

Hierarchical Event Descriptor (HED) Tags for Analysis of Event-Related EEG Studies

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Background

There have been multiple efforts to standardize terminologies used in cognitive paradigms by developing formal database ontologies (NEMO [7], BrainMap [4], CogPO [5] and NeuroLex [6]) but none of these is very often used to describe EEG events in research and publications. We believe a key missing factor is the ease of use of these ontologies: although formal ontologies in Web Ontology Language (OWL) format [3] are elegant and can be readily processed by computers, their apparent complexity to human eyes does not encourage their casual use by (non-programmer) researchers.

To address this problem we have built upon the popular tagging method, extensively used on the web (particularly on social sites, e.g. image tags on Flickr, video tags on YouTube...) -- a hierarchy of standard, but extensible, descriptors for EEG events. Our Hierarchical Event Descriptor (HED) ontology generation system is a base set of descriptor tags, in part adapted from the BrainMap [4] and CogPO [5] ontologies, and organized hierarchically. HED tags can be used to describe many types of EEG experiment events in a uniform, easily extensible, and both human and machine readable manner. The main contribution of HED is to offer a user-friendly interface for using the underlying ontology in EEG acquisition and analysis workflow.

Hierarchical Event Descriptor (HED) Tags

In the same way that we tag a picture on Flickr, or a video clip on Youtube (e.g. *cat*, *cute*, *funny*), we can tag EEG experimental event types used in event-related EEG research. The hierarchical structure of the HED tags makes it easy to search across variations of the same type of event across studies (supporting EEG data meta-analysis), while preserving a more detailed description of each event type. For example, an event marking the presentation of a visual feedback stimulus, in EEG study A, may present a red circle to the participant on a black screen background, while in study B the visual feedback stimulus is a blue rectangle on a white screen background. In HED syntax, these event types can be described as:

Study A: Stimulus/Feedback,
 Stimulus/Visual/Color/Red
 Stimulus/Visual/Shape/Ellipse/Circle/Height/2-deg
 Stimulus/Visual/Shape/Ellipse/Circle/Width/2-deg
 Stimulus/Visual/Background/Uniform Color/Black

Study B: Stimulus/Feedback,
 Stimulus/Visual/Color/Blue
 Stimulus/Visual/Shape/Rectangle/Height/2-deg
 Stimulus/Visual/Shape/Rectangle/Width/3-deg
 Stimulus/Visual/Background/Uniform Color/White

These descriptors explicitly capture some salient commonalities across and differences between the two event types. If these feedback events are accompanied by an auditory beep at 500 Hz with 25-dB amplitude, the following tag may be added:

 Stimulus/Auditory/Loudness/25-dB,
 Stimulus/Auditory/Tone/500-Hz,
 Stimulus/Auditory/Tone/RampUp/10-ms,
 Stimulus/Auditory/Tone/Ramp Down/10-ms.

While higher levels of the HED hierarchy are fixed (revised infrequently in discrete version levels based on community feedback), lower levels can be extended, with no restriction, to describe any event type in the desired details. For example

 > Stimulus/Visual/Shape/Ellipse/Circle

may be extended to

 > Stimulus/Visual/Shape/Ellipse/Circle/Filled

to provide more information about the circle.

HED can be used to describe EEG ‘conditions’ (i.e., sets of similar events) extracted from experimental paradigms used in EEG studies. In addition to describing stimulus-presentation events, HED can also be used to describe subject motor responses (e.g., button press, swipe, etc.), subject states (e.g., Drowsy, Attending Visual), and combinations of these two (e.g., button press while subject is drowsy).

Since HED can be easily interpreted by computers, it can facilitate search and meta-analysis of event-related EEG dynamics across multiple studies. HED tags may also be used to organize events from a study in a logical hierarchy so they can be more easily analyzed. For example several event subtypes may be aggregated into a more general type and then compared to other event types.

We have developed a companion XML-based specification, called ESS (EEG STUDY Schema) to hold all the information necessary to analyze an EEG study, e.g subject gender, handedness, age and group associations, task and paradigm description..., in a format that is both machine and human understandable (the XML file is automatically formatted and become a readable report about the EEG study). To achieve this goal, ESS relies on HED descriptions of experimental events and tasks that are embedded into ESS XML document.

How to use HED

To describe a ‘time-locking event’ (an EEG experiment event type with a well-defined onset latency), look under *Time-Locked Event* section below and find nodes that best describe the event. Form each tag by separating different levels with a forward-slash (‘/’) character. Add any number of sub-level descriptions to these tags to make them more precise (as exemplified above). Placement of / at the beginning and end of HED tags is optional (Stimulus/Visual = /Stimulus/Visual = /Stimulus/Visual/). Finally, join your tags with commas ‘,’ or semicolons ‘;’ to form a full HED string.

