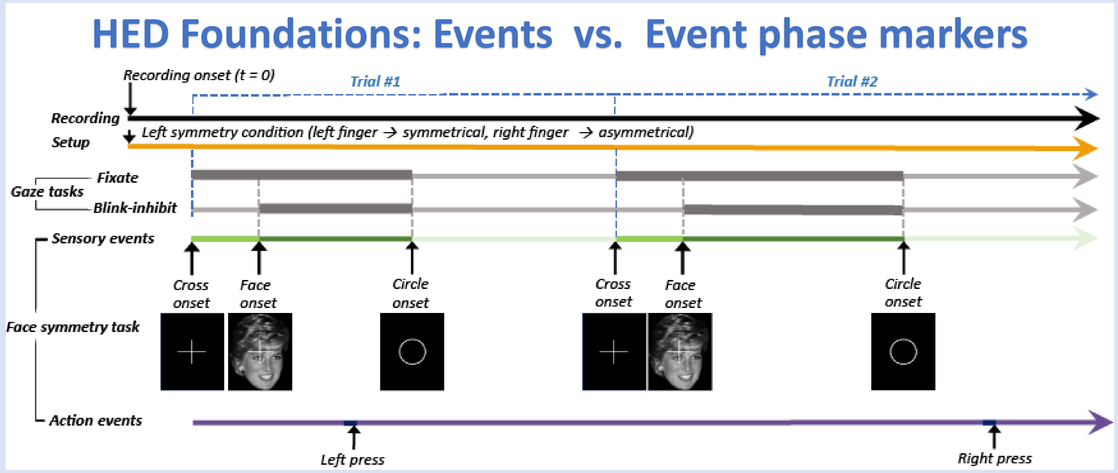
# Recording details of events in time-series data: The Hierarchical Event Descriptor (HED) system


D. TRUONG [1], S. SHIRAZI [1], M. DENISSEN [2], D. HERMES [3], A. DELORME [1], K. A. ROBBINS [4], S. MAKEIG [1]

1. Swartz Center of Computational Neuroscience, INC, UCSD, La Jolla, CA, USA
2. University of Salzburg, Salzburg, Austria
3. Physiology and Biomedical Engineering, Mayo Clinic, Rochester, MN, USA
4. University of Texas San Antonio, San Antonio, TX, USA (Emeritus)


hedtags.org

## HED Foundations: Events vs. Event phase markers

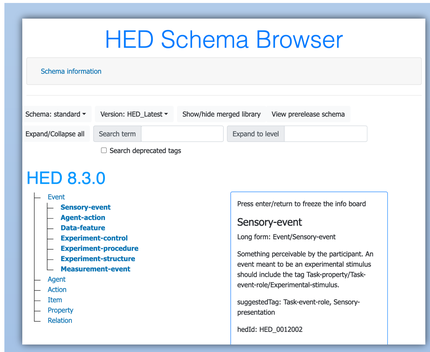


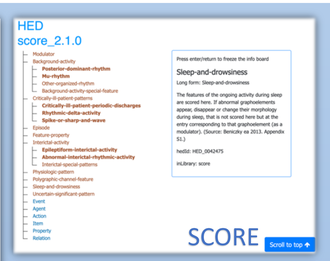

| onset | event_type | face_type | value | stim_file |
|---|---|---|---|---|
| **0.00** | setup_right_sym | n/a | 102 | n/a |
| **24.21** | show_face_initial | unfamiliar_face | 3 | u032.bmp |
| **25.03** | show_circle | n/a | 0 | circle.bmp |
| **25.15** | left_press | n/a | 256 | n/a |
| **26.73** | show_cross | n/a | 1 | cross.bmp |
| **27.25** | show_face | unfamiliar_face | 14 | u032.bmp |
| **27.89** | left_press | n/a | 256 | n/a |
| **28.10** | show_circle | n/a | 0 | circle.bmp |
| **29.80** | show_cross | n/a | 1 | cross.bmp |
| **30.35** | show_face | unfamiliar_face | 13 | u088.bmp |

