\ Arduino_Task\\Arduino_Task.ino" to the Arduino_Task board.
 - Upload "\\Arduino programs\\ Arduino_Master \\Arduino_Master.ino" to the Arduino_Master board.

3. HomeCage GUI

HomeCage GUI is created for user to easily interface with the Arduino_Master board during experiment. To use HomeCage GUI, copy folder “\Matlab GUI\” to the PC, connect the system to the PC and run “\Matlab GUI\homecage_gui.m” program in MATLAB. HomeCage GUI shows up as Fig.3.1. The main functions are described as follows:

3.1. Cage block

- Set the mouse name, experiment start date and the COM port for the corresponding cage. Click **open** button to communicate to Arduino_Master board.
- Click **Msg** to get the experiment information (message) in last 24 hours.
- Click **Plot_** to plot the mouse behaviour data in last 24 hours.
- The last 24 hours data/message stored in the local PC will be clear once click **close** button or disconnect the USB cable from PC.

3.2. Control panel

- Chose the cage that you want to interface with.
- Click **read** to get the on-line motor positions and mouse weight and show in the corresponding text fields.
- Set a value in text field of **MotorFB**, click **Move& Set** to move the FB motor and set its position value in the Arduino code.
- Set a value in text field of **MotorLR**, click **Move& Set** to move the LR motor and set its position value in the Arduino code.
- Set a value in text field of **MotorPol**, click **Move** to move the Pole motor.
- Set a value in text field of **FinalFB**, click **Set** to set the final position value of the FB motor in the Arduino code.
- Set a value in text field of **Left/Right**, click **Set&Reward** to set the reward size and a drop of water comes out of lickport.



Fig.3.1

4. Operation Procedures

1. Move the Automated Home-cage system to the workstation where there are the compressed air supply and the power outlet.
2. Connect the plastic tube from the system to the compressed air supply (4 bars).
3. Adjust the manual pressure regulator to 2 bars and check if there is air leaking.
4. Make sure the Arduino switch is toggled to "OFF".
5. Copy the two initial parameter files (**PARAF.TXT** and **PARAS.TXT**) in the folder '**initial config files**' to a blank SD card and insert the SD Card into the SD card shield.
6. Adjust the height of the lickport to make sure it is higher than the bottom edge of the headport opening.
7. Power up the 12V and 24V adapter and then connect Arduino_Master board to USB hub via USB cable.
8. The lickport will be moved into the headport opening.
9. Run "**Matlab GUI\homecage_gui.m**" program in MATLAB. Set the mouse name, start date and the com port in the corresponding cage block of the HomeCage GUI. Click **open** button to start receiving data from Arduino_Master board.
10. After toggled the Arduino switch to "ON". Trial 1 starts, and the pole drops down. Touching the lickport by your hand will trigger another trial.
11. Put bedding, food, hiding tube into the home-cage.
12. Put the mouse into the home-cage.
13. Cover the home-cage with the lid and the system enclosure with the top panel.

5. Maintenance

5.1. Connect to PC

- if you want to use HomeCage GUI to interface with Arduino_Master board and check mouse behaviour while experiment is running, the Automated Home-cage System needs to connect to a PC, even though it can be fully function without connecting to a PC.

5.2. SD Card

- For a new mouse, copy the two initial parameter files (**PARAF.TXT** and **PARAS.TXT**) in the folder '**initial config files**' to a blank SD card to start the experiment. While the trials are going on, there are six files stored in the SD Card. Refer to "example data\README.txt" for the detail explanations of these files.
- When putting a different mouse to the same cage, make sure to change the SD card for the specific mouse.
- When changing SD Card, i.e. pulling one out from and push the other one into the SD Card shield, make sure the Arduino switch is turned off.

5.3. Lickport Position

During Auto-training, check and adjust the Lickport position periodically:

- When the lickport retracts out of the headport, adjust its height to a bit higher than the bottom edge of headport opening (Fig.5.1) and make sure it is still at the center of the head port opening in left-right direction.
- When lickport reaches the final position, there is a one-time adjustment of the position to make sure the mouse can access both tubes of the lickport and the lickport is roughly in the center (Fig.5.2). The final forward/backward position can be adjusted via the HomeCage GUI as described in above section 3.