There are few locations in the hierarchy in which new nodes may be added at the same level of the declared nodes (otherwise, new nodes cannot be added at the same level). For example you can extend Stimulus/Visual/Shape/Ellipse/Circle/ to Stimulus/Visual/Shape/Ellipse/Circle/**Filled** but you should not extend Stimulus/Visual/Shape/Ellipse/ to Stimulus/Visual/Shape/**Egg** (Egg does not exist under Stimulus/Visual/Shape and this tag does not allow for custom first-level child nodes]. On the other hand, Stimulus/Auditory/Tone does allow adding nodes immediately under, so Stimulus/Auditory/Tone/**Square Wave** is valid.

To describe subject states (e.g. drowsy, tired) start from /State node. You may combine subject state tags with Time-locked tags (e.g. visual stimulus when subject was drowsy).

To describe an experimental paradigm, use any of the nodes under /Paradigm. Add tags that are common across all events under /Context.

For example,

Context/Afternoon	[for experiments always conducted in the afternoon]
Context/Moving Vehicle	[for experiments always conducted in a moving vehicle]

The HED Node Hierarchy section below shows the current fixed top-level HED nodes. The root (Time-Locked Event) node is assumed by default and does not need to be included. Additional explanation is provided for some nodes and placed in square brackets (‘[]’).

Example 1: An RSVP study of target recognition in a satellite imagery viewing task

Here we explain how to use HED tags to describe events in sample RSVP task. Each recording session of this experiment comprised of 504 4.9-s image bursts of 49 oval image clips from a large satellite image of London presented at a rate of 12/s. Some (60%) of these bursts contained one image in which a target white airplane shape was introduced at a random position and orientation. Following each burst, subjects were asked to press one of two buttons to indicate whether or not they had detected a target airplane in the burst. Figure 1 shows a time line of each RSVP burst. For further details see (Bigdely-Shamlo et al., 2008).

