A Universal Description Language for Behavioral Tasks

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MOTIVATION

Technological advances in neuroscience, in part supported by the BRAIN Initiative, have dramatically increased the possibilities for monitoring, quantifying, and manipulating brain activity during behavior. In contrast, efforts to describe behavior have lagged behind. One reason for this is that there is no general formal framework to design or describe behavioral tasks, which are typically performed using specialized and often ad hoc hardware and software systems. The lack of universal behavioral task descriptions makes it challenging to communicate, share, publish, and reuse behavioral tasks

APPROACH

We propose BEADL (BEhavioral tAsk Description Language) to abstract and standardize behavioral task descriptions on two layers. A graphical layer specifies elements to describe behavioral tasks as a state machine in a formal flow diagram and how the task controlling system interacts with a subject. This graphical layer has been designed to be easy to understand while retaining all aspects of the behavioral task. The second layer is a corresponding, XML-based description of the task. This layer forms the rigid, yet extensible foundation of BEADL and hides hardware implementation related details form the graphical representation.

CONCLUSION

- Graphical representations of BEADL task descriptions simplify designing and communicating trial-based behavioral tasks
- BEADL exposes the inherent logic of a behavioral task and ensure clarity and precision in task design
- Behavioral data produced with task designed with BEADL will be compatible with NWB:N data format
- This standardized language allows more transparency and reproducibility in behavioral experiments

Basic BEADL elements

StateName / max_duration=x	output action
input event	grace period=X

Default state description

`output action`

Basic output action performed by the system (such as controlling LEDs, reward valves, trigger I/Os etc.)

`output_action()`

Advanced output action triggered by the system through separate functions (callbacks)

`input event`

Event triggerred by the subject (e.g. lick detection) causing a transition to another state

`input event`

Event triggerred be the system or derived from internal or external measurements causing a transition

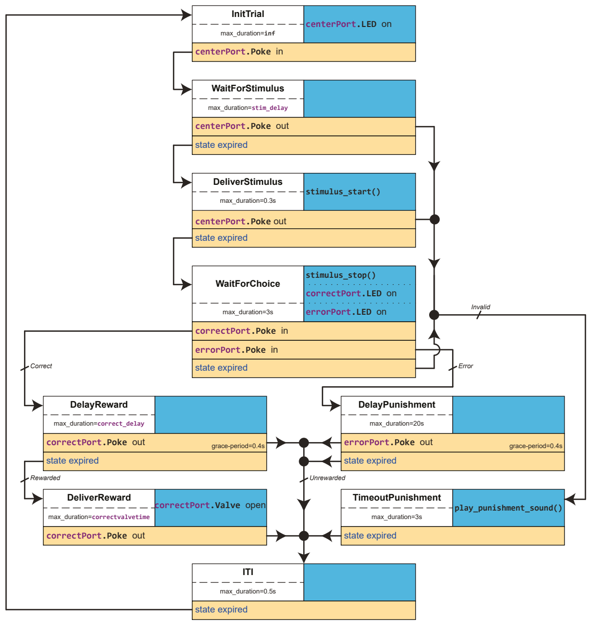
`BEADL_argument`

Trial dependent value specified outside the trial and can be updated from trial to trial during a session

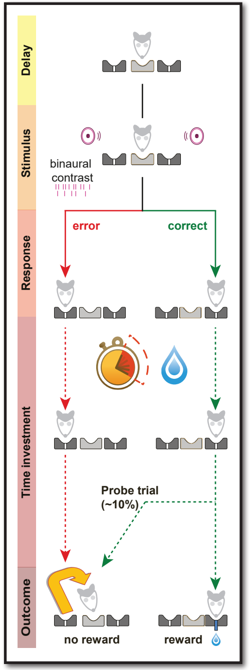
`grace period=X`

(Optional) Minimum duration the associated input event needs to last to trigger a transition

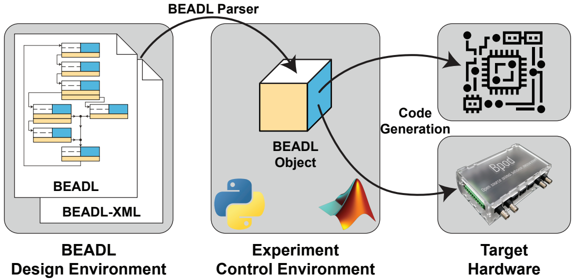
BEADL design example: Confidence-Reporting Task



2 more examples in supplemental document



Basic BEADL design workflow



BEADL Use Cases

Task Name	Lab	Species	Task Specificities
Foraging Task	Kepecs Lab (WashU)	Mice	Altering the height of a bridge as an effort manipulate
Confidence-Reporting Task	Kepecs Lab (WashU)	Mice, rats	Grace period during time invested (waiting for reward)
Check-or-Go task	Boraud Lab (Bordeaux)	Monkeys	Reward based on two virtual variables that can be updated indefinitely during a trial
Light Chasing Task	Kepecs Lab (WashU)	Mice, rats	Classical visual 2-AFC
Impulsivity Task	Kepecs Lab (WashU)	Mice	Stimulus delivery can be reset indefinitely during a trial and grace period before lick initiation
Force Pertubation Task	Kepecs Lab (WashU)	Mice	Tracking of the position of a joystick while varying external force
Memory Confidence Task	Frank Lab (UCSF)	Rats	Amount of reward delivered proportionaly to the animal bet during a trial
Visual Change Detection Task	Allen Institute	Mice	Stimulus as continuous stream of images updated on a complex schedule relying on trial and metatrial variables
Olfactory Discrimination Task	Rinberg Lab (NYU)	Mice	Classical olfactory 2-AFC