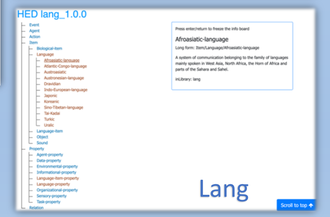
```
Sensory-event, Experimental-stimulus,
(Face, Image, Unfamiliar),
(Face, Item-count/1,Item-interval/0),
(Image, Pathname/u032.bmp),Experimental-trial/1,
(Visual-presentation,
(Background-view, Black),
(Foreground-view,
    (
        (Center-of, Computer-screen),
        (Cross, White)
    ),
    (Grayscale,
        (Face, Hair, Image)
    )
)
),
(Event-context, (Recording))
```

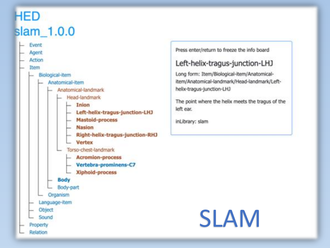
*HED annotation of first visual presentation of an image of unfamiliar face at 24.21 seconds onset*

- Event markers link experience to the recorded data.
- Current practice relies primarily on magic numbers and local lab jargon to label event markers.
- Data analysts must assemble and interpret available information about experiment event onsets, then write custom code for each archived dataset separately.
- **Using HED, events, experiment conditions, and task relationships, can be described in standardized vocabulary, and in a *human-readable* and *machine-actionable* way, enabling *automated* analysis, re-analysis, and mega/meta-analysis of shared data.**

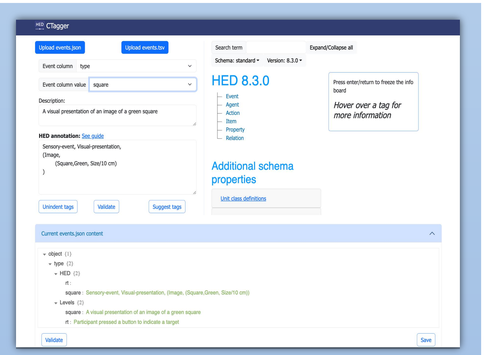


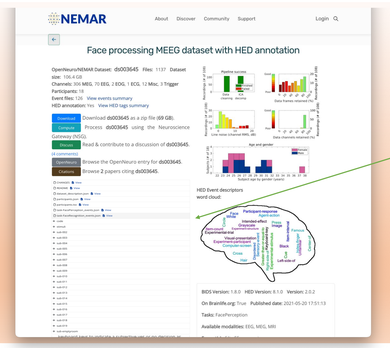




- HED terms comes from standardized vocabulary (***HED schema***) organized in a hierarchical manner.
- HED annotations consist of comma-separated tags drawn from this vocabulary.
- Standard schema contains terms that describe experiment stimuli and participant actions.
- Communities can develop specialized ***library schemas*** that extend the standard schema.
- We currently have library schemas for clinical (SCORE), language (Lang), and sensor location and motion (SLAM) annotations. Contributors are welcome!




- The HED system also includes tools to help with the annotation, validation, search, and analysis of HED tags in Python, MATLAB, and Javascript.
- The web tool *CTagger* (above) allows users to browse the HED schema(s), select appropriate HED tags to describe their events, validate annotations, and assemble annotation for an example event file.
- AI-assisted tools are being developed, including a multi-agent LLM-based tag assistant to help with the automated generation of HED annotations.




- HED annotations can be simply placed in a single ***events.json*** file at the top level in the hierarchy of a BIDS dataset.
- HED annotations in this file, as well as descriptions of the ***events.tsv*** columns, will be applied to all event files in the dataset.
- Data archives supporting HED and BIDS, such as NEMAR.org, can automatically parse the annotation and generate figures and statistics about the experiment and their events, among other data quality metrics (left figure).



Funding: R24-MH120037, R01-EB023297, RF1-MH126700, R01-NS04293