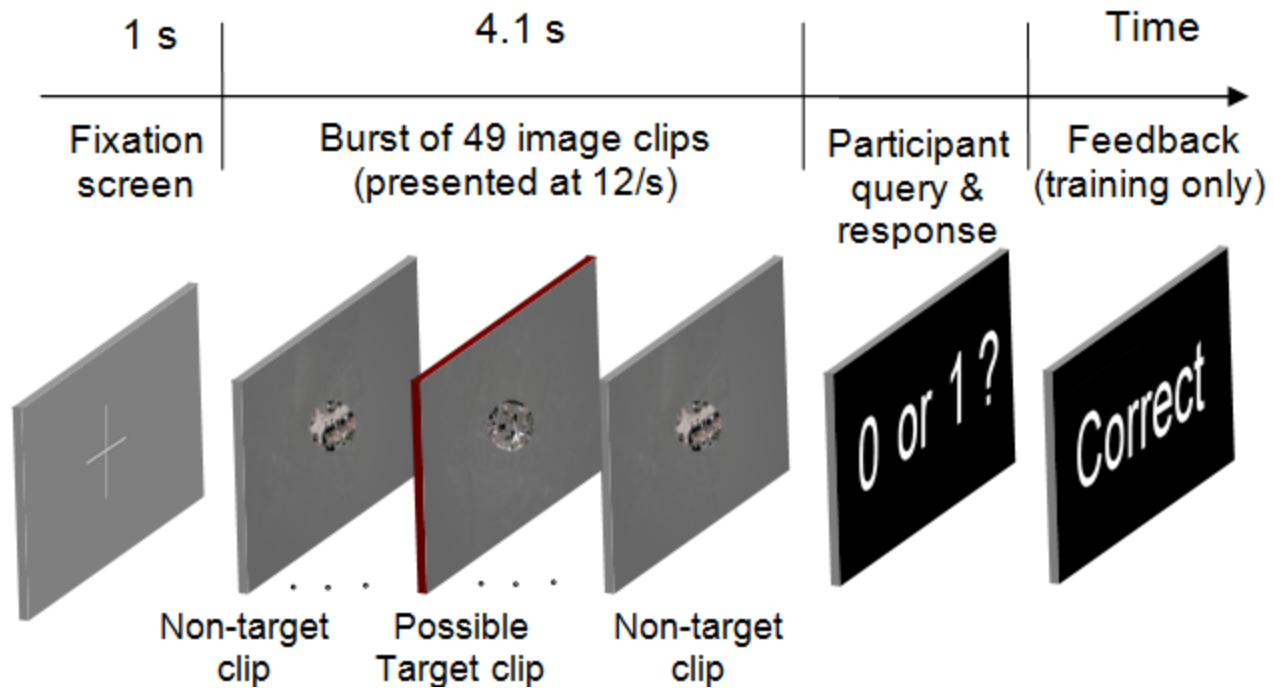


Figure 1. Time-line of each RSVP burst. Participant response feedback ('Correct' or 'Incorrect') was delivered only during Training sessions (rightmost panel).

We now use HED tags for form HED strings describing events in Figure 1, from left to right:

1. Display of a silver fixation cross on a gray background:
Stimulus/Visual/Shape/Cross,
Stimulus/Visual/Uniform Color/Silver,
Stimulus/Visual/Achromatic
Stimulus/Visual/Screen Location/Center,
Stimulus/Visual/Background/Uniform Color/Gray,
Stimulus/Visual/Fixation Point
Stimulus/Instruction/Fixate
2. Non-Target image presentation event:
Stimulus/Visual/Achromatic,
Stimulus/Non-Target
3. Target image presentation event:
Stimulus/Visual/Achromatic,
Stimulus/Target
4. Participant being asked how many target they have detected (0 or 1?):
Stimulus/Visual/Language
Stimulus/Instruction/Count
Stimulus/Visual/Uniform Color/White,
Stimulus/Visual/Achromatic

Stimulus/Visual/Background/Uniform Color/Black

5. Participant answers the question by pressing one of two buttons with her right hand:

Response/Button Press

Response/Hand/Right Hand

6. Feedback (Correct or Incorrect answer) event:

Stimulus/Visual/Language/Word/Noun

Stimulus/Visual/Language/Latin/English

Stimulus/Feedback/Correct (or /Incorrect)

Stimulus/Visual/Uniform Color/White,

Stimulus/Visual/Achromatic

Stimulus/Visual/Background/Uniform Color/Black

Finally, the paradigm is specified as /Paradigm/Oddball Discrimination Paradigm.

Example 2, An emotion induction task:

In this experiment [2] subjects were seated comfortably with eyes closed in a dimly lit room with air-tube fed ear-bud earphones. Imagination of emotional states was encouraged and guided by a set of pre-recorded verbal suggestions. Each session began and ended with 2 min of eyes closed silent rest. The task then began with a recorded verbal explanation of the task, followed by approximately 5 min of verbal guided imagery relaxation instructions to promote a relaxed, inwardly-focused state. A series of 15 guided imagery narratives, each describing a different emotion and potential scenario, were then presented, separated by voice-guided relaxation interludes. Subjects were instructed to use whatever imagery they deemed suitable for stimulating a vivid and embodied experience of the suggested emotion, and were encouraged to pay attention to somatic sensations associated with the target emotion. Subjects were told to take as much time as they needed to recall or imagine a scenario that would induce a realistic experience of the suggested emotion.

Subjects indicated the onset of the suggested emotion by pressing a right-hand button. They were asked to experience each suggested emotion for 3–5 min, though no external time indicators were provided to the subjects, and to press a second, left-hand button when the experience of the emotion subsided. This initiated a verbal 15-s relaxation suggestion, followed by the next emotion induction.

HED strings for sample events of this study:

1. Sound clip instructing subject to sit still for two minutes (while pre-baseline brain activity is being recorded):

Stimulus/Task/Task Rest Start

Stimulus/Instruction/Rest,

Stimulus/Auditory/Language/Sentence/1

Stimulus/Auditory/Language/English (Stimulus/Auditory/Language/ extended to specify English)

2. Button press subject feels a certain emotion:

Response/Button press

State/Happy (name of the emotion)

3. Sound clip that generally guides relaxation and gives a foundation imagery (4 sentences):

Stimulus/Instruction/Imagine,
Stimulus/Auditory/Language/Sentence/Paragraph/4

Restrictions on HED Identifier Names

A HED identifier may contain any characters except for the characters '/' (forward slash), ',' (comma), ';' (semicolon), and '"' (quotes). In order to use these characters in a HED identifier the HED identifier may be wrapped by a pair of double-quote (") characters. In order to use the quote character inside a quoted HED identifier the two-character escape sequence '\" (backslash double-quote) shall be used. This is the only escape sequence recognized by the HED grammar. The following is a list of valid example HED identifiers:

