Behavioral Observation Research Interactive Software (BORIS) user guide

version 3.2

BORIS web site: www.boris.unito.it

BORIS GitHub repository

BORIS twitter feed

BORIS discussion group

BORIS Facebook page

BORIS Google+

Contents

Legal

Install BORIS

BORIS can be installed following instructions on the BORIS site at download page

If you want to try BORIS without installing it you can download the VirtualBox virtual appliance from the BORIS site. In this case you must first install VirtualBox

Launch BORIS

Start BORIS by clicking on its icon. For launching BORIS from sources see the BORIS web site. When launching BORIS for the first time it may take some time to show up. Please be patient!

> ***Warning***
>
> On Mac OS X 10.9 and above, launching can be stopped according to the **Security & Privacy** settings of your computer. They can be changed opening **System Preferences...** > **Security & Privacy** > **General** and selecting the option **Anywhere** in the frame **Allow apps downloaded from**. Alternatively you can repeat the operation right-clicking on the BORIS icon and then clicking **Open** in the following two dialog boxes.

> ***Warning***
>
> On Microsoft-Windows, launching can be stopped by a **Security warning**: *The publisher can not be verified. Are you sure you want to run this software?* Click the **Run** button to launch BORIS.

At the first launch, BORIS will ask you to allow the automatically check for new version. Internet access is required for this feature. If you choose **Yes** BORIS will check for new version about every 15 days. This option can be changed on the **Preferences** window (See general preferences)

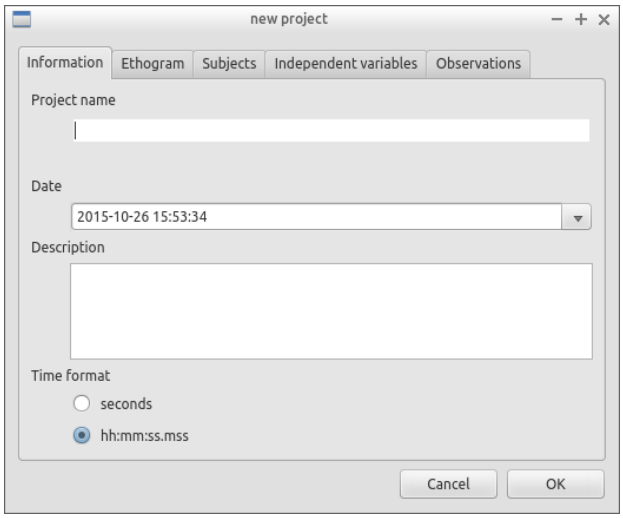
You can launch BORIS from command line by specifying the project file to open as the first argument.

Create a new project with BORIS

The BORIS project file is the container for all information related to the project. It contains the ethogram, the independent variables, the subjects and all observations data. The save menu option (File -> Save project) will save all this information. You can also activate the **automatic backup** feature (see **Preferences**). BORIS allows creating an unlimited number of projects but only one project can be opened at a time.

A video tutorial about creating a project is available at https://www.youtube.com/watch?v=UGou4EVcLm0

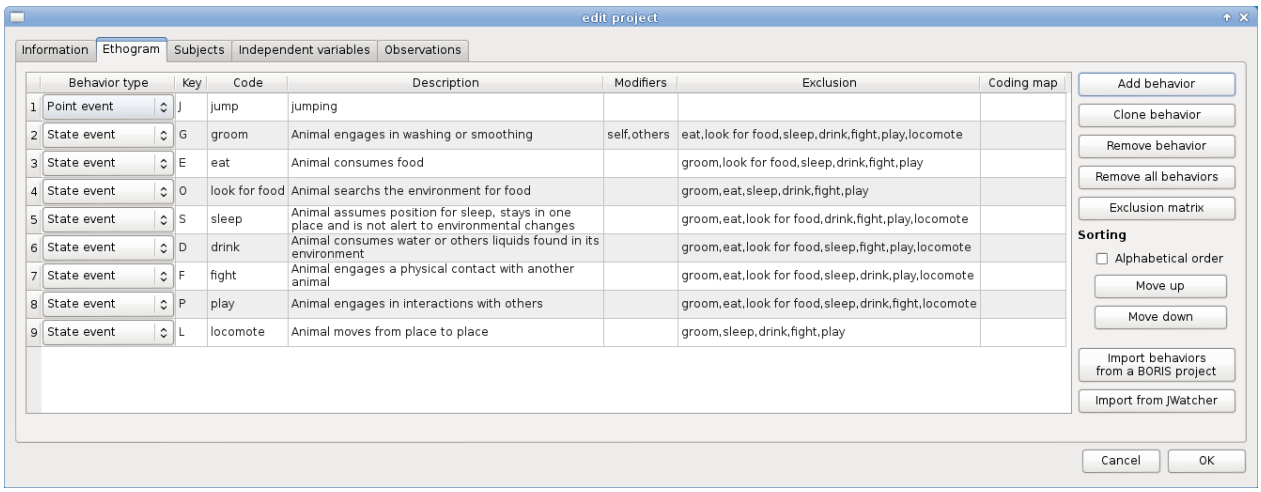
To create a new project, under the menu **File** , select **New project**. You can determine your project name by writing in the **Project name** field in the **Information** tab. Once the project will be saved, the **Project file path** will show the full path to your project file. **Date** will automatically set on the current date and time, but you can alternatively set this info on your media date and time, or whatever you prefer. **Description** can host all the relevant information about your project, can be also left empty. **Time format** can be alternatively set to **seconds** or to **hh:mm:ss.mss**. This choice can be changed at anytime under **File** > **Preferences** (for MAC users, **BORIS** > **Preferences**) > **Default project time format**.



Set an ethogram

Switching to the **Ethogram** tab, you can alternatively:

- set your ethogram from scratch;
- import an existing ethogram from another BORIS project;
- import an ethogram from a JWatcher global definition file (.gdf).
- import an ethogram from a plain text file



Set your ethogram from scratch

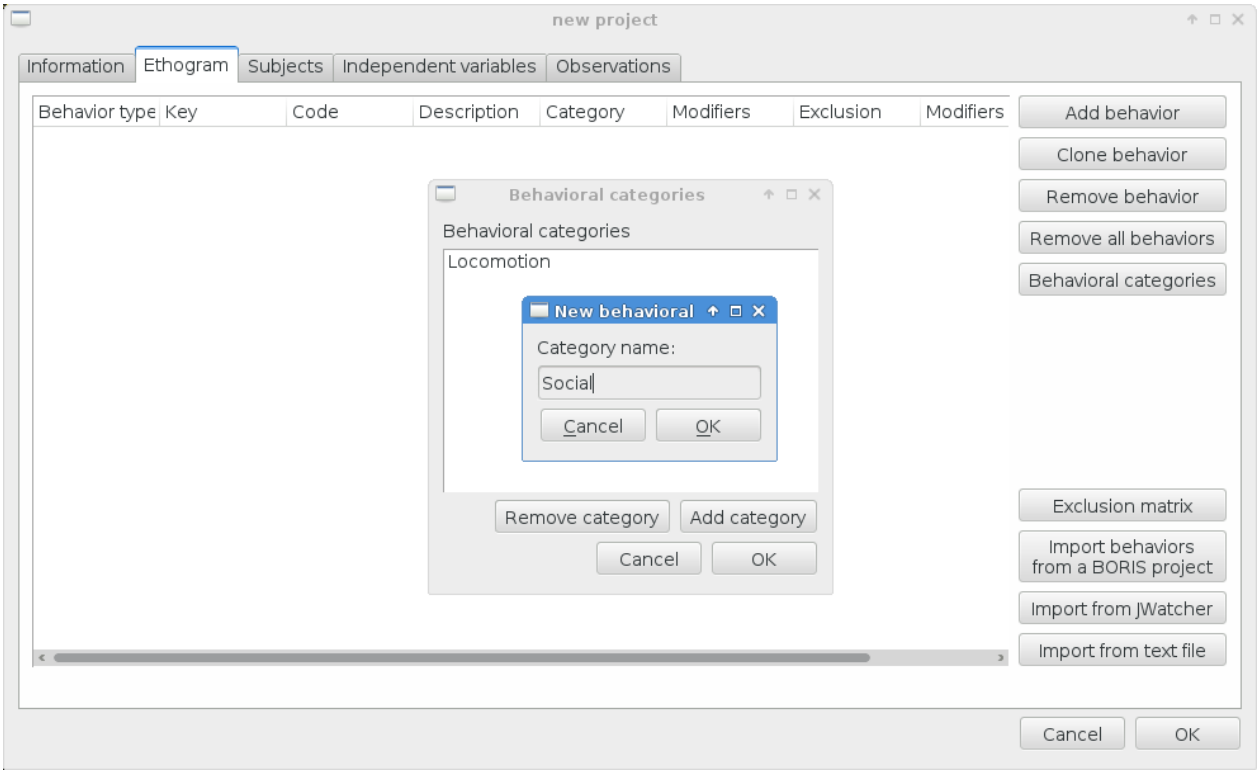
Clicking on the **Add behavior** button you can add a new row in the *Ethogram* table and behavior type will be automatically set to **Point event**. You can switch between **State event** and **Point event** at your convenience from the **Behavior type** column. You can also add a **Coding map** to either a **State event** (**State event with coding map**) or a **Point event** (**Point event with coding map**; see the "Coding map" section for details).

An existing behavior can be duplicated using the **Clone behavior** button. Its code have then to be changed. On a selected behavior, click on the **Remove behavior** button to remove. The **Remove all behaviors** button will clear the **Ethogram** table. Both the above-mentioned operations must be confirmed when prompted.

Behavioral codes (**Code** column) can be sorted alphabetically by checking the **Alphabetical order** checkbox. Alternatively they can be sorted manually by using the **Move up** and **Move down** buttons.

Categories of behaviors

Defining categories of behaviors can be usefull for the analysis of coded events (for example the time budget analysis). Click the **Behavioral categories** button and add a the categories of behaviors. Behaviors can then be included or not in a defined category.



Set keys and codes

For each behavior you have to set a keyboard key (**Key** column) that will be then used to code the behavioral events. You can choose whether you want to set a unique key for each behavior or use the same key for more than one behavior. In the case you set the same key for more than a behavior, BORIS will pause your coding and ask which of the behavior you want to record. The keys are case-insensitive.

> ***Important***
>
> Do not use the / and * keys! They are reserved for the frame-by-frame mode.

In the **Code** column, you have to add a unique code for each behavior. Duplicated codes are not accepted and BORIS will warn in red about duplicates on the bottom left of the *Ethogram* tab. The code can be an alphanumeric string (which must not include the pipe character **|**).

The **Category** column allow you to include the behavior to a predefined category.

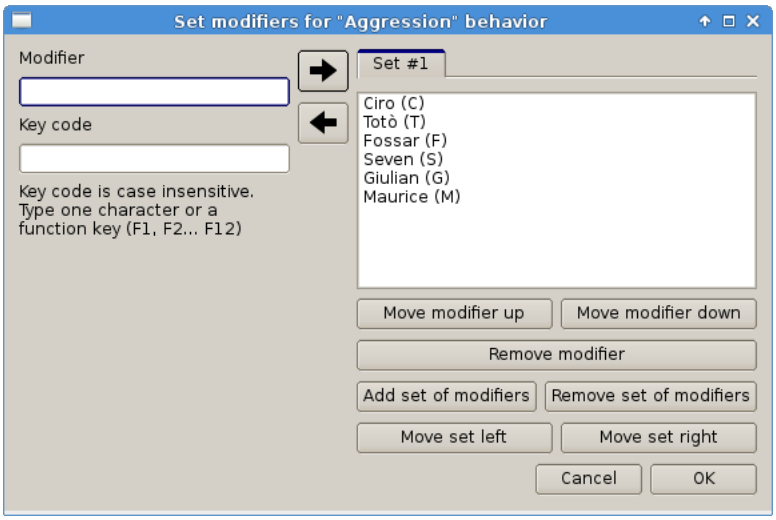
The **Description** of your behavior is optional. The **Description** column can be useful to add information about a specific behavior, its characteristics (e.g. to standardise observation between different users) or to refer to external information (e.g. reference to a previous ethogram).

