Inducing, measuring and estimating the different types of attentions in EEG signals

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What does the word Attention refers to?

<table>
<thead>
<tr>
<th>Attention</th>
<th>Intensity</th>
<th>Selection processes</th>
</tr>
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<tbody>
<tr>
<td>Alertness</td>
<td>Sustained</td>
<td>Selective attention</td>
</tr>
<tr>
<td>(Tonic &amp; Phasic)</td>
<td>attention</td>
<td>Divided attention</td>
</tr>
</tbody>
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**Attention-related processes are reflected in EEG activity:**

→ Correlation between the amplitude of the signal **Theta** and the amount of Selective attention [Schacter (1977). *Biological psychology.*]


→ Low (12-15Hz) and high (18-30Hz) frequency **Beta** waves are respectively associated with Selective attention and Alertness [Arruda et al. (2009). *Applied psychophysiology and biofeedback*]
**Aim.**

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**Aim** - Contributing to these questions’ answer:

- Which are the EEG characteristics of each attention type?
- Can we differentiate attention types based on EEG signal?
How to elicit the attentional states?

• What should I ask the participants?
• How long should each task last?
• Which and how many targets should be presented?
• Though which modality should the targets be presented (visual and/or auditory)?
• Which and how many distractors should be presented?
• Etc...
Which prerequisite for the protocol?

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<tr>
<th></th>
<th>Duration (sec)</th>
<th>Modality of targets</th>
<th>Number of target</th>
<th>Number of distractor</th>
<th>Warning before stimuli</th>
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<tbody>
<tr>
<td>Alertness - Tonic</td>
<td>2 * 210</td>
<td>eye</td>
<td>80</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Alertness - Phasic</td>
<td>2 * 210</td>
<td>eye</td>
<td>80</td>
<td>0</td>
<td>120ms tone</td>
</tr>
<tr>
<td>Sustained attention</td>
<td>1 * 840</td>
<td>eye</td>
<td>160</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
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<td>2 * 210</td>
<td>eye</td>
<td>80</td>
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<td>-</td>
</tr>
<tr>
<td>Divided attention</td>
<td>2 * 210</td>
<td>eye + ear</td>
<td>40 + 40</td>
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Alertness
Divided
Which prerequisite for the protocol?

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Stimuli-related data saved with EEG data
Concretely in OpenViBE.

All the code is accessible at: https://gitlab.inria.fr/lpillett/attentional-states
Alertness
- Keyboard stimulator
- Lua Stimulator
- Display
- Stimulation Listener

Configuring Alertness_Tonic_Circle settings:
- Lua Script
- Experiment duration (int sec)
- Target display (int msec)
- Target nbr
- Warning
- Target_Stimulation
- Baseline duration (sec)

Override settings with configuration file:
- Load...
- Save...
- Default
- Revert
- Apply
- Cancel

Scenario Configuration:
- Run 1
- Part 1
- Participant_ID 0

Data from keyboard and EEG headset
Stimuli
Play the sounds
Stimuli
CSV File Writer & Generic Stream writer & GDF file writer: Save the data
Emotion initialize(Box)

```lua
-- Global variables
alex_before_warm_min = 100 -- msec
alex_before_warm_max = 1000 -- msec
answer_wait = 1.260 -- sec
time_warm_est = 400/1000 -- sec

-- In minute
ap_duration = boxGetSetting() -- sec

-- In second
target_duration = ap_duration / 1000 -- sec

-- target_nbr = boxGetSetting()

warning = boxGetSetting()

baseline_duration = boxGetSetting() -- sec

trials_duration = ap_duration / target_nbr -- sec

-- Initializes random seed
math.randomseed(os.time())
```

Emotion process (Box)

```lua
local t =

-- Manages baseline
boxSendStimulation(t, OVTK_StimulationId_ExperimentStart, t, 0)

boxSendStimulation(t, OVTK_StimulationId_BaselineStart, t, 0)

boxSendStimulation(t, OVTK_StimulationId_Been, t, 0)

boxSendStimulation(t, OVTK_StimulationId_BeenStop, t, 0)