- MyIdentifier
- My-Id<en>ti:fier
- "My/Iden;ti,fier"
- "My\"Identifier"

HED Node Hierarchy

Time-Locked Event [default]

- Stimulus [input from outside world, exogenous]
 - Visual
 - Fixation Point
 - Shape
 - Ellipse
 - Circle
 - Rectangle
 - Square
 - Star
 - Triangle
 - Gabor Patch
 - Cross [by default a vertical-horizontal cross, for rotated add /rotated/ tag]
 - Rotated
 - # [in degrees]
 - Luminance
 - # [in candela, e.g 25 cd]
 - Size
 - # [in degrees, e.g 5 deg]
 - Checkerboard
 - Uniform Color
 - Aqua [these are CSS 3 basic color names, available in Appendix 1]
 - Black

- Blue
- Fuchsia
- Gray
- Green
- Lime
- Maroon
- Navy
- Olive
- Purple
- Red
- Silver
- Teal
- White
- Yellow
- Red
 - # [R value of RGB, between 0 and 1]
- Blue
 - # [B value of RGB, between 0 and 1]
- Green
 - # [G value of RGB, between 0 and 1]
- Hue
 - # [H value of HSV, between 0 and 1]
- Saturation
 - # [S value of HSV, between 0 and 1]
- Value
 - # [V value of HSV, between 0 and 1]
- Achromatic [gray, is only in black, white or between]
 - # [white intensity between 0 and 1]
- Screen Location [if centered at a screen location, not all over the screen]
 - Center
 - Top
 - Bottom
 - Left
 - Right
 - Upper Left
 - Lower Left
 - Upper Right
 - Lower Right
 - Angle [clockwise angle]
 - Center Displacement
 - # [displacement from screen center, in any direction, in degrees]
- Up-down Separated [stimuli presented both at the top and the bottom of fovea]
 - # [separation in degrees]

- Bilateral [for bilateral visual field stimulus presentations]
 - # [separation in degrees]
- Foveal [presented exactly where the subject is now looking]
- Peripheral [presented where the subject is not directly looking]
- Clock Face
 - # [hour:min]
- 3D Object
- Abstract Pattern
- Non-Linguistic Symbol
 - Meaningful
 - Not Meaningful
 - Newly Learned Meaning
- Braille Character
- Face
 - Whole face with hair
 - Whole face without hair
 - Cut-out
 - Parts only
 - Nose
 - Lips
 - Chin
 - Eyes
 - Eye
- Movie
 - Motion
 - In 3D Space
 - Body
 - Point Light
 - Motion Capture
 - Video
 - Animation
 - Outline
 - Social [e.g., mother-child interaction, videotaped or animated by a triangle and a square]
 - On Screen
 - Down [e.g. /2 deg]
 - Up
 - Horizontal
 - Right [e.g. /3 deg]
 - Oblique
 - Clock Face
 - # (e.g., 4:30)
 - Flickering

- Checkerboard
- Dots
- Steady State [fixed stimulus onset asynchrony]
- # (flicker rate in Hz)

[Note: above, also need/could use starting position on screen, end position, velocity in deg/s, etc.]

- Film Clip [any clip from a commercial film, TV,...]
- False Font
- Food
- Fractal
- LED
- Random Dot
- Language
 - Asian
 - Chinese
 - Japanese
 - Latin
 - English
 - German
 - French
 - [allow extension here for other language families]
 - Character
 - Digit
 - Pseudo-character [alphabet-like but not really]
 - Letter [Authograph, valid letters including numbers, e.g. A, B, 5...,]
 - Word
 - Noun
 - Proper [a proper noun, refers to a unique entity, such as London, Jupiter, ...]
 - Common [refers to a class of entities (cities, planets, persons, corporations), or non-unique instances of a certain class (a city, another planet, these persons, our corporation)].
 - Verb
 - Adjective
 - Pseudoword
 - # [number of words]
 - Sentence
 - Full
 - Partial
 - # [number of sentences]
 - Paragraph
 - # [number of paragraphs]
 - Story