The following three columns (**Modifiers**, **Exclusion**, **Coding map**) cannot be edited from the **Ethogram** table.

Set the modifiers

Modifiers can be used to add attributes to a behavior. A single behavior can have two or more modifiers attached (e.g. "play" may have "solitary" or "social" as modifiers). The use of modifiers can be convenient to significantly reduce the number of keys and simplify the behavioral coding. In BORIS modifiers can also be added in different modifier sets [e.g. "play, social" may have a modifier set (#1) for "brothers" and another (#2) for "sisters"]. In the case of using sets of modifiers, you can attach one modifier for each set.

To add modifiers to a behavior, you need to double-click the **Modifiers** cell corresponding to the behavior you want to add the modifiers to.



When the **Modifiers** window is open you can add and/or remove sets using the buttons **Add set of modifiers** and **Remove set of modifiers**. Within a set of modifiers, you can add and remove modifiers using the **Modifier** field and clicking on the **right-arrow** button (to add) and the **Remove modifier** button (to remove). The selected modifier can be edited using the left-arrow button. The **Key code** box can be used to set a key for the modifier (optionnal).

The modifier position into the modifiers' set can be manually set using the **Move modifier up** and **Move modifier down** buttons.

The position of a modifiers' set can be customized (using the **Move set left** and **Move set right** buttons)

Modifiers can not contain the following characters: **(**, **)** and **|** (pipe character).

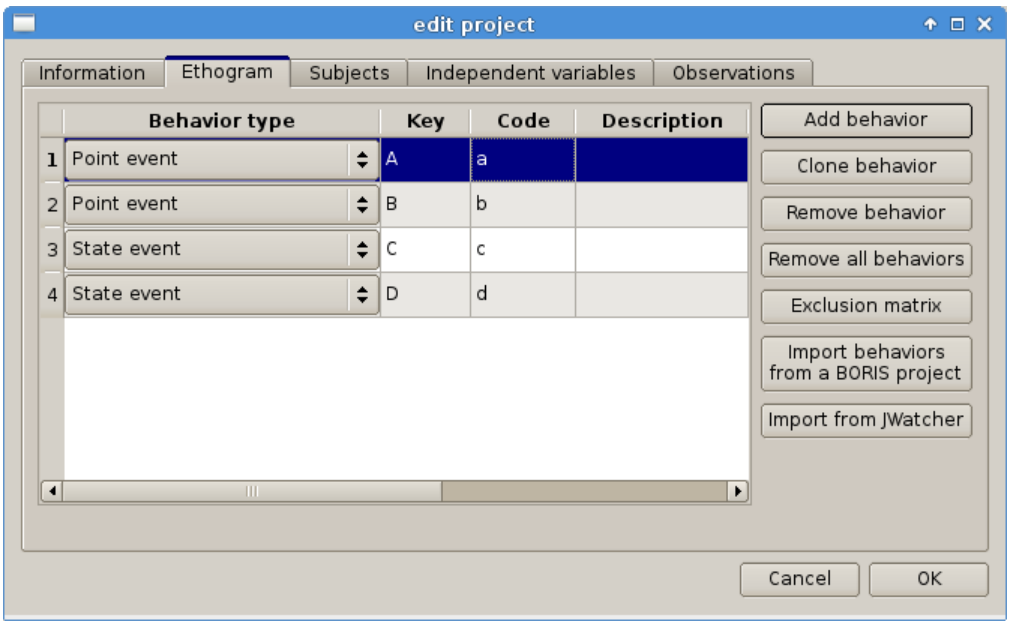
Click **OK** to save modifiers in the **Ethogram** table.

Set the exclusion matrix

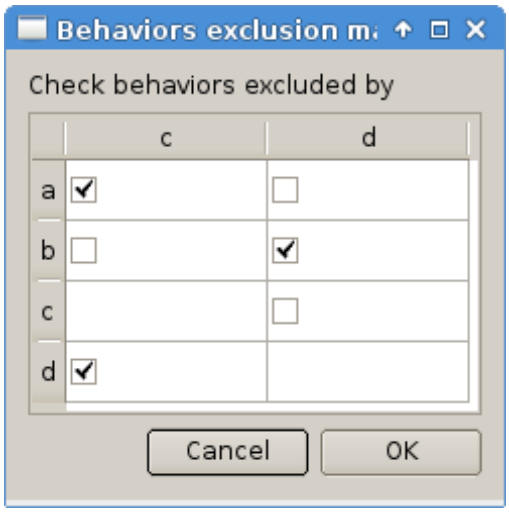
The occurrence of an event (State or Point) can exclude the occurrence of a state event. This can be set using the **Behaviors exclusion matrix** window, which can be opened clicking on the **Exclusion matrix** button. BORIS will ask for including **Point events** or not and a new **Exclusion matrix** window will open.

Exclusive behavior may be selected by checking on the corresponding cell in the automatically-generated matrix. We suggest to work on the **Exclusion matrix** when all the behaviors have been added to your ethogram.

For example, for the following ethogram:



The **Exclusion matrix** could be:



- the behavior **a** (Point event) will exclude the behavior **c** (State event) but not **d** (State event)
- the behavior **b** (Point event) will exclude the behavior **d** but not **c**
- the behavior **d** (State event) will exclude the behavior **c**

During the observation, the excluding event will stop all the current excluded state events one millisecond before the occurence of the event.

Import an ethogram from an existing project

Behaviors within an ethogram can be imported from an existing BORIS project (.boris) using the **Import behaviours from a BORIS project** button. BORIS will ask to select a BORIS project file and whether imported behaviors should replace or be appended to the **Ethogram** table. Imported behaviors will retain all the previously defined behavior parameters (namely Behavior type, Key, Code, Description, Modifiers and Exclusion information).

Import an ethogram from a JWatcher global definition file (.gdf)

Behaviors can be imported from a JWatcher global definition file (.gdf) using the **Import from JWatcher** button. BORIS will ask to select a JWatcher file (.gdf) and whether imported behaviors should replace or be appended to the **Ethogram** table. Behavior type and exclusion information for the behaviours imported from JWatcher have to be redefined.

Import an ethogram from a plain text file

Behaviors can be imported from a plain text file using the **Import from text file** button. The fields must be separated by TAB, comma (,) or semicolomn (;). All rows must contain the same number of fields.

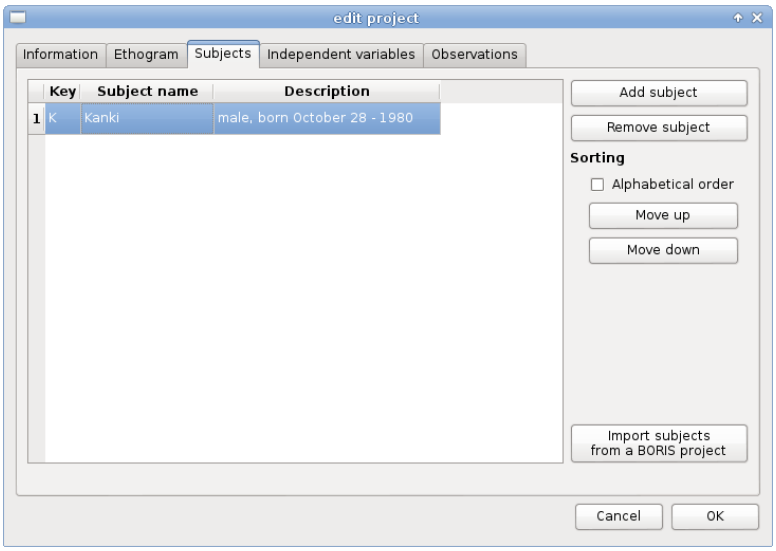
The fields will be interpreted as:

- field #1: event type (point or state)
- field #2: key (case insensitive)
- field #3: code (must be unique)
- field #4: behavior category (empty if no category)
- field #5: description (optional)

All fields after the 5th will be ignored.

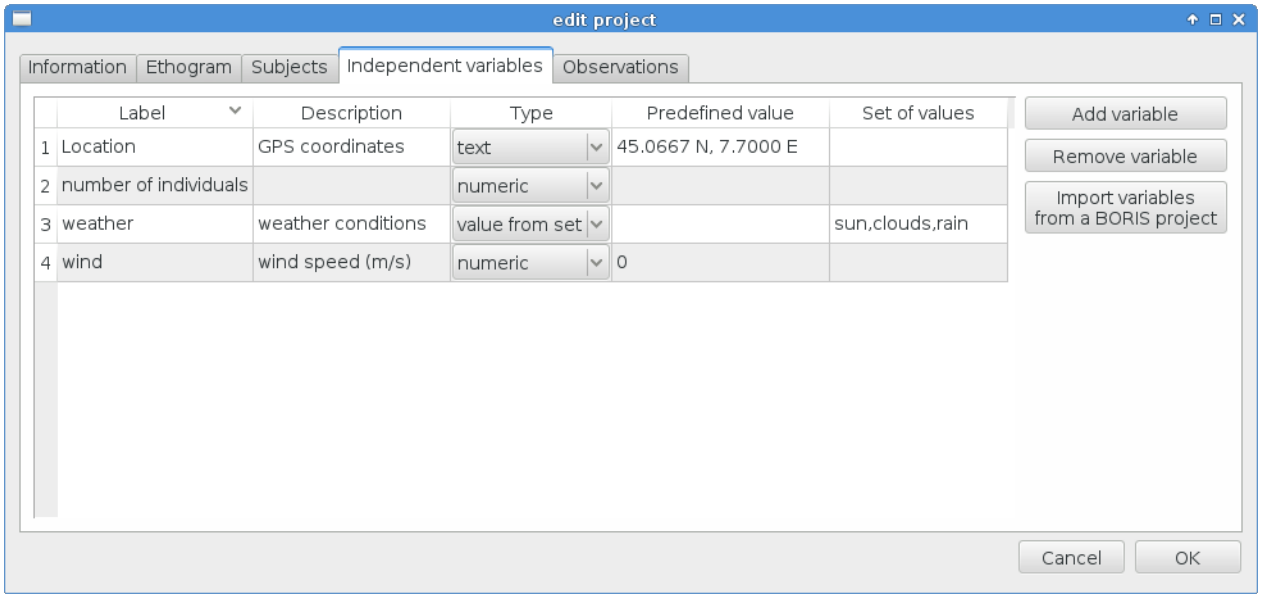
BORIS will ask to select a plain text file (by default: *.txt *.csv *.tsv) and whether imported behaviors should replace or be appended to the **Ethogram** table. The missing information for the behaviours imported from text file have to be redefined.

Define the subjects



BORIS allow coding behaviors for different subjects within a single observation. The **Subject** table allows specifying subjects using a **Key** (e.g. the "K" on your keyboard), **Subject name** (e.g. "Kanzi"), **Description** (e.g. male, born October 28 - 1980). In this case, pressing "K" will set "Kanzi" as the focal subject of the behavioural coding. Pressing "K" again will deselect "Kanzi" and set to "no focal subject". The definition of one or more subjects is not mandatory. Addition, removal and sorting of the subjects follows the same logic of the *Ethogram* table (see **Set your ethogram from scratch** for info). The subjects can also be imported from an existing BORIS project using the **Import Subjects from a BORIS project**.

Define the Independent variables



BORIS allows adding information about the observation using **Independent variables**. This can be used to specify factors that may influence the behaviors (e.g. group composition, temperature, weather conditions) but will not change during a single observation within a project. Each independent variable can be defined by a **Label** (e.g. weather), a **Description** (e.g. weather conditions), a **Type** (*text*, *numeric* or *value from set*). The values of a set are defined in the **Set of values** column separating the available values with a comma (**,**).

The values for the independent variables can be set when creating a new observation. Addition, removal and sorting of the independent variables follows the same logic of the **Ethogram** table (see **Set your ethogram from scratch** for info). The independent variables can also be imported from an existing BORIS project using the **Import Variables from a BORIS project**.

Observations' tab

The **Observations** table in BORIS shows information about all the previous observations within a project. A selected "Observation" can be removed using the "Remove observation" button (you will be prompted for confirmation). This operation cannot be undone and deleted observations cannot be recovered once the project is saved. The **Observations** table shows four columns **id Date Description Media**.

