Home

Welcome to the documentation for the Bonsai workflow developed for the Sound Lateralization Task that is going to be performed by the Circuit Dynamics and Computation group at the Champalimaud Foundation.

The experimental setup makes use of the capabilities of the Harp devices (which implement the Harp protocol) and the Bonsai visual programming framework, which work really well together.

The documentation for the task is divided in 3 sections:

- **Installation and Configuration** - This section is a step-by-step guide for setting up everything that is needed to run the task in a new setup. It includes instructions for installing the task's software, the firmware for each Harp device used in the task, calibrating the hardware and configuring the task.
- **Task** - This is the section where the task is described. It contains a high-level explanation of the task, as well as a more low-level one.
- **Extensions** - Since there was a need to create custom Bonsai nodes written in C# to implement functionality which was difficult to implement or wasn't available natively in Bonsai (namely the reading of configuration files), a section documenting these nodes had to be created. There is also a description of every parameter from each configuration file.

If you find any bug in the project or any missing/incorrect/out-of-date documentation, feel free to create an issue on GitHub or contribute with a pull-request.

If you want to build the documentation locally click here.

Bill of Materials

This bill of materials (BOM) contains **EVERYTHING** needed to build a setup. From the less memorable screw to the super expensive syringes used for reward delivery.

> **NOTE**
>
> This BOM is destined to the people from the Champalimaud Foundation (CF). Nonetheless, the goal is that people outside CF are also able to order everything and build the setup.

> **WARNING**
>
> This BOM specifies the part numbers used by the lab for these setups, but not every component needs to be of a specific part number.
>
> The only things that need to be of a specific model are the Harp Devices, the Behavior Poke Port Breakout v1.1, the Poke Small v1.1 and the 12V Power Supplies.
>
> It's possible to use a different camera model, but please confirm that the camera can be used in Bonsai (although for some cameras the Bonsai workflow will probably need to be adapted).

Harp

This section contains the setup components that relate to the Harp devices somehow (except for the Camera that has a section of its own).

Devices

The Harp devices are assembled by the Hardware and Software Platform, so place an Agendo request to order them.

> **WARNING**
>
> For people outside of the Champalimaud Foundation, it's possible to order the Harp devices in the Open Ephys Production Site.
>
> It's also possible to assemble the devices in-house with the right equipment since all of them are under an open source license. Some devices (like the Harp SyringePump) must be built in-house since they are not sold externally.

Item	Description	Amount	Observations
Harp Behavior	General-purpose Harp board	1	-
Harp SoundCard	Delivers the auditory stimulus	1	-
Harp Audio Amplifiers	Amplifies the auditory stimulus	2	1 Harp Audio Amplifier per speaker
Harp ClockSynchronizer	Synchronizes the timestamps from every Harp device	1	-
Harp SyringePump	Device used for reward delivery	2	-
Harp CurrentDriver	Drives/controls the LED/laser used in optogenetics	1	Optional

Peripherals

For this part of the BOM, a peripheral is considered to be anything that either interacts with the Harp devices or is needed make the different devices work and/or interact with each other.

Item	Description	Amount	Part Number	Part of the Harp Device kit	Agendo	Observations
Behavior Poke Port Breakout v1.1	Makes the ethernet ports pins from the Harp Behavior available	3	-	✗	✓	Connects to the Harp Behavior
RJ-to-RJ cables	-	3	IM1037	✗	✗	Connects the Harp Behavior to the Behavior Poke Port Breakout v1.1
Poke Small v1.1	Board with infrared beam to detect animal pokes	3	-	✗	✓	Connects to the Behavior Poke Port Breakout v1.1

Item	Description	Amount	Part Number	Part of the Harp Device kit	Agendo	Observations
3.5 mm-stereo-audio-jack-to-bare-wires	-	3	BC-A3ML006F	✗	✗	Connects the Poke Small v1.1 to the Behavior Poke Port Breakout v1.1
5 mm white/blue LED	Placed on the box lid to give cues to the animal	1	-	✗	✗	Connects to the LED0 pins of the Harp Behavior
3 mm green LED	Placed in the central poke to give cues to the animal	1	-	✗	✗	Connects to the LED1 pins of the Harp Behavior
RCA-to-RCA cables	-	2	-	✓	✗	Connects each Harp Audio Amplifier to the Harp SoundCard
Speakers	Deliver the auditory stimulus	2	*TODO*	✗	✗	1 speaker per Harp Audio Amplifier
Banana Plug	4 mm Triple Contact Plug (Black or Red) - Pack of 10 units	4	557-0100	✗	✗	Connects the speakers to the Harp Audio Amplifiers
10 ml Glass Syringe	Hamilton 1000 Series Gastight Syringes: Luer Lock Syringes,	2	Hamilton 81620	✗	✗	Used for the Harp SyringePump