- Natural Scene
 - Drawing [e.g. cartoons]
 - Line Drawing
 - IAPS [International Affective Picture System]
 - Bistable [this could be either abstract line drawings or object illustrations]
 - Background
 - Uniform Color
 - Aqua [these are CSS 3 basic color names, available in Appendix 1]
 - Black
 - Blue
 - Fuchsia
 - Gray
 - Green
 - Lime
 - Maroon,
 - Navy
 - Olive
 - Purple
 - Red
 - Silver
 - Teal
 - White
 - Yellow
 - Red
 - # [R value of RGB, between 0 and 1]
 - Blue
 - # [B value of RGB, between 0 and 1]
 - Green
 - # [G value of RGB, between 0 and 1]
 - Hue
 - # [H value of HSV, between 0 and 1]
 - Saturation
 - # [S value of HSV, between 0 and 1]
 - Value
 - # [V value of HSV, between 0 and 1]
- Auditory
 - Reward [e.g., trumpets!]
 - Cash Register
 - Ding
 - [extend here]
 - Warning
 - Fire Alarm
 - [extend here]

- Nameable [could be described by a word]
- Loudness
 - # [in dB]
- Music
- Chord Sequence
- Click
 - ABR [Auditory Brainstem Response]
- Noise
 - White
 - Colored [not white, 1/f, spectrum]
- Syllable
- Tone
 - # [in Hz]
 - Ramp Up
 - Ramp Down
 - [extend here]
- Nonverbal Vocal Sound
- Nonvocal Sound
- Language
 - Word
 - Name
 - Noun
 - Verb
 - Adjective
 - Pseudoword
 - # [number of words]
 - Sentence
 - Full
 - Partial
 - # [number of sentences]
 - Paragraph
 - # [number of paragraphs]
 - Story
 - [extend with language names here]
- Animal Voice
- Real world sounds [people, machines, etc..]
- Emotional sounds
- File
 - [file name or quoted path name]
- Direction
 - Azimuth
 - # [relative azimuth of the sound, preferably in degrees, clockwise]
 - Elevation

- # [relative elevation of the sound, preferably in degrees]
 - Left
 - Front
 - Right
 - Back
- TMS
 - With SPGS [SPGS = spatial position guiding system]
 - Without SPGS [SPGS = spatial position guiding system]
- Tactile
 - Vibration
 - Acupuncture
 - Eye Puff
- Pain
 - Heat
 - Cold
 - Pressure
 - Electric Shock
 - Laser-evoked
- Taste
- Smell
- Target [something the subject is looking for is detected]
- Oddball [unexpected, infrequent]
 - One Stimulus [see [http://dx.doi.org/10.1016/0167-8760\(96\)00030-X](http://dx.doi.org/10.1016/0167-8760(96)00030-X)]
 - Two Stimuli [see [http://dx.doi.org/10.1016/0167-8760\(96\)00030-X](http://dx.doi.org/10.1016/0167-8760(96)00030-X)]
 - Three Stimuli [see [http://dx.doi.org/10.1016/0167-8760\(96\)00030-X](http://dx.doi.org/10.1016/0167-8760(96)00030-X)]
 - Silent counting
 - Button pressing for target
 - Button pressing for all
 - # [Probability, between 0 and 1]
- Novel [Genuine once or so per experiment event]
- Expected [of low information value]
 - Standard
 - Distractor
 - Non-Target
- Feedback
 - Correct [confirm, something went well, last action was correct]
 - Incorrect
 - Expected [feedback was expected, for example they were often correct and they are again correct]
 - Unexpected [feedback was expected, for example they were often correct and they are again correct]
 - On Accuracy [feedback was provided by evaluating their accuracy]
 - On Reaction Time [feedback was provided by evaluating their reaction time]

- To Self [default]
- To Other [observed feedback to another person, typically in a social paradigm]
- Deterministic [should have a fixed relationship to what happened before]
- Stochastic [non-deterministic, it does not have fixed relationship with what has happened before in the experiment]
- Reward
 - Low
 - Medium
 - High
 - # [monetary values in some currency, for example \$1, or the ratio of the reward to the maximum possible (3 of max 10 becomes 0.3), or x Points]
- Penalty
 - Low
 - Medium
 - High
 - # [absolute monetary values in some currency, for example \$1, or the ratio of the reward to the maximum possible (3 of max 10 becomes 0.3), or x Points]
- Error
 - Self Originated
 - Other Originated
 - Human
 - Non-human
 - Expected
 - Unexpected
 - Planned [the error feedback was given regardless of the validity of subject response, e.g. in a yoked design]
- Threat
 - To Self
 - To others
 - Close
- Task Rest Start [stop doing the task and rest, or just rest if the task has not yet begun]
- Task Rest End [stop resting and prepare for or start performing the task]
- Presented action of another person [e.g., saw someone pick up something]
- Priming
 - Semantic
 - Motoric
 - Emotional
 - Perceptual
- Instruction
 - Attend
 - Fixate
 - Recall
 - Generate