Open an existing project with BORIS

To open an existing BORIS project, under the menu **File** , select **Open project**. A BORIS project file is a container for all information related to a set of observations as the ethogram, the independent variables, and the subjects. BORIS allows creating an unlimited number of projects but only one project can be opened at a time.

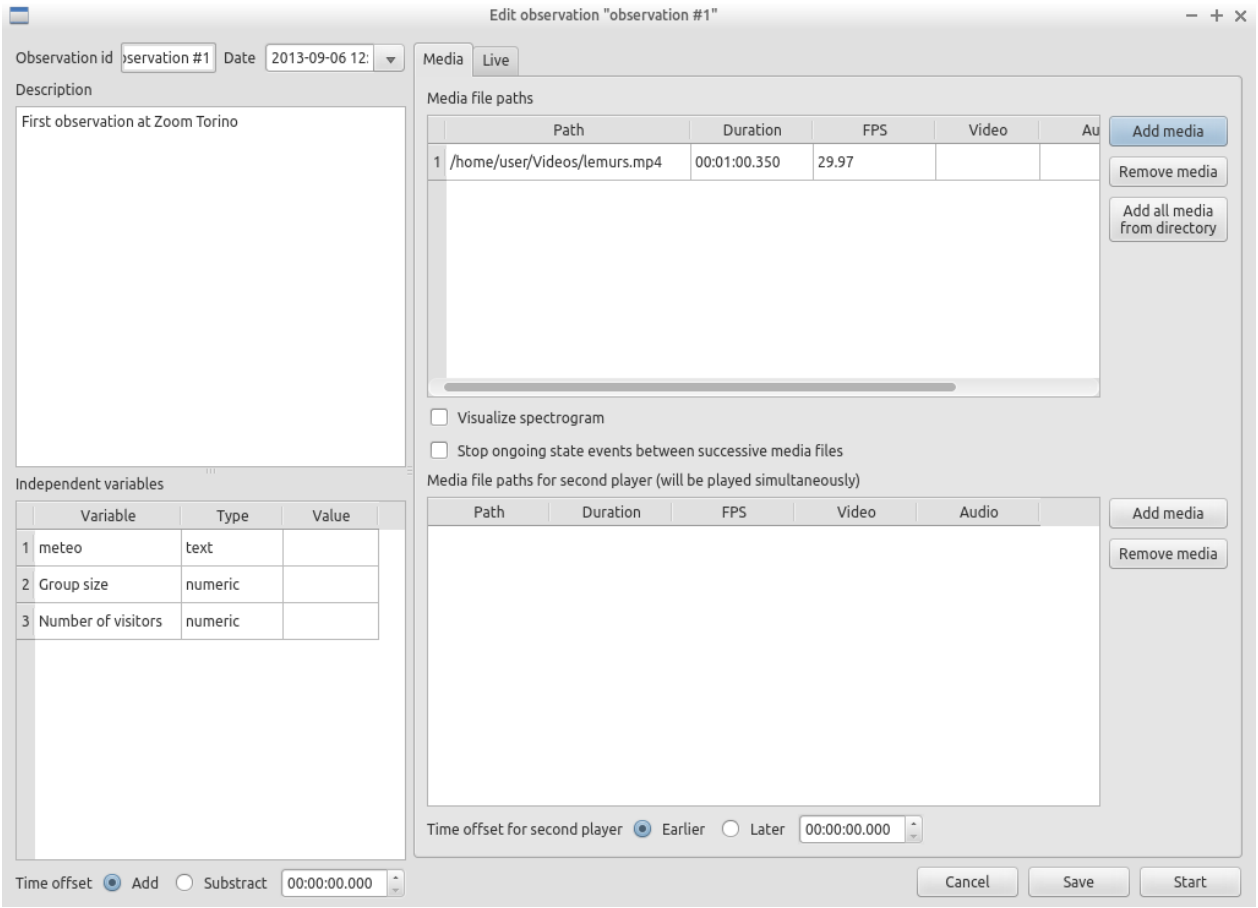
Observations

Create a new observation

A video tutorial about making an observation is available at https://www.youtube.com/watch?v=ef-d6WEc0po

To create a new observation you must first Create a new project with BORIS or Open an existing project with BORIS.

Clicking on **Observations** > **New observation** will show the **New observation** window.



This window allow adding various observation data:

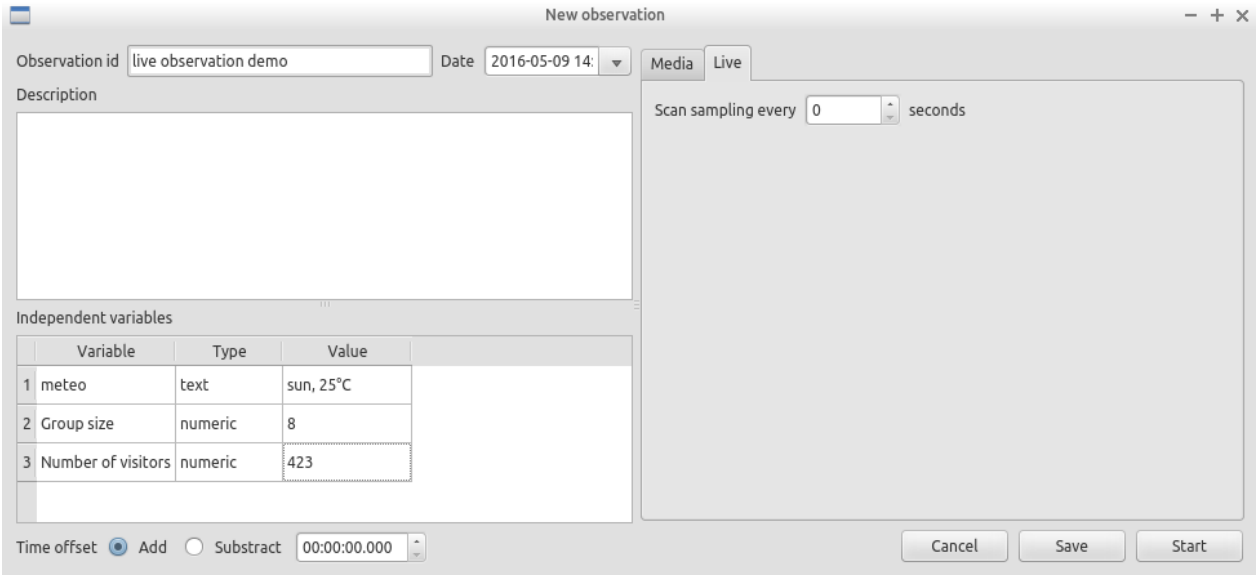
- a mandatory **Observation id** (must be unique across all observations);
- **Date**, which will be automatically set on the current date and time, but you can alternatively set this info on your media date and time, or whatever you prefer.
- **Description**, which can host all the relevant information about your observation, but can be also left empty.
- **Independent variables** (e.g. to specify factors that may influence the behaviors but will not change during the observation within a project). See the independent variables section for details.
- **Time offset**. BORIS allow specifying a time offset that can be added or subtracted from the media timecode.

You must then indicate if you want to make an observation based on pre-recorded media (audio / video) or a live observation.

Live observation

During the live observation BORIS will show you a timer that will be used for recording time for coded events.

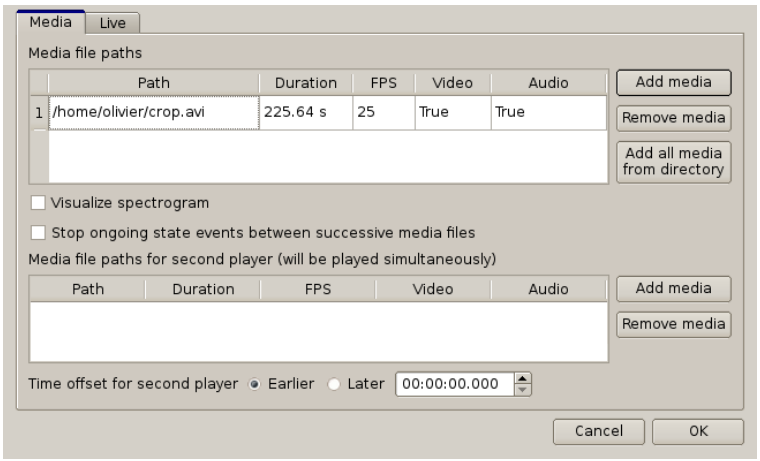
Choose the **Live tab** to make a live observation.



In the above tab you can select a time for **Scan sampling** observation. In this case the timer will stop at every time offset you indicated and all the coded events will have the same time value.

Media based observation

Choose the **Media tab** to make an obervation based on media.



In the **Media tab** there are two playlists. In the **Media file paths** playlist you can add one or more media files using the **Add media** button. Information about the selected media file will be extracted and displayed in the media list: media file path, media duration (in seconds), number of frames by second (FPS), video stream, audio stream .

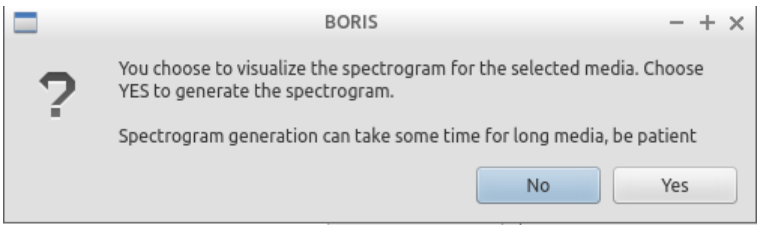
If you have to add various media files, you can use the **Add all media from directory** button, in this case all the media files found in the selected directory will be added in the playlist.

The **Remove media** button can be used to remove the selected media files.

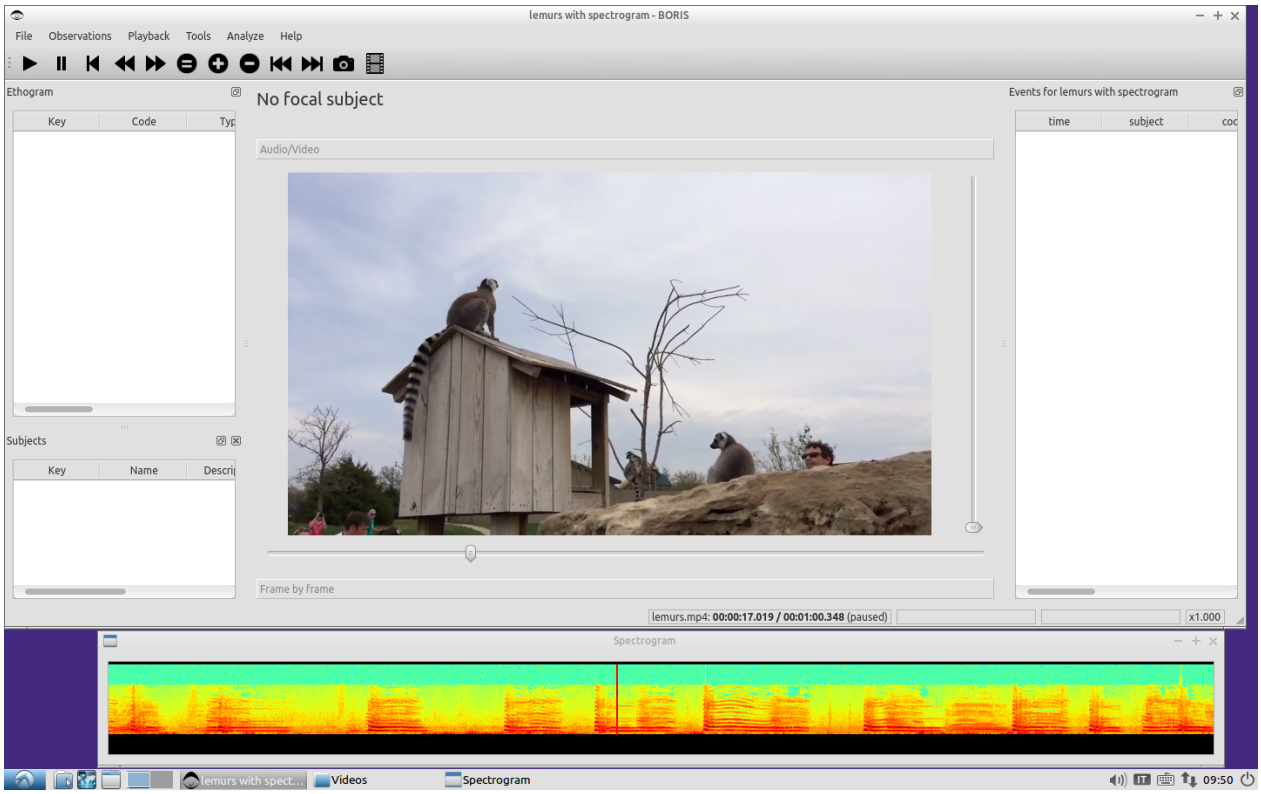
All the media types reported at http://www.videolan.org/vlc/features.html can be played in BORIS. The media queued in the *Media file paths* will be played sequentially. This means that an event occurring at time t_x in the media file queued as second (e.g. second_video.mp4) in the playlist will be scored as happening at time $t_1 + t_x$ (where t_1 is the duration of the first media file, e.g. first_video.mp4).