Item	Description	Amount	Part Number	Part of the Harp Device kit	Agendo	Observations
	TLL Termination					
4-way Stopcock	Pack of 10 units	2	Masterflex 30600-04	❌	❌	Attaches to the end of the syringe (1 per Harp SyringePump)
Nylon Male Luer Fitting	Pack of 25 units	2	Masterflex MFLX45505-31	❌	❌	Attaches to one end of the stopcock (1 per Harp SyringePump)
Nylon Female Luer Fitting	Pack of 25 units	2	Masterflex 45502-00	❌	❌	Attaches to one end of the stopcock (1 per Harp SyringePump)
Spouts	Used in reward delivery	2	B14200 100 BULK	❌	❌	Used in reward delivery. Glued to the physical lateral pokes
Flexible Tubing	Masterflex Tygon E-3603 Non-DEHP Tubing - 15 meters per unit	2	Masterflex 06407-71	❌	❌	Connects the spouts to one of the luer fittings (either male or female)
Mini USB cable	-	5/6*	AK-300130-018-S	✔	❌	Connects the Harp boards to the computer
Micro USB cable	-	1	-	✔	❌	Used to upload sounds to the Harp SoundCard
3.5 mm-stereo-	-	4/5*	*TODO*	❌	❌	Connects the Harp ClockSynchronizer to

Item	Description	Amount	Part Number	Part of the Harp Device kit	Agendo	Observations
audio-jack-to-jack cable						every other Harp device
12V Power Supply**	AC/DC Wall Mount Adapter 12V 12W	9/10*	VER12US120-JA	✔***	❌	1 is used to power the LED strip that illuminates the behavior box, the remaining are used to power the Harp devices
BNC-to-bare-wires conector**		1	810-4605	❌	❌	Connects the LED strip to the power supply

* if the Harp CurrentDriver is being used

** the number of power supplies can be decreased as explained in the subsection below

*** the power supply used to power the LED strip that illuminates the behavior box must be ordered separately

Reducing the number of power supplies

From the table above, it's pretty noticeable that a lot of power supplies are required, which takes up a lot of space and power outlets. It's possible to use the same power supply for different devices according to their characteristics. The devices can be grouped in the following way:

- Harp Behavior, Harp SoundCard and Harp CurrentDriver*
- V+ of the Harp Audio Amplifiers
- V- of the Harp Audio Amplifiers
- Both Harp SyringePumps

From the list above, it's possible to switch the last line from the previous table with the lines from the table below.

Item	Description	Amount	Part Number	Comes with Harp Device	Agendo	Observations
12V Power Supply	AC/DC Wall Mount Adapter 12V 12W	5	VER12US120-JA	✔***	✘	1 is used to power the LED strip that illuminates the behavior box, the remaining are used to power the Harp devices
2-to-1 cables for the 12V power supplies	-	4/3*		✘	✔***	-
4-to-1 cables for the 12V power supplies	-	0/1*		✘	✔***	-

* if the Harp CurrentDriver is being used

Mechanical Components

This section contains the mechanical components of the setup that were developed and assembled in-house.

> **WARNING**
>
> The files for the mechanical components are not currently available online and can't also be ordered, so people outside of the Champalimaud Foundation will have to develop and assemble their own.

Item	Description	Amount	Part Number	Observations
Behavior box	-	1	-	Made of acrylic
Physical pokes	-	3	-	Preferably made of metal, but can also be 3D printed
Speaker holder	-	2	-	Preferably made of metal, but can also be 3D printed
Speaker holder pole	Hollow alluminium tube	2	-	-
Box LED holder	-	1	-	3D printed

Camera

This section contains the hardware needed to setup the camera and fix it to the lid of the behavior box. Click here to go to the camera configuration instructions.