- Repeat
- Breath-Hold
- Imagine
- Rest
- Count
- Move
 - Natural/Constrained
 - Walk
 - Breathe
 - Move upper torso
 - Move lower torso
 - Move whole body
- Speak
- Sing
- Detect
- Name
- Smile
- Discriminate
- Read
- Track
- Encode
- Eye-Blink Inhibition
- Subliminal
 - unmasked
 - Masked
 - Forward
 - Backward
- Supraliminal [by default this is what assumed about each stimulus]
- Liminal [at the 75%/25% perception threshold]
- Onset [it is assumed by default that a stimulus event marks the onset of the stimulus]
- Offset [vs. Onset]
- Congruence
 - Congruent
 - Incongruent
 - Semantic [semantic similarity similarity]
 - Temporal Synchrony
 - Synchronous
 - Asynchronous
- Response [self-initiated action, can be extended]
 - Button Press
 - Touch Screen

- Keyboard
 - Response Device
- Button Hold [press and keep pressed]
- Hand
 - Right
 - Left
 - Finger
 - Tap
 - Lift
- Leg
 - Right
 - Left
 - Walk
 - Start Stride
 - Peak stride
 - End Stride
- Speech
- Head
 - Turn
- Torso
 - Turn
- Movement
 - Onset Velocity
 - Peak Velocity
 - Offset Velocity
 - Onset Acceleration
 - Peak Acceleration
 - Offset Acceleration
 - Onset Jerk
 - Peak Jerk
 - Offset Jerk
 - Turn [change in direction of movement]
- Follow
- Lead
- Point
 - Object [to an object]
 - Direction [to a direction]
- Eye
 - Saccade
 - Start
 - Middle
 - End
 - Fixation

- Blink
- Close [and keep closed for $> \sim 0.1$ s]
- Open [and keep open for $> \sim 0.1$ s]

State

- Emotion
 - Awe
 - Frustration
 - Joy
 - Anger
 - Happiness
 - Sadness
 - Love
 - Fear
 - Compassion
 - Jealousy
 - Contentment
 - Grief
 - Relief
 - Excitement
 - Disgust
 - Negative Valence
 - # (a number between 0 and 1)
 - Positive Valence
 - # (a number between 0 and 1)
- Awake
 - Task-relevant
 - Task-irrelevant
 - Induced
 - Sense of Community
 - Sense of Social Justice
 - Stress Level
 - # (a number between 0 and 1)
 - Task Load
 - # (a number between 0 and 1)
 - Emotion
 - Awe
 - Frustration
 - Joy
 - Anger
 - Happiness
 - Sadness
 - Love

- Fear
 - Compassion
 - Jealousy
 - Contentment
 - Grief
 - Relief
 - Excitement
 - Disgust
 - Negative Valence
 - # (a number between 0 and 1)
 - Positive Valence
 - # (a number between 0 and 1)
- Under time pressure
 - Response Window
 - Competitive [subject is competing against an opponent, for example when the faster respondent wins]
- Social Interaction [social]
 - pseudo [instructed so but actually not, the other person may not exist in real world, e.g. be a computer program agent]
- Passive [not engaged in any particular task]
- Attention
 - Top-down
 - Bottom-up
 - Covert
 - Overt
 - Implicit
 - Explicit
 - automatic
 - Orienting
 - Alerting
 - Control
 - Divided
 - Focused
 - Sustained [being alert]
 - Auditory
 - Visual
 - Tactile
 - To a Location [Spatial]
 - Right
 - Left
 - Top
 - Bottom
 - Center

- Low Conscious
 - Sleep
 - Drunk
 - Anesthesia
 - Locked-in
 - Coma
 - Vegetative
 - Brain-Death
-

Participant [for identifying different participants in social, multi-person experiments]

- Role [The role of the participant associated with the event, e.g. viewer, follower, leader, is placed at a lower level, e.g. Participant/Role/Leader]
- ID [subject may swap their roles during the experiment but still need to be each identified by a unique ID, which may or may not be numeric. For example all stimuli presented to a particular participant is tagged as: Participant/ID/Player 1].