Spectrogram visualization

BORIS allow you to visualize the sound spectrogram during the media observation. Activate the *Visualize spectrogram* check box. BORIS will ask you to generate the spectrograms for all media files loaded in the first player.



The spectrogram visualization will be synchonized to the media position during the observation.



Close current behavior between videos

If this option is selected BORIS will close all ongoing State events between successive media files.

This option can be usefull if you have to code various short media files enqueued in the first player (for example the output of a Camera trap).

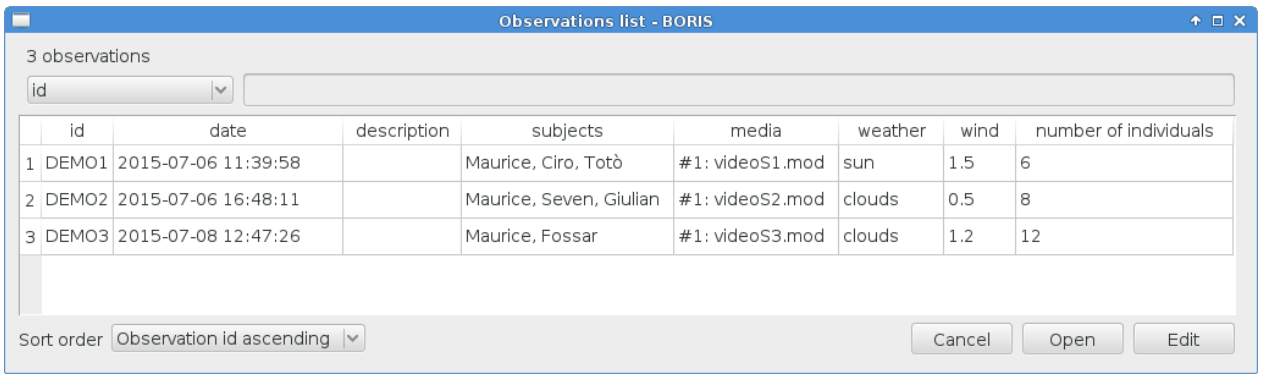
Simultaneous play

BORIS also allows simultaneous playback of two media recorded independently (e.g. videos recorded from different points in a room; or a video and an audio recording of the same observation). The videos to be played simultaneously can be loaded in the **Media file paths for second player** playlist. In this case only one video per playlist is accepted. If the two media are not synchronised you can specify a time offset for the second player.

Click OK to start coding. The **Observation** window will be closed and you'll be transferred to the main **BORIS** window.

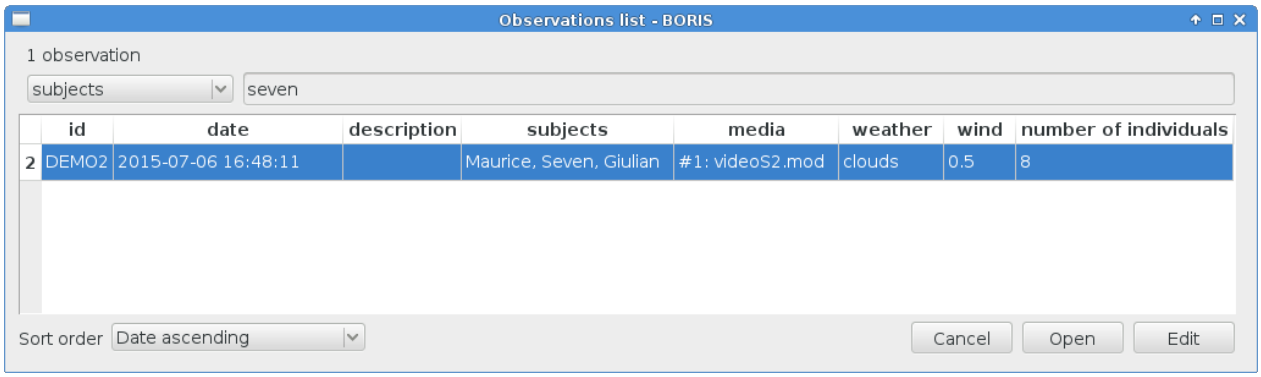
Observations list

The **Observations** > **Observations list** will show you all the observations contained in the current BORIS project.

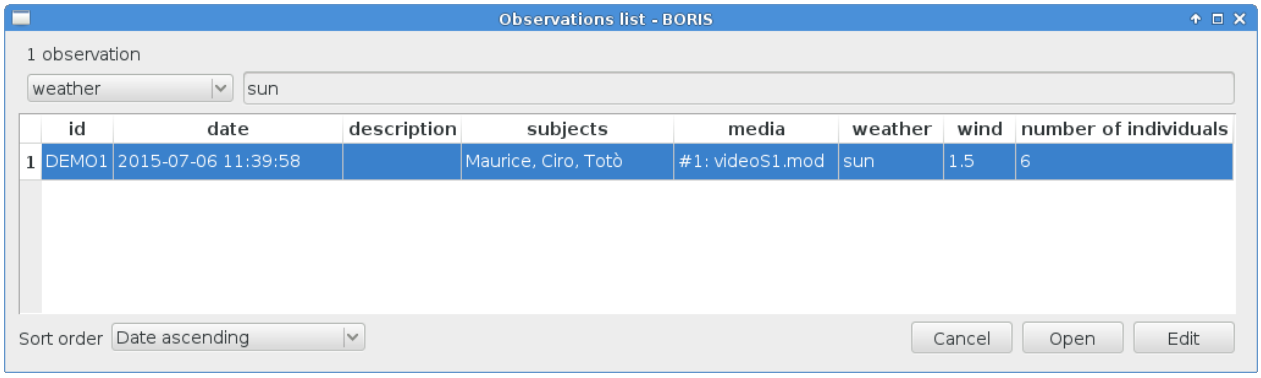


The observations list can be filtered selecting a field in the drop-list box.

In the following example observations are filtered: only observations containing the **Seven** subject are shown:



Observations can be filtered with **Independent variables** values:



The observations list can be sorted using the **Sort order** dropdown list.

Delete an observation

An observation can be deleted from the project using the following procedure: **File** > **Edit project** > **Observation's tab** > **Select observation to remove** > **Remove observation** button

Please note that the deletion is irreversible.

Import observations from a project file

The **Observations** > **Import observations** option allows to import obserations from a BORIS project file into the current project. Choose the project file and then the observations to import. BORIS will check if observations with same id are already existing in the current project. BORIIS will also check if behaviors and/or subjects used in the imported observations are not defined in the current project.

Coding your media

When looking at the BORIS main window, the window title bar shows the **Observation id** - **Project name** - **BORIS**. The media (the first in the queue) will be loaded in the media player and paused.

Media controls are available in the toolbar

Key to the symbols:

- **Play**
- **Pause** (the SPACE bar can be used)
- **Rewind** reset your media at the beginning
- **Fast backward** jumps for n seconds backward in your media (See general preferences to set n)
- **Fast forward** jumps for n seconds forward in your media (See general preferences to set n)
- **Set the playback at speed 1x**
- **Increase playback speed** (See general preferences to set the step value)
- **Decrease playback speed** (See general preferences to set the step value)
- **Jump to the previous media file**
- **Jump to the next media file**
- **Take a snapshot** of current video or frame
- **Switch between VLC and frame-by-frame modes**

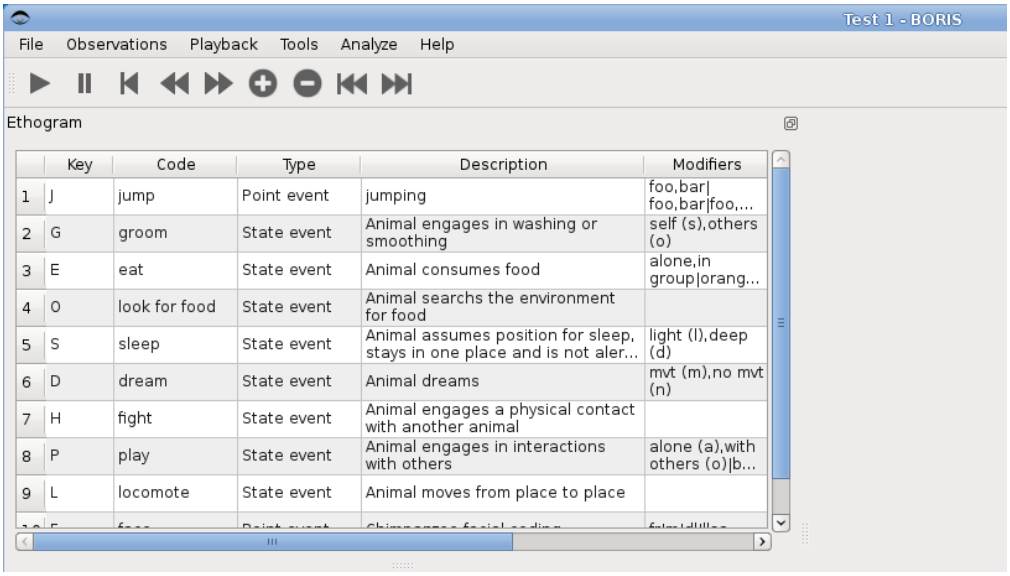
In frame-by-frame mode:

- **Move on frame back**
- **Move one frame forward**

The media can be controlled by special keyboard keys:

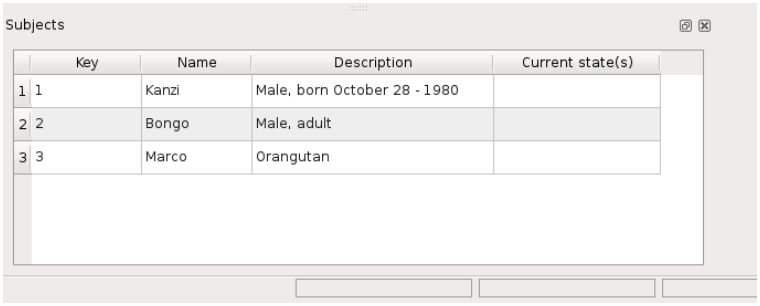
- **Page Up** key: switch to the next media
- **Page Down** key: switch to the previous media
- **Up arrow** key: jump forward in the current media
- **Down arrow** key: jump backward in the current media
- **ESC**: switch between VLC and frame-by-frame mode

Ethogram widget in the main window



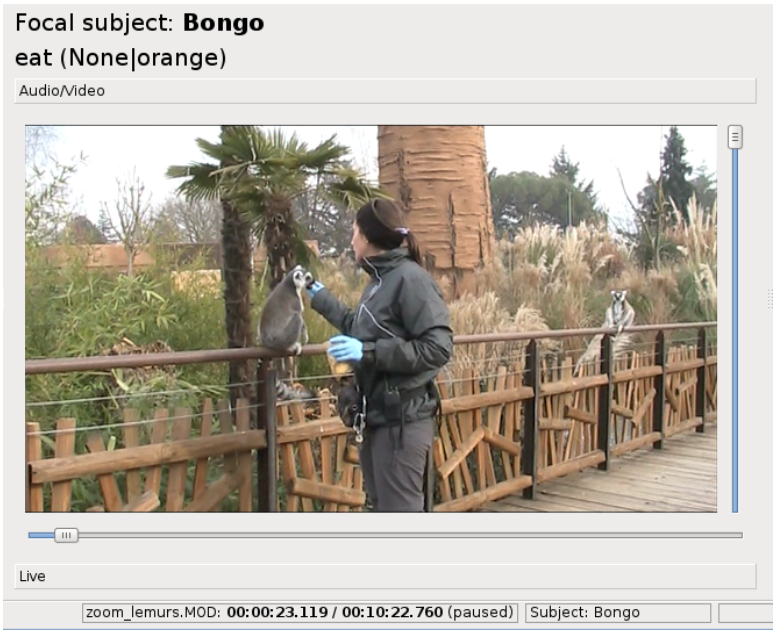
The **Ethogram** widget provide the user with the list of behaviors defined in the **Ethogram**. It can be used to record an event by double clicking on the corresponding row. The **Key** column indicates the keyboard key assigned to each behavior (if any). Pressing a key will record the corresponding behavior (that will appear in the *Events* widget).