Item	Description	Amount	Part Number	Observations
FLIR Camera		1	BFS-U3-16S2M-CS	-
Camera Lens		1	A4Z2812CS-MPIR	-
Camera USB cable	USB-A to Micro-B Straight with Thumbscrews, 3 Meters	1	CEI USB3-1-1-2-3M	This cable MUST be connected to a USB 3.0 port for performance
Camera GPIO cable	6 Pin Female Straight Plug (Hirose HR10A-7P-6S) to Flying Leads, 3 Meters	1	CEI MVA-50-3-X-3	Connects to the Harp Behavior to trigger/monitor the camera frames
Tripod Adapter	BFS 30 mm BFLY CM3 Tripod Adapter	1	ACC-01-0003	Used to fix the camera to the Thorlabs poles in the behavior box
Thorlabs 75mm post	Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 75	1	TR75/M	Connects to the camera

Item	Description	Amount	Part Number	Observations
	mm			
Thorlabs 150mm post	Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 150 mm	1	TR150/M	Fixes the camera structure to the box lid
Thorlabs post clamp	Rotating Clamp for Ø1/2" Posts, 360° Continuously Adjustable, 5 mm Hex	1	SWC/M	Fixes both Thorlabs posts to each other
M6 Screw	15/16 mm	1		Fixes the longer post to the behavior box lid
M6 Setscrew	M6 x 1.0 Stainless Steel Setscrew, 16 mm Long, 25 Pack	1	SS6MS16	Connects the Thorlabs post to the Camera

Others

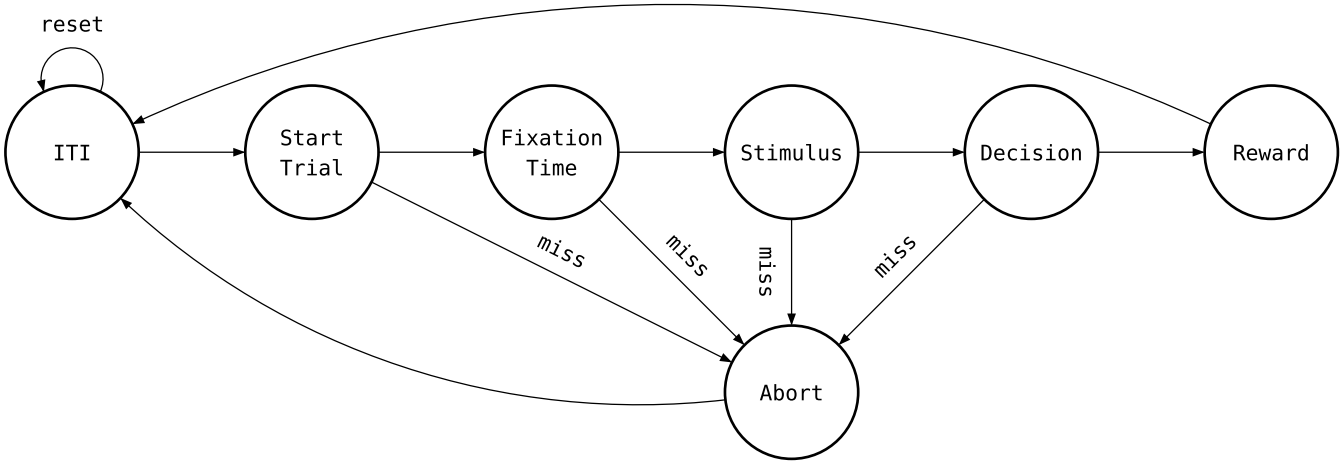
This section contains the remaining components needed for the setup. None of these components needs to be the exact model present on the list. It just corresponds to the models that have been used by the lab, but feel free to use different ones, as long as they work.

Item	Description	Amount	Part Number	Observations
Computer	Mini PC Blackview MP100 Mini PC AMD Ryzen 7 5825U/16GB/512GB SSD	1	MP100(16+512)-BLACK	-
Screen	-	1	-	-
HDMI cable	-	1	-	-
Keyboard	-	1	-	-
Mouse	-	1	-	-
USB Hub	HUB USB 3.0 TP-Link UH700 7 Ports	1	P004616	-
Power extension with 6 electrical	Must be appropriate to 90˚ plugs	1		To plug all of the power supplies in a setup

Item	Description	Amount	Part Number	Observations
outlets				
KVM switch		-		Optional: useful in case one wants to use the same screen + mouse + keyboard kit in different computers
12V LED Strip		1		-
Optogenetics Light Source	-	-	-	Optional

State Machine

The sound lateralization task implemented in the current project, which is based on [1], was designed as a state machine, where the progression through the different states is driven by certain events. The figure below is a representation of the state machine that describes this task.