Fig.5.1

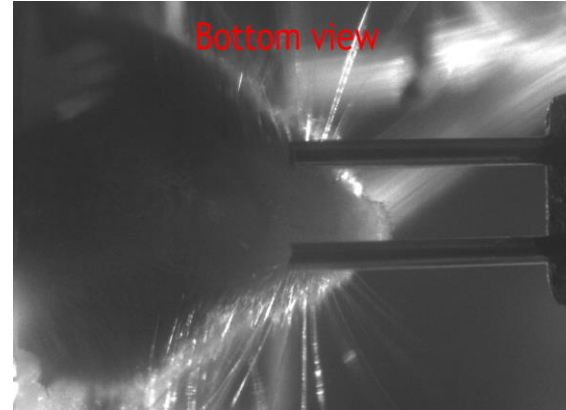


Fig.5.2

5.4. Clean Home-cage

The home-cage can be detached from the system to be cleaned:

- Unscrew the two screws (inside home-cage) that fixes the home-cage with the headpot.
- Detach the 6pin connector that connects weighting stage to the circuit board on the right side of the enclosure.
- When clean the home-cage, be sure to take good care of the weighting stage (no hard press of the stage), the 6pin connector and the ribbon cable.

5.5. Power on/off

- In general, the system can be power on all the time.
- In the event you want to power off the system, follow the sequence: turn off the Arduino Switch, unplug 12V adapter and 24V adapter, unplug USB cable from PC, turn off the air supply.
- In the event you want to power on the system, follow the sequence: turn on the air supply, plug in 12V adapter and 24V adapter, plug in USB cable from PC, turn on the Arduino Switch.

5.6. Add/Modify protocol

To modify an existing protocol or add a new protocol, you should modify the existing states or create new states by editing the function "send_protocol_to_Bpod_and_Run()" in "\Arduino programs\Arduino_Master\Arduino_Master.ino".

- In function "send_protocol_to_Bpod_and_Run()", modify/add new state using function "CreateState()".
- The function "CreateState()" constructs a state struct defined by the input arguments and returns a constructed state. There are 5 input arguments:
 - Name: The name of the state.
 - TimeOut: A float variable indicating the state timeout.
 - nChangeConditions: The number of state transitions defined.
 - StateChangeConditions: The pointer to the state transitions.
 - nOutputActions: The number of output actions.
 - Outputs: The pointer to the output actions.

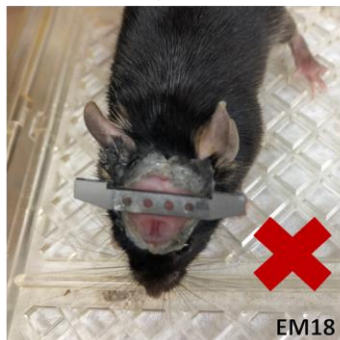
6. Trouble Shooting

6.1. Mice do not enter trigger head fixation for extended period of time

6.1.1. Mouse cannot poke in the headport (Fig.6.1)

- Check the headbar position: anterior edge of headbar should line up with lambda suture; depressions go face up.
- NO glue or dental cement should occlude either side of the headbar.
- Headbar position should be consistent from mouse to mouse.

Headbar too far anterior and divots on wrong side
Caked dental cement prevents smooth insertion



Top of headbar aligned with lambda, divots on right side
No excess dental cement around or on top of bar



Fig.6.1.

6.1.2. Mouse cannot access the lickport because the lickport is far from mouse

- The lickport position needs to be adjusted, refer to section 5.3 for how/when to adjust the lickport position.

6.1.3. The program cannot detect licking when mouse licking

- Check if metal sheet on the weighting stage is electrically connected with the Lickometer to form a complete circuit. The resistance between metal sheet on the weighting stage and the aluminum tape on headport should be less 10 Ohm if the connection is good.
- Check if the **9v battery** are in the good shape and the voltage is more than 8 Volt.
- The Lickometer may be malfunctioned, refer to section 9.8 of “Automated Home-cage System construction Manual” for how to check Lickometer.

6.2. Mice do not advance in training for extended period of time

6.2.1. The pole does not drop down during the task

- The pole may be stuck. Increase the air pressure to 3-4 bar to let the pole drop down then go back to 2 bars as normal.
- Try manually press down the pole (together with the motor).

6.2.2. Reward could be running slow

- Check periodically that water is coming out and the flow on the two lickspouts is evenly.
- Check if there is any clog in tubes and solenoid. Clean the water lines if necessary.
- Check if the solenoid is malfunctioned.

- 6.2.3. The mouse triggers self-release too frequently.
- Make sure the mouse is not on the platform, and then click the **Tare** button in HomeCage GUI.
 - Check if the top panel of the weighting stage is block by bedding or other stuff.
- 6.2.4. Too much pole activity can cause the motor to malfunction
- Check the pole is presented at the correct location. This should be checked periodically.