Subjects widget in the main window



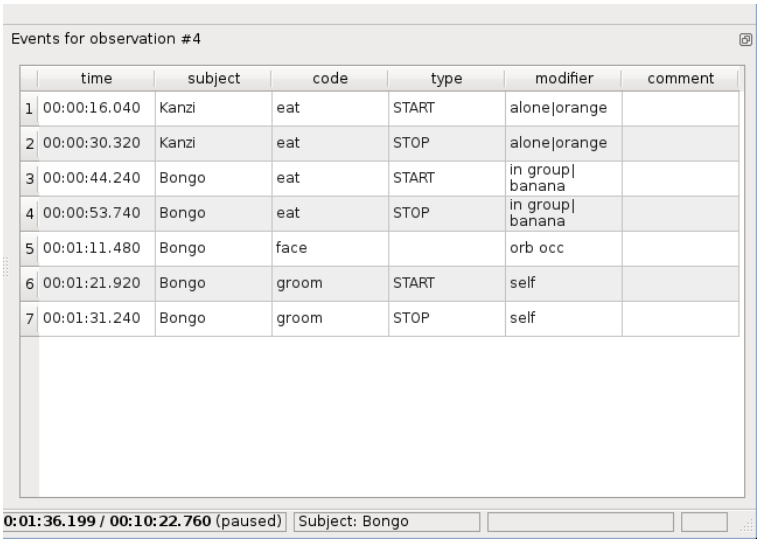
The **Subjects** widget provide the user with the list of subjects defined in the **Subject** tab in the **Project** window. It can be used to add information about the focal subject on the recorded behaviors by double clicking on the corresponding row. When a subject is selected his/her name appears above the media player. The **Key** column indicates the keyboard key assigned to each subject (if any).

Media player widget in the main window



The **Media player** widget has two controls: the media position (horizontal slide bar) and the audio volume (vertical slide bar) provide the user with the list of subjects defined in the **Subject** tab in the **Project** window. The horizontal slide bar can be used to navigate the media file.

Events widget in the main window



The **Events** widget shows all the recorded behaviors with the following parameters (columns):

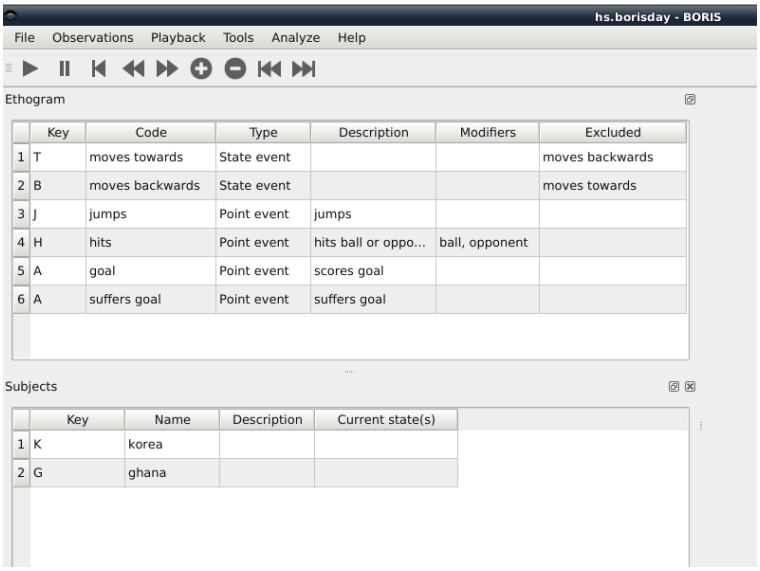
- **time**, the time at which the event occurred;
- **subject**, the focal subject (if any);
- **code**, the behavior code;
- **type**, in case of a state event indicates whether the time corresponds to the start or to the stop.
- **modifier**, indicates the modifier(s) that was(ere) selected (if any);
- **comment**, is an open field where the user can add notes.

A tracking cursor (red triangle) will show the current event. This cursor can be positioned above the current event, see tracking cursor position option in Preferences window.

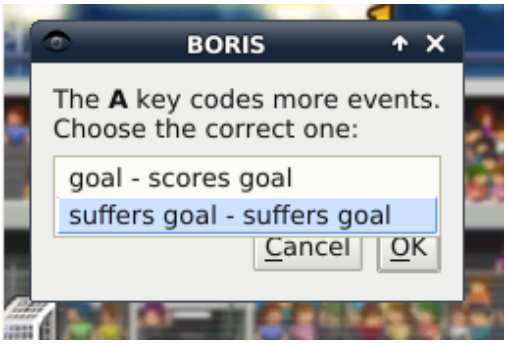
A double-click on a row will reposition the media player to the moment of the corresponding event. See Time offset for media reposition in Preferences window to customize the time offset for media repositioning.

Record an event

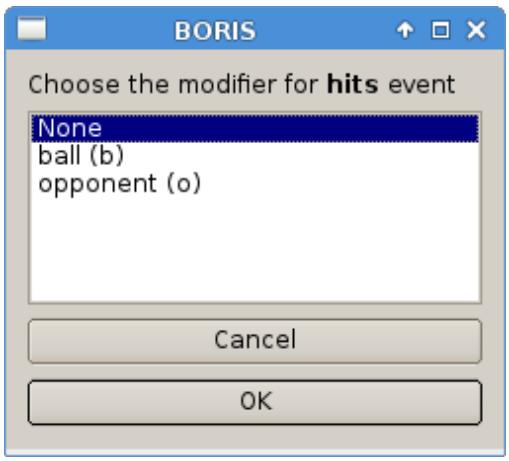
Once ready to begin your coding, you can start the media player using the **Play** button (or the Space bar). The behaviors can be recorded using the keyboard with the predefined keys, by double-clicking the corresponding row in the **Ethogram** table or by using the **Coding pad** (See coding pad).



If the pressed key defines a single event, the corresponding event will be recorded in the **Events** table. In the case you have specified the same key for two (or more) events (e.g. key A in the figure below), BORIS will prompt you for the desired behavior.



In the case you have specified modifiers (one or more sets), BORIS will prompt you for the desired modifier(s) if any (e.g. **ball** or **opponent** in the figure below). You can select the correct one using the mouse or the keyboard (**b** key or **o** key)



In the case your behavior type is a *Point event with coding map* or a *State event with coding map*, BORIS will show the *Coding map* window and will allow selecting the desired area(s). In case you click a part of the map in which two (or more) areas overlap, the corresponding codes will be recorded.

A recorded event can be edited (once selected) using the *Observations* > *Edit event* menu option. The resulting *Edit event parameters* allows modifying every parameter (e.g. time, subject, code, modifiers, and comment).

The *Observations* > *Add event* menu option allows adding a new event by specifying its time and the other parameters.

Frame-by-frame mode

You can switch between play and frame-by-frame modes using the dedicated button in the toolbar:

In frame-by-frame mode the video will stop playing and the user will visualize the video frame by frame.

You can move between frames by using the arrow keys in the toolbar (on the right) or by using keyboard special keys:

For the both modes (VLC and frame-by-frame):

- **Page Up** key: switch to the next media
- **Page Down** key: switch to the previous media
- **Up arrow** key: jump forward in the current media
- **Down arrow** key: jump backward in the current media
- **ESC**: switch between VLC and frame-by-frame mode

Only for the frame-by-frame mode:

- **Left arrow** key: go to the previous frame
- **Right arrow** key: go to the next frame

If you have a numeric keypad you can use the following keys in alternative:

- The key **/** will allow you to view the previous frame
- The key * will allow you to view the next frame

To return in the VLC mode press again the frame-by-frame button in the toolbar.

Exporting events data

The coded events can be exported in various format (**Observations** > **Export ?**):

Export events

This function will export the events of selected observations in TSV, XLS or ODS formats. These formats are suitable for further analysis.

	A	B	C	D	E	F
1	Observation id	demo #1				
2						
3	Media file(s)					
4						
5	Player #1	/home/olivier/crop.avi				
6	Player #1	/home/olivier/crop2.avi				
7						
8	Observation date	2015-Nov-30 10:39:18				
9						
10	Description					
11						
12	Time offset (s)	0				
13						
14	independent variables					
15	variable	value				
16	group size	7				
17	weather conditions	rain				
18						
19	time	subject	code	Modifier	comment	status
20	4.3	Subject #1	eat	salad	test	START
21	10	Subject #1	eat	salad		STOP
22	26.6	Subject #2	eat	meat		START
23	113.988	Subject #2	eat	meat		STOP
24	116.588	Subject #1	jump			POINT
25	118.988	Subject #1	jump			POINT
26	120.863	Subject #2	jump			POINT
27	122.438	Subject #2	jump			POINT
28						

Export aggregated events

This function will export the events of the selected observations in the following formats:

- **tabular format** (TSV, CSV, XLS, ODS, HTML)
- **SQL** format for populating a SQL database
- **SDIS** format for analysis with the GSEQ program available at http://www2.gsu.edu/~psyrab/gseq

The **State events** are paired and duration is available.

Example of tabular export

	A	B	C	D	E	F	G	H	I	J
1	Observation id	Observation date	Subject	Behavior	Modifiers	Behavior type	Start	Stop	Comment start	Comment stop
2	demo #1	2015-Nov-30 10:39:18	Subject #1	jump		POINT	116.588	0		
3	demo #1	2015-Nov-30 10:39:18	Subject #1	jump		POINT	118.988	0		
4	demo #1	2015-Nov-30 10:39:18	Subject #1	eat	salad	STATE	4.3	10	test	
5	demo #1	2015-Nov-30 10:39:18	Subject #2	jump		POINT	120.863	0		
6	demo #1	2015-Nov-30 10:39:18	Subject #2	jump		POINT	122.438	0		
7	demo #1	2015-Nov-30 10:39:18	Subject #2	eat	meat	STATE	26.6	113.988		
8										
9										
10										

Example of SQL export:

```
CREATE TABLE events (id INTEGER PRIMARY KEY ASC, observation TEXT,
                     date DATE, subject TEXT, behavior TEXT,
                     modifiers TEXT, event_type TEXT, start FLOAT,
                     stop FLOAT, comment_start TEXT,
                     comment_stop TEXT);

INSERT INTO events (observation, date, subject, behavior, modifiers,
 event_type, start, stop, comment_start, comment_stop ) VALUES
("demo #1","2015-11-30 10:39:18","Subj #1","jump","","POINT",116.588,0,"","",
("demo #1","2015-11-30 10:39:18","Subj #1","jump","","POINT",118.988,0,"","",
("demo #1","2015-11-30 10:39:18","Subj #1","eat","salad","STATE",4.3,10.0,"vvv","",
("demo #1","2015-11-30 10:39:18","Subj #2","jump","","POINT",120.863,0,"","",
("demo #1","2015-11-30 10:39:18","Subj #2","jump","","POINT",122.438,0,"","",
("demo #1","2015-11-30 10:39:18","Subj #2","eat","meat","STATE",26.6,113.988,"","");
```

Export events as behavioral strings

Behavioral string can be used with the BSA service: Behavioral Strings Analysis (BSA)

Example:

```
# observation id: demo#1
# observation description:
# Media file name: crop.avi, crop2.avi


Subject #1:
eat|eat|jump|jump

Subject #2:
eat|eat|jump|jump
```

Export events as Praat TextGrid

Example:

```
File type = "ooTextFile"
Object class = "TextGrid"

xmin = 4.3
xmax = 113.988
tiers? <exists>
size = 2
item []:
    item [1]:
        class = "IntervalTier"
        name = "Subject #1"
        xmin = 4.3
        xmax = 10.0
        intervals: size = 1
        intervals [1]:
            xmin = 4.3
            xmax = 10.0
            text = "eat"
    item [2]:
        class = "IntervalTier"
        name = "Subject #2"
        xmin = 26.6
        xmax = 113.988
        intervals: size = 1
        intervals [1]:
            xmin = 26.6
            xmax = 113.988
            text = "eat"
```

Extract sequences from media files

Sequences of media file corresponding to coded events can be extracted from media files:

1. Click on **Observations** > **Extract events from media files** option.
2. Choose the observation(s).

3. Select the events to be extracted.
4. Select a destination directory that will contain the extracted sequences.
5. Select a time offset (in seconds, the default value is 0).