From the figure, notice that from most states there are two possible states that these states can progress to. This happens because there are certain conditions that have to be met in order for the state machine to progress to the next "desired" state.

A brief description of each individual state can be found below.

Inter-Trial Interval (ITI)

The Inter-Trial Interval (ITI) state is, as the name suggests, the time interval that separates two consecutive trials.

Since there is a need to setup each trial (for example, to (re)set some parameters) and the duration of the ITI is, typically, a few seconds, this state is also a preparation of the new trial.

If the `iti.can_reset` parameter (located in the `training.csv` file) is `True`, this state resets everytime the animal is poking the CNP before the ITI is over.

Start Trial

A trial starts when the rodent pokes his nose in the central nose port (CNP). So this state consists of waiting that the rodent starts poking the CNP. If there is a poke within a certain time limit (determined by the `max_wait` parameter of the `training.csv` file), the task continues as it is supposed to, otherwise this trial is aborted.

Fixation Time

This is the state that precedes the stimulus presentation. The rodent must stay in the CNP during the entire time this state lasts so that the task progresses as expected, otherwise the trial is aborted.

The fixation time is divided into 2 parts: the Opto Onset Time and the Sound Onset Time. The fixation time starts in the Opto Onset Time. When it ends the optogenetics stimulation starts (if it applies to the current trial) and the Sound Onset Time starts. When it ends, the sound stimulus is presented.

Each of these parts is composed by the sum of a fixed duration and random variable modeled by a exponential distribution.

$$t_{\text{Opto Onset Time}} = t_{\text{Base Fix}} + (X \sim \text{Exp}(\lambda)) = t_{\text{Sound Onset Time}}$$
$$t_{\text{Fix}} = t_{\text{Opto Onset Time}} + t_{\text{Sound Onset Time}}$$

The advantage of modelling the fixation time with the exponential distribution is that it has a constant hazard rate, which in practice means, in the animal's perspective, that the probability of the sound starting (and therefore the fixation time ending) at any time given that a certain amount of time has already passed is constant. This way, it's difficult for the animal to predict when the sound is going to start.

Stimulus

This is the state where the stimulus is presented. The stimulus stops when either the rodent leaves the CNP (if `reaction_time.turn_sound_off` is `True`) or when the animal enters one of the LNP's (if `reaction_time.turn_sound_off` is `False`) or when the defined presentation time elapses (the presentation time is defined by `reaction_time.max_value`).

If the animal leaves the CNP before the minimum reaction time (defined by `reaction_time.min_value`) or after the maximum reaction time (defined by `reaction_time.max_value`), the trial is aborted.

Decision

In this state, the animal has to pick the side (left or right) which corresponds to the speaker that played the loudest sound by poking in either lateral nose port (LNP).

If the animal pokes either LNP before the minimum movement time or after the maximum reaction time, the trial is aborted. This also happens when the animal pokes in one of the LNPs but doesn't stay in it for the minimum required time (`lnp_time.min_value`).

Reward

The Reward state evaluates whether the rodent got the answer right or not. In case the answer is wrong, a penalty time is applied (10 seconds for instance). If the answer is right, the animal gets the reward (water). This is the final state of a successful trial.

Abort

The Abort state is triggered when some condition is not met in one of the previous states. This state consists of a small time penalty. The penalty time is defined by the `penalty_time.abort` parameter of the `training.csv` file, unless a fixation abort occurred. If that's the case, then the penalty time is defined by `penalty_time.fixation_abort`. This is the final state of an unsuccessful trial.

References

[1] J. L. Pardo-Vazquez et al., “The mechanistic foundation of Weber’s law,” Nat Neurosci, vol. 22, no. 9, pp. 1493–1502, Sep. 2019, doi: 10.1038/s41593-019-0439-7.

Namespace Animal

Classes

Animal

AutobiasCorrection

BiasedBlockDistribution

BiasedSession

DeserializeFromJson
Deserializes a sequence of JSON strings into data model objects.

DeserializeFromYaml
Deserializes a sequence of YAML strings into data model objects.

FixationTime

OptoLED

Optogenetics

ReactionTime

Reward

SerializeToJson
Serializes a sequence of data model objects into JSON strings.

SerializeToYaml
Serializes a sequence of data model objects into YAML strings.

Session

Sound

TimeConstrains

Enums

OptoLEDMode

OptogeneticsMode

OptogeneticsRampMode