Context [describes the context of the whole experiment, also includes tags that are common across all events]

- [add common tags across all stimuli/ and/or responses here, e.g if all experiment events share /State/Drowsy, you can place it here instead of tagging each event individually]
- With Chin Rest
- Sitting
- Standing
- Prone [e.g. on a bed]
- Running
 - Treadmill
 - # Speed (meters per second)
- Walking
 - Treadmill
 - # Speed (meters per second)
-
- Indoors [default]
 - Clinic [recording in a clinical setting, e.g. in a hospital or doctor's office]
- Outdoors
- Motion platform [subject is on a motion platform, e.g. simulated car movements]
- Screen Distance
 - # [distance in meters from subject eyes to the presentation screen , e.g. 0.3 for 30 cm from subject eyes to the monitor]
- [extend here]

Experiment Control [information about states and events of the software program that controls the experiment]

- Sequence
 - Permutation ID
 - # [permutation number/code used for permuted experiment parts]
 - Experiment Begins
 - Experiment Ends
 - Block Begins
 - # [block number]
 - Block Ends
 - # [block number]
 - Trial Begins
 - # [trial number]
 - Trial Ends
 - # [trial number]
 - Pause Begins
 - Pause Ends
- Task [task-specific events, such as moving a piece in a chess game]
 - Action
 - Correct
 - Incorrect [e.g., due to timeout]
 - Missed
 - Inappropriate
- Synchronization
 - Display Refresh
 - Trigger
- Status
 - Waiting For Input
 - Loading
 - Error
- Setup
 - Parameters
 - (experiment parameters in some (quoted) string)

Custom

This node can be used to organize events in an alternative (parallel) hierarchy: you can define your custom tags and hierarchies without any restriction under this node. These tags will still be matched to each other, for example */Custom/Dance/Waltz* is considered a subtype of */Custom/Dance*.

Example: */Initial Score/#* [monetary values in some currency, for example \$1, or the ratio of the reward to the maximum possible (3 of max 10 becomes 0.3), or x Points]

Paradigm

- Action imitation task
- Action observation paradigm
- Action observation task
- Acupuncture task
- Adult attachment interview
- Alternating runs paradigm
- Animal naming task
- Antisaccade-prosaccade task
- Attention networks test
- Attentional blink task
- Audio-visual target-detection task
- Autism diagnostic observation schedule
- Ax-cpt task
- Backward digit span task
- Backward masking
- Balloon analogue risk task (BART)
- Behavioral investment allocation strategy (BIAS)
- Behavioral rating inventory of executive function
- Benton facial recognition test
- Birmingham object recognition battery
- Block design test
- Block tapping test
- Boston naming test
- Braille reading task
- Breath-holding
- Breathhold paradigm
- Brixton spatial anticipation test
- California verbal learning test
- California verbal learning test-ii
- Cambridge face memory test
- Cambridge gambling task
- Cambridge neuropsychological test automated battery
- Catbat task
- Category fluency test
- Cattell culture fair intelligence test
- Chewing-swallowing
- Chimeric animal stroop task
- Choice reaction time task
- Choice task between risky and non-risky options
- Classical conditioning
- Clinical evaluation of language fundamentals-3
- Color trails test

- Color-discrimination task
- Color-word stroop task
- Complex span test
- Conditional stop signal task
- Conditioning paradigm
 - Behavioral conditioning paradigm
 - Classical conditioning paradigm
- Continuous performance task
- Continuous recognition paradigm
- Counting stroop task
- Counting-calculation
- Cued explicit recognition
- Cups task
- Deception task
- Deductive reasoning paradigm
- Deductive reasoning task
- Delayed discounting task
- Delayed match to sample task
- Delayed nonmatch to sample task
- Delayed recall test
- Delayed response task
 - Delayed matching to sample paradigm
 - Sternberg paradigm
- Devils task
- Dichotic listening task
- Digit cancellation task
- Digit span task
- Digit-symbol coding test
- Directed forgetting task
- Divided auditory attention
- Divided auditory attention paradigm
- Doors and people test
- Dot pattern expectancy task
- Drawing (Cognitive Atlas Term)
- Drawing paradigm
- Dual-task paradigm
- Early social communications scales
- Eating paradigm
- Eating-drinking
- Embedded figures test
- Emotional regulation task
- Encoding paradigm
- Encoding task

- Episodic recall
- Episodic recall paradigm
- Eriksen flanker task
- Extradimensional shift task
- Eye Saccade paradigm
 - Anti saccade paradigm
 - Simple saccade paradigm
- Face monitor-discrimination
- Face n-back task
- Fagerstrom test for nicotine dependence (Cognitive Atlas Term)
- Film viewing
- Finger tapping task
- Fixation task
- Flashing checkerboard
- Flexion-extension
- Forward digit span task
- Free word list recall
- Glasgow coma scale
- Go-no-go task
- Grasping task
- Gray oral reading test - 4
- Haptic illusion task
- Hayling sentence completion test
- Heat sensitization-adaptation
- Heat stimulation
- Hooper visual organization test
- Imagined movement
- Imagined objects-scenes
- Immediate recall test
- Inductive reasoning aptitude
- International affective picture system
- Intradimensional shift task
- Ishihara plates for color blindness
- Isometric force
- Item recognition paradigm
 - Serial item recognition paradigm
- Item recognition task
- Kanizsa figures
- Keep-track task
- Letter comparison
- Letter fluency test
- Letter n-back task
- Letter naming task

- Letter number sequencing
- Lexical decision task
- Listening span task
- Macauthur communicative development inventory
- Matching familiar figures test
- Matching pennies game
- Maudsley obsessive compulsive inventory
- Mechanical stimulation
- Memory span test
- Mental rotation task
- Micturition task
- Mini mental state examination (Cognitive Atlas Term)
- Mirror tracing test
- Mismatch negativity paradigm
- Mixed gambles task
- Modified erikson scale of communication attitudes
- Morris water maze
- Motor sequencing task
- Music comprehension-production
- N-back task
- Naming (Covert)
- Naming (Overt)
- Nine-hole peg test
- Non-choice task to study expected value and uncertainty
- Non-painful electrical stimulation
- Non-painful thermal stimulation
- Nonword repetition task
- Object alternation task
- Object-discrimination task
- Oculomotor delayed response
- Oddball discrimination paradigm
 - Auditory oddball paradigm
 - Visual oddball paradigm
- Oddball task
- Olfactory monitor-discrimination
- Operation span task
- Orthographic discrimination
- Paced auditory serial addition test
- Pain monitor-discrimination task
- Paired associate learning
- Paired associate recall
- Pantomime task
- Parrott scale

- Passive listening
- Passive viewing
- Pattern comparison
- Phonological discrimination
- Picture naming task
- Picture set test
- Picture-word stroop task
- Pitch monitor-discrimination
- Pointing
- Porteus maze test
- Positive and negative affect scale
- Posner cueing task
- Probabilistic classification task
- Probabilistic gambling task
- Probabilistic reversal learning
- Pseudoword naming task
- Pursuit rotor task
- Pyramids and palm trees task
- Rapid automatized naming test
- Rapid serial object transformation
- Reading (Covert)
- Reading (Overt)
- Reading paradigm
 - Covert braille reading paradigm
 - Covert visual reading paradigm
- Reading span task
- Recitation-repetition (Covert)
- Recitation-repetition (Overt)
- Remember-know task
- Response mapping task
- Rest
- Retrieval-induced forgetting task
- Reversal learning task
- Reward task
- Rey auditory verbal learning task
- Rey-ostereith complex figure test
- Reynell developmental language scales
- Rhyme verification task
- Risky gains task
- Rivermead behavioural memory test
- [extend here]

Label

- [a short label for the event. For example /Label/Accept Button. Please note that the information under this tag will not be used in the analysis and is provided solely for the convenience in referring to events in the context of a single study.]

Description

- [A detailed description of the event as text, can be used to complement information encoded in other HED tags. Please note that information under this tag would be unusable by computers and analysis software and should not be used as the main method for describing events (use HED tags other than Description and Label to explain events in a machine-understandable manner)]


Group ID







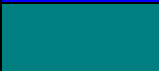
- [a string that uniquely identifies a group of related of events, e.g. events that describe visual and auditory stimulus onsets and offsets of a particular bird may all be tagged with /Group ID/Bird #54]

HED [Hierarchical Event Descriptor]

- # [HED specification version number: normally there is no need to specify the version number in the HED string since it will be matched by default to the most recent compliant version, but this tag can be used to specify the exact HED version the HED string was based on.]

Appendix 1: CSS 3 Color Names

	Color name	Hex rgb	Decimal
	black	#000000	0,0,0
	silver	#C0C0C0	192,192,192
	gray	#808080	128,128,128
	white	#FFFFFF	255,255,255
	maroon	#800000	128,0,0
	red	#FF0000	255,0,0
	purple	#800080	128,0,128
	fuchsia	#FF00FF	255,0,255

	green	#008000	0,128,0
	lime	#00FF00	0,255,0
	olive	#808000	128,128,0
	yellow	#FFFF00	255,255,0
	navy	#000080	0,0,128
	blue	#0000FF	0,0,255
	teal	#008080	0,128,128
	aqua	#00FFFF	0,255,255

Reference

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- [3] OWL 2 Web Ontology Language Document Overview. Available: <http://www.w3.org/TR/owl2-overview/>
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