The time offset will be substracted from the starting time of event and added to the stopping time. All the extracted sequences will be saved in the selected directory followind the file name format:

{observation id}_{player}_{subject}_{behavior}_{start time}-{stop time}

Export transitions matrix

3 transitions matrix outputs are available: The matrix of frequencies of transitions, the matrix of frequencies of transition after each behavior and the matrix of number of transitions.

Matrix of frequencies of transitions

This matrix contains the frequencies of total transitions. The sum of all frequencies must be 1.

Example of frequencies of transitions matrix:

	eat	sleep	walk
eat	0.0	0.286	0.143
sleep	0.143	0.0	0.143
walk	0.286	0.0	0.0

In this matrix you can see that the **eat** behavior precedes the **sleep** behavior with a frequency of **0.286** of the total number of transitions.

Matrix of frequencies of transitions after behavior

This matrix contains the frequencies of transitions after each behavior. The sum of each row must be 1.

Example:

	eat	sleep	walk
eat	0.0	0.667	0.333
sleep	0.5	0.0	0.5
walk	1.0	0.0	0.0

In this example you can see that **sleep** follows **eat** with a frequency of **0.667** and **walk** follows with a frequency of **0.333**.

Matrix of number of transitions

This matrix contains the number of transitions after each behavior.

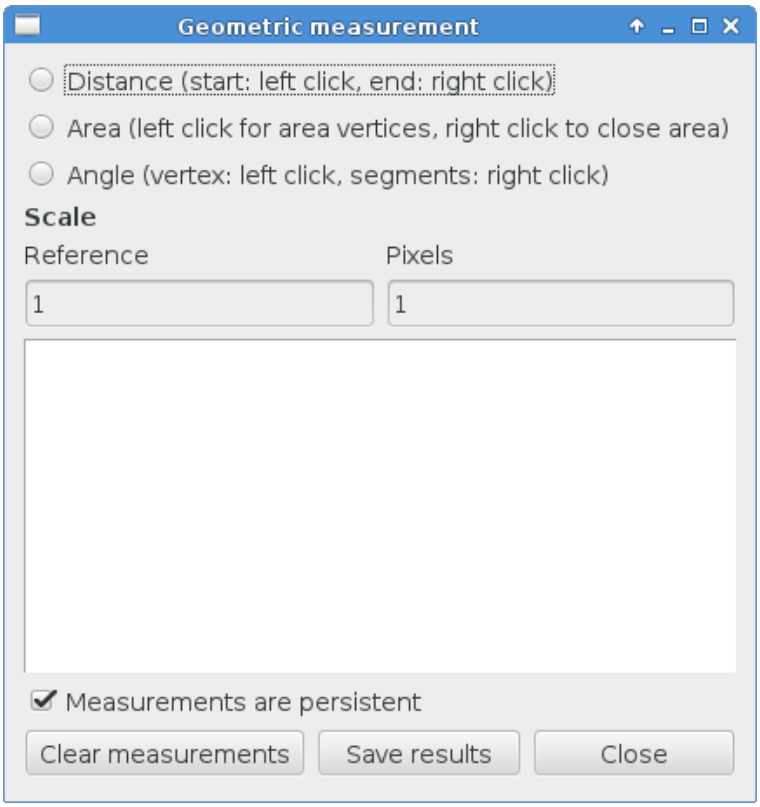
Example:

	eat	sleep	walk
eat	0	2	1
sleep	1	0	1
walk	2	0	0

Tools

Geometric measurements

Geometric measurements can only be made in frame-by-frame mode. Distances, areas and angles can be measured. Click on **Tools** > **Geometric measurements** to activate the measurements. The **Measurements window** will be shown:

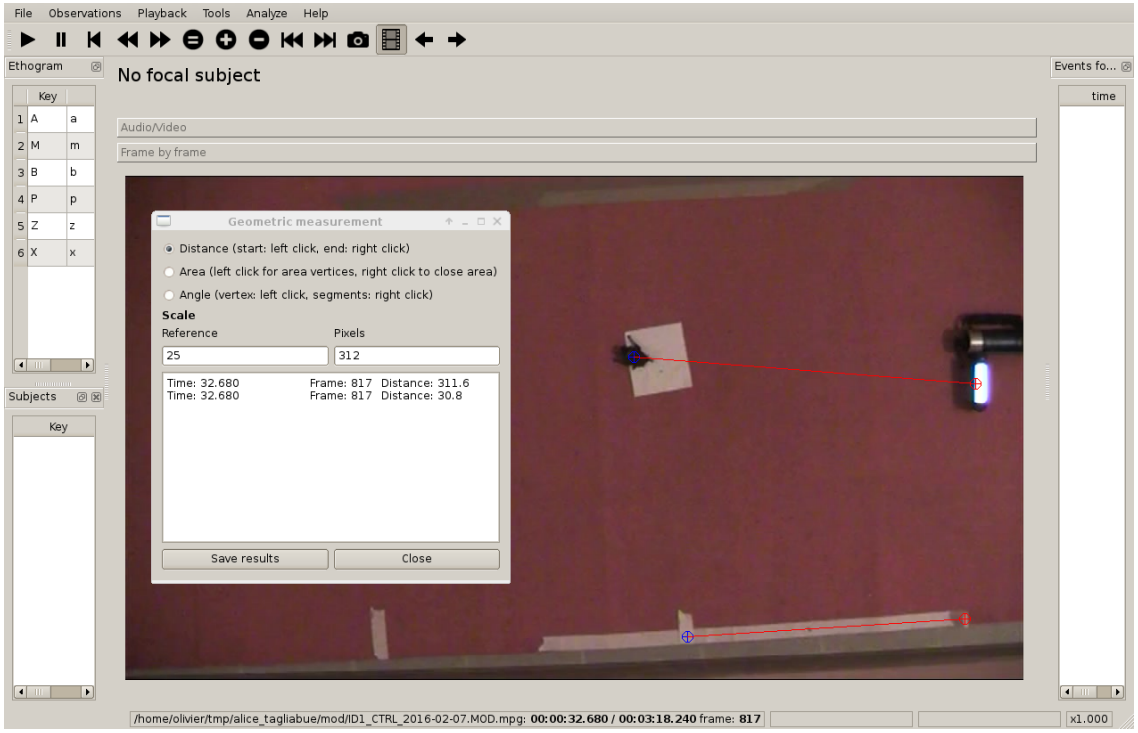


Setting the scale

For distance and area measurements you can set a scale in order to have results of measurements in a real unit (like centimeters, meters etc). 1) measure a reference object (that have a known size) on the frame (with the distance tool. See next chapter for details) and set the pixel distance in the **Pixel** text box. 2) Set the real size of the reference object in the **Reference** text box (must be a number without unit).

Distance measurements

Select the **Distance** radio button. Click the left mouse button on the frame bitmap to set the start of the segment that will be measured. A blue circle with a cross will be drawn. Click the right mouse button to set the end. A red circle with a cross will be drawn. The distance between the two selected points will be available in the text area of the **Measurements window**.



Area measurements

Select the **Area** radio button. Click the left mouse button on the frame bitmap to set the area vertices. Blue circles with a cross will be drawn. Click the right mouse button to close the area. The area of the drawn polygon will be available in the text area of the **Measurements window**.

Angle measurements

Select the **Angle** radio button. Click the left mouse button on the frame bitmap to set the angle vertex. A red circle with a cross will be drawn. Click the right mouse button to set the two segments. Blue circles with a cross will be drawn. The angle between the two drawn segments will be available in the text area of the **Measurements window**.

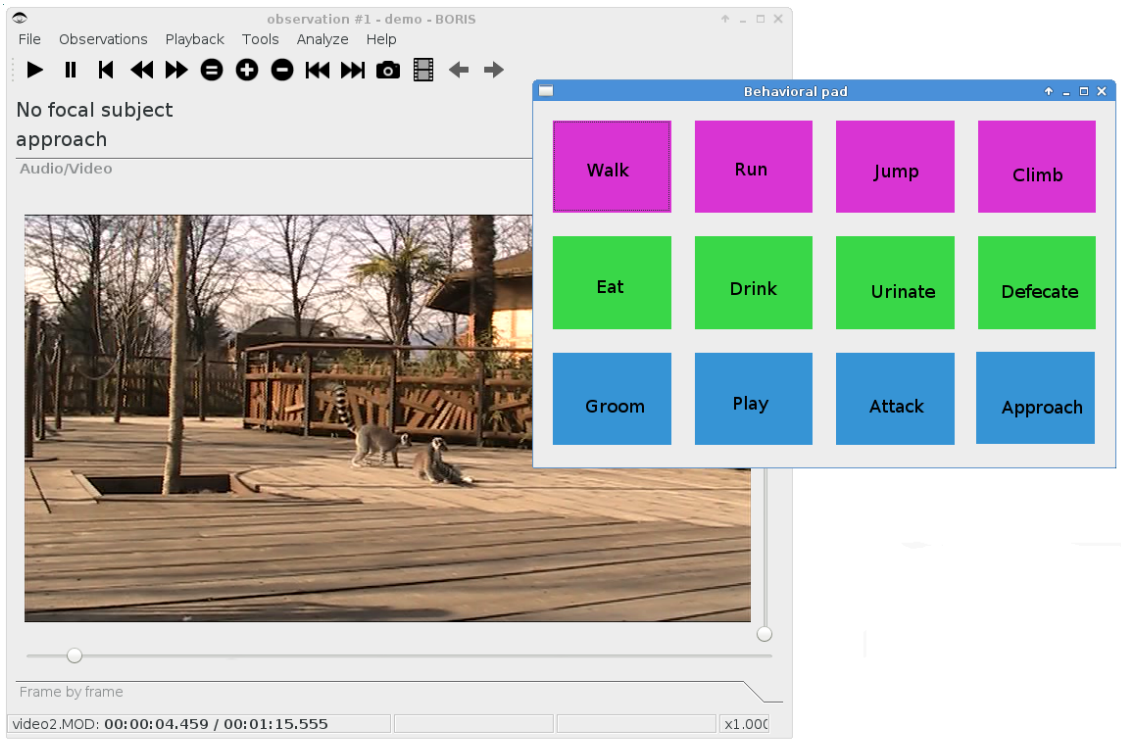
Persistent measurements

If the Measurements are persistent checkbox is checked the measurement schemes will be available on all

frames otherwise they will be deleted between frames.

Coding pad

During observation a coding pad containing the available behaviors can be displayed (**Tools** > **Coding pad**). This **Coding pad** allows the user to code using a touch-screen or by clicking on the buttons. When the **Coding pad** is displayed you can continue to code using the keyboard.



Transitions flow diagram

BORIS can generate DOT scripts and flow diagrams from the transitions matrices (See Observations > Create transition matrix for obtaining the transitions matrices).

DOT script (Graphviz language)

Tools > Transitions flow diagram > Create transitions DOT script

Choose one ore more transitions matrix files and BORIS will create the relative DOT script file(s).

The DOT script files can then be used with Graphviz (Graph Visualization Software) or WebGraphviz (Graphviz in the Browser) to generate flow diagram of transitions.

See DOT (graph description language) for details.

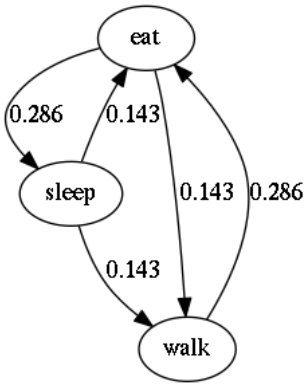
Flow diagram

If Graphviz (Graph Visualization Software) is installed on your system (and the **dot** program available in the path) BORIS can generate flow diagram (PNG format) from a transitions matrix file.

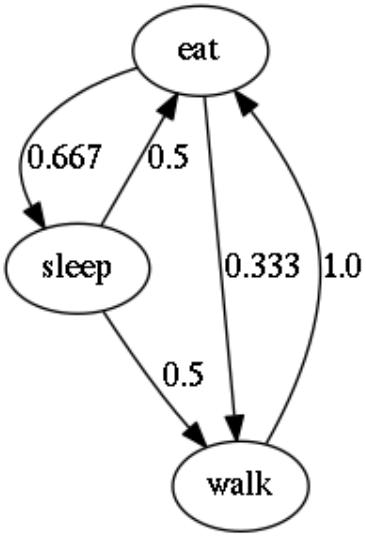
Tools > Transitions flow diagram > Create transitions flow diagram

Choose one ore more transition matrix files and BORIS will create the relative flow diagram.

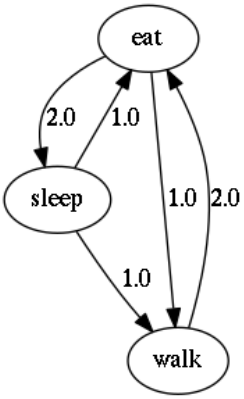
Flow diagram of frequencies of transitions



Flow diagram of frequencies of transitions after behavior



Flow diagram of number of transitions



Re-encoding and resizing a video file

BORIS can re-encode and resize your video files in order to reduce the size of the files and have a smooth coding (specially with two video files playing together). The re-encoding and resizing operations are done with the embedded ffmpeg program with high quality parameters (bitrate 2000k).

Select the files you want re-encode and resize and select the horizontal resolution in pixels (the default is 1024). The aspect ratio will be maintained.

You can continue to use BORIS during the re-encoding/resizing operation.

The re-encoded/resized video files are renamed by adding the re-encoded.avi extension to the original files.

> ***Warning***
>
> The MTS video files should be re-encoded to be used in frame-by-frame mode. Otherwise the extracted frames are not reliable.

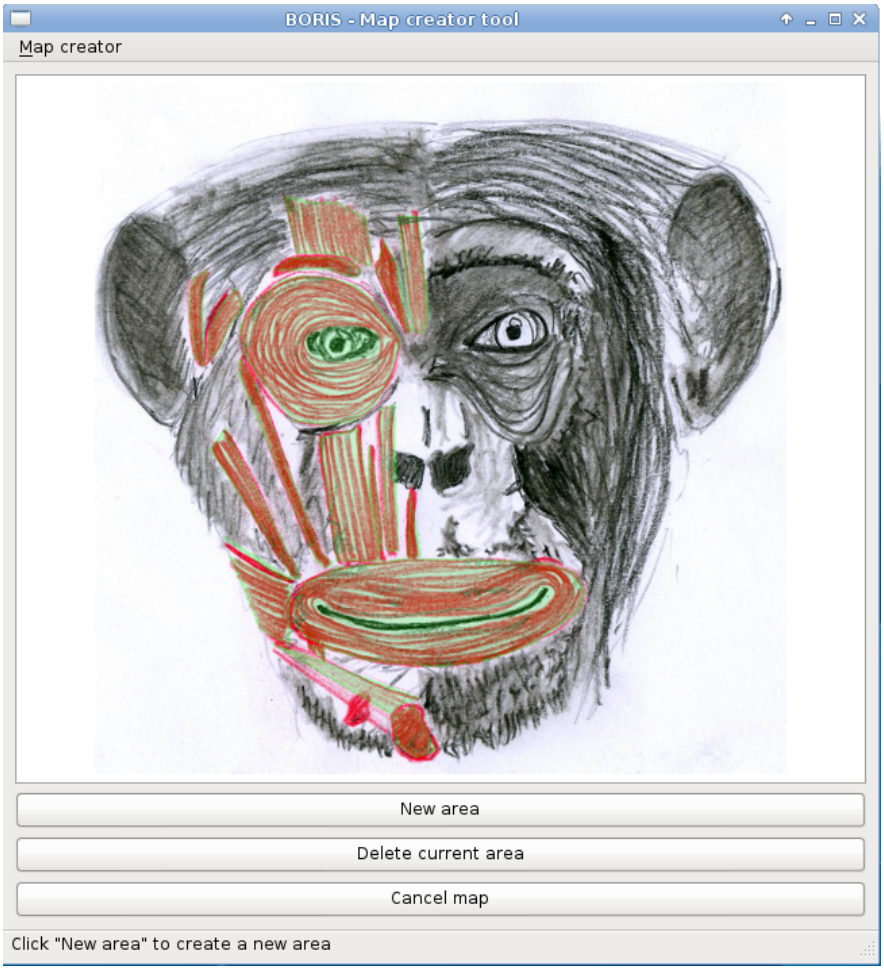
Coding maps

A coding map is a bitmap image with user-defined clickable areas. BORIS allows creating a coding map using the **Map creator** tool (**Tools** > **Map creator**). Clickable areas may correspond to specific modifiers that can be meaningful for the behavioral coding. Facial expression is the case we thought to when developing this function.

Creating a coding map

Loading a bitmap for a coding map

To create a new coding map, launch the **Map creator** tool (**Tools** > **Map creator**). The BORIS main window will be replaced by the **Map creator** window. Click on **Map creator** > **New Map** and enter a name for the new map in the edit box. You have to load a bitmap image (JPEG or PNG) using the **Load bitmap** button. The loaded image will be displayed.



If the size of your bitmap image is bigger than 512 x 512 pixels BORIS will resize it to 512 x 512 keeping the aspect ratio and store the resized version in the coding map file.

Adding areas to a coding map

To create clickable areas on a coding map, you have to click on the **New area** button and enter an **Area code** in the edit box. The new area can now be defined by clicking on the image. The drawing tool allows defining a irregular polygon (a plane shape with straight sides, which does not have all sides equal and all angles equal) by clicking to determine subsequent vertices. It can be convex or concave. Straight sides must not cross each other. Once selected an area can be deleted using the **Delete area** button. When an area is closed and its name has been defined in the **Area code** field, it can be saved by using the **Save area** button. The areas can partially overlap each other. See the **Using a Coding map** section for more details. Once all areas are added the entire map can be saved using the **Save map** option menu (**Map creator** > **Save map**). The map is now saved in its own file (.boris_map) which is NOT part of the BORIS project. A map can be edited at anytime by opening the map file from the **Open map** menu option (**Map creator** > **Open map**).

Adding a coding map to your project

Creating a Coding map is not automatically adding the map to your project. The Coding map have to be added to your project by selecting the corresponding **Behavior type** (**Point event with coding map**, **State event with coding map**). BORIS will ask to select the file name containing the coding map (.boris_map) and load the coding map in the project. The coding map name will appear in the **Coding map** column and will be saved in the BORIS project file.

NOTE: If you later modify your coding map you must reload the new version in your BORIS project.

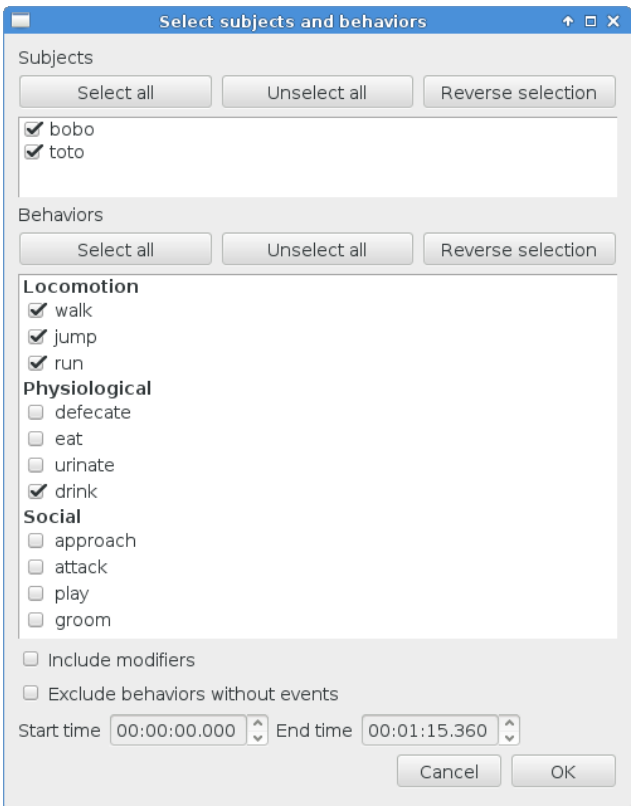
Analysis

Time budget

The **Time budget** analysis can be done by behavior or by category of behaviors. Choose the option from the **Analysis** menu.

The **Time budget** analysis can be done on one or more observations. If you select more than one observation you must then choose for a global time budget analysis that will contain all selected observations or a time budget analysis for every single observation.

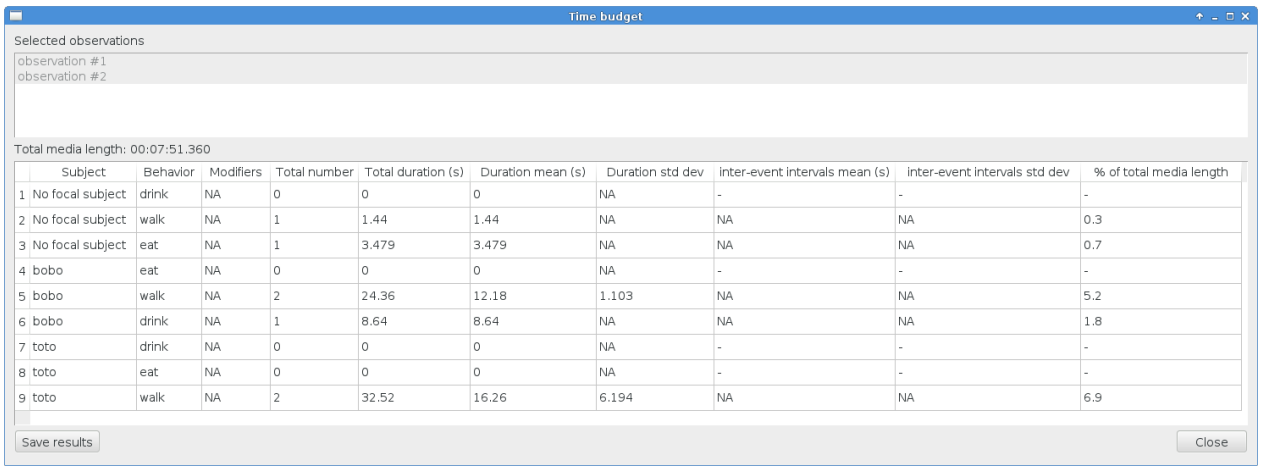
The **Analysis** > **Time budget** menu option shows the time budget for the events of one or more observations. You must first select the subjects and behaviors you want to include in the time budget analysis:



All behaviors can be selected or unselected by clicking on the Category (bold).

You can choose to include or not the behavior modifiers in the Time budget analysis and to exclude behaviors without coded events.

The Time budget analysis can be restricted to a portion of the observation. Use the **Start time** and **End time** boxes to select strting time and ending time.



	Subject	Behavior	Modifiers	Total number	Total duration (s)	Duration mean (s)	Duration std dev	inter-event intervals mean (s)	inter-event intervals std dev	% of total media length
1	No focal subject	drink	NA	0	0	0	NA	-	-	-
2	No focal subject	walk	NA	1	1.44	1.44	NA	NA	NA	0.3
3	No focal subject	eat	NA	1	3.479	3.479	NA	NA	NA	0.7
4	bobo	eat	NA	0	0	0	NA	-	-	-
5	bobo	walk	NA	2	24.36	12.18	1.103	NA	NA	5.2
6	bobo	drink	NA	1	8.64	8.64	NA	NA	NA	1.8
7	toto	drink	NA	0	0	0	NA	-	-	-
8	toto	eat	NA	0	0	0	NA	-	-	-
9	toto	walk	NA	2	32.52	16.26	6.194	NA	NA	6.9

The percent of total time will be calculated (if available). The total time is intended as the total media length.

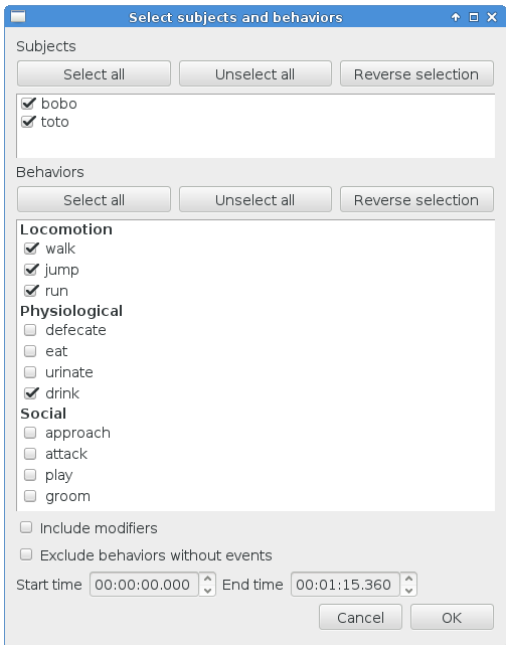
The time budget results can be saved in various formats for further analysis: TSV, CSV for plain text file, HTML or Microsoft Excel (XLS), Open Document Spreadsheet (ODS).

> ***Note***
>
> If a STATE behavior has an odd number of coded events, BORIS will report "UNPAIRED" instead of results"

Plot events

The **Analysis** > **Plot events** menu option plots the events from one observation by subject and behaviours along a time axis.

You must first select the subjects and behaviors you want to include in the plot:



You can choose to include or not the behavior modifiers (if any) and to exclude behaviors without coded events.

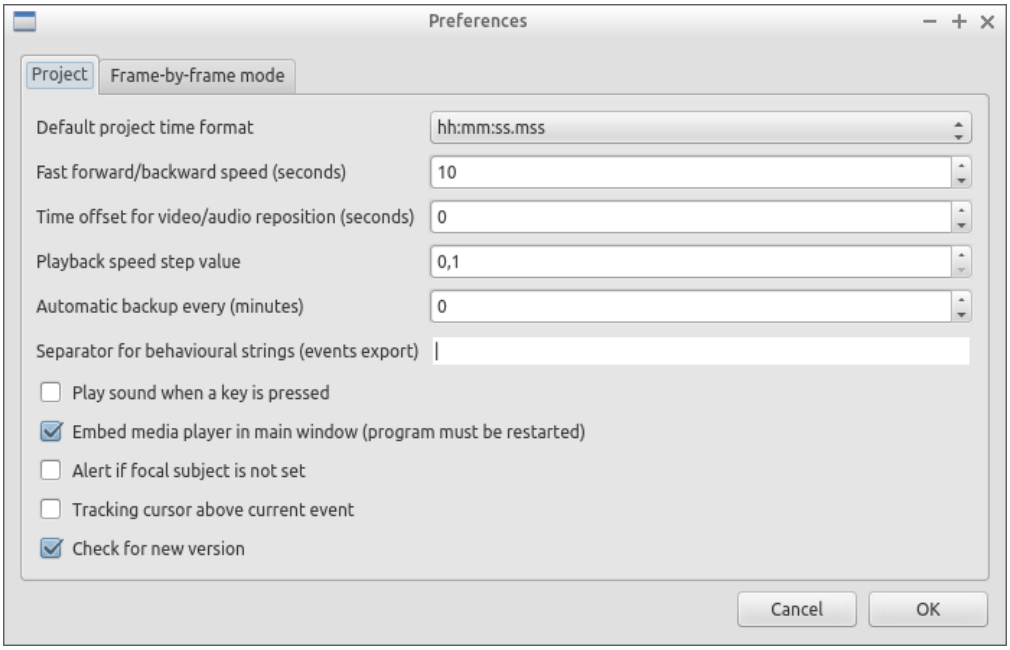
The plot can be exported in various formats like bitmap (PNG, JPG, TIFF) or vectorial graphic (SVG, PDF, EPS, PS). The SVG format can be further edited with the Inkscape vector graphics editor.

> ***Note***
>
> If a STATE behavior has an odd number of coded events, BORIS will give you this error message: "The STATE behavior XXX is not paired"

Preferences

You can customize BORIS using the Preferences window (**File** > **Preferences**)

General preferences



Default project time format

This option allows the user to choose the format for displaying time in the project. Please note that time is internally always saved in seconds with a precision of 3 decimal digits

Fast forward/backward speed (seconds)

This option allows the user to customize the amount of time for "jumping" forward or backward in media.

Time offset for media reposition (seconds)

This value indicates the time offset for repositioning the media after double-click on a row event of the *Events* table. 'for example -4 seconds indicates that after a double-click the media will be repositioned 4 seconds before the recorded event.'

Playback speed step value

This value indicate how much the speed will be increased or decreased after pressing the *change playback speed* buttons.

Automatic backup every (minutes)

if set BORIS will save your project automatically every n minutes. 0 indicate no automatic backup.

Play sound when a key is pressed

Activate a sound signal after every keypress event

Embed media player

This option allows the user to detach from the main window or embed the media player in the main window. On Mac OS X the media player can not be detached from main window.

Alert if focal subject is not set

If this option is activated BORIS will show an alert box if no focal subject is selected

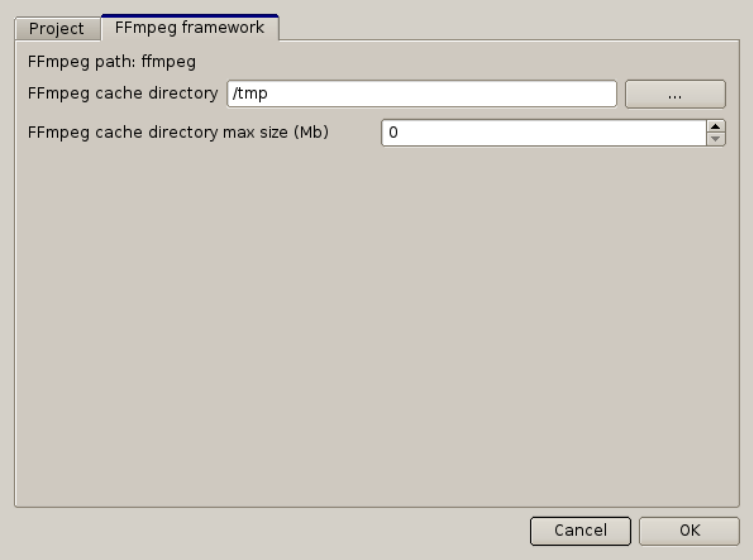
Tracking cursor above current event

Check this box to position the tracking cursor above the current event in events list table.

Check for new version

Check for new version on BORIS web site every 15 days (internet access required)

FFmpeg framework



The path for the ffmpeg executable program is displayed. From version 2.8 FFmpeg is included with BORIS.

FFmpeg cache directory

This indicates the directory that will be used as image cache for frame-by-frame mode and spectrogram visualization. If you do not specify a path, BORIS will use the default temporary directory of your system.

FFmpeg cache directory max size

Indicate a size limit (in Mb) for the image caching. 0 indicates no limit

Various

Citing BORIS

If you have used BORIS for publications, please cite:

```
Olivier Friard and Marco Gamba
BORIS: a free, versatile open-source event-logging software for video/audio coding
and live observations.
Methods in Ecology and Evolution. 2016.
DOI: 10.1111/2041-210X.12584
```

Bug reports and features request

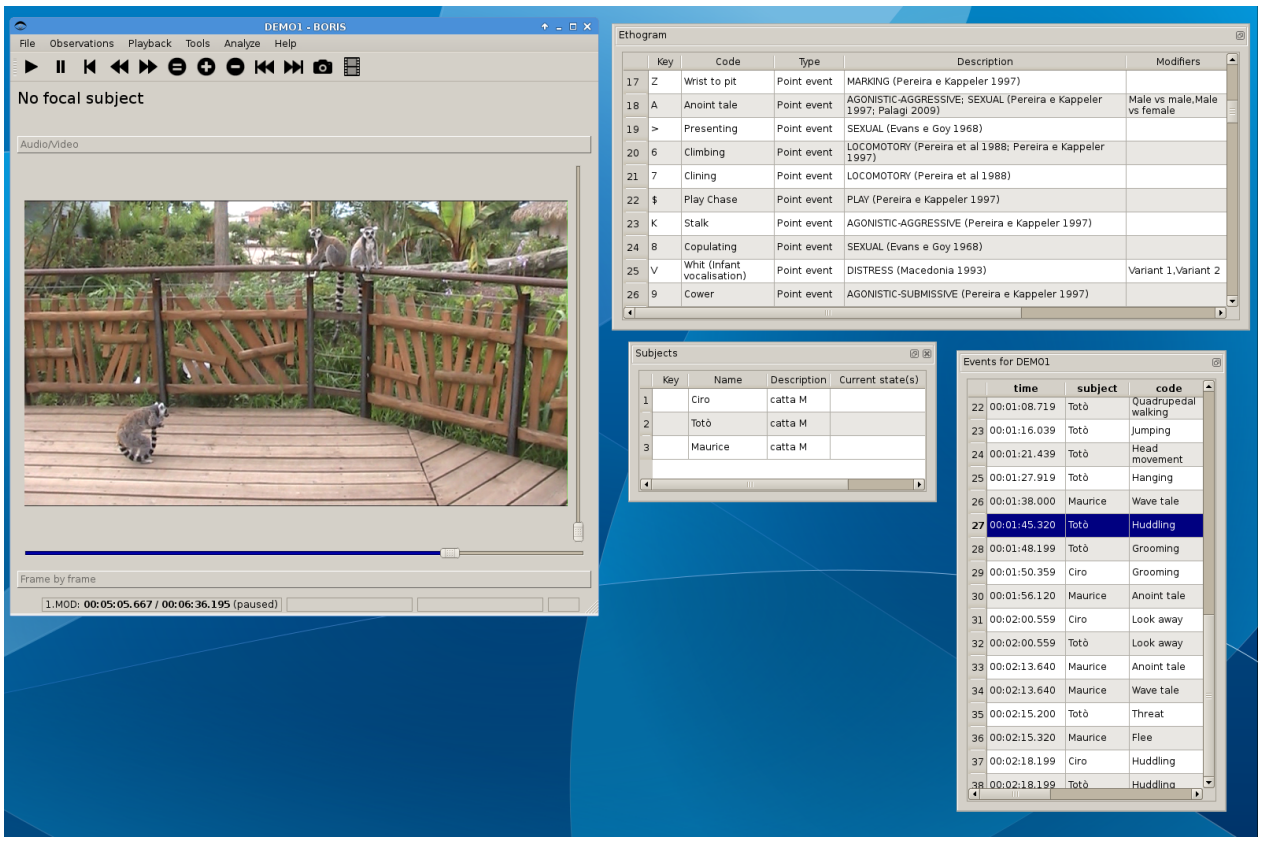
Please send bug reports and features request by e-mail (see web site http://www.boris.unito.it)

or by using the BORIS GitHub repository (https://github.com/olivierfriard/BORIS).

In case of bug report please verify that you are using the last version of BORIS and indicate your operating system, its version and the CPU architecture (32/64 bits). You may also include the BORIS project that gave you an error. Any information you will provide will not be disclosed to any third party.

Docking

All elements, including the media player can be undocked from the main window and positioned where you prefer (e.g. they can be on the same desktop over one or two screens).



Acknowledgement

The authors would like to acknowledge Sergio Castellano, Valentina Matteucci and Laura Ozella for their precious help.

Valid keys for triggering behavior

BORIS will not make difference between lower case and upper case characters

- keys from A to Z
- keys from 0 to 9
- function keys from F1 to F12
- à é è ù ì ç
- ! " £ $ % & / ( ) = ? ^ [ ] @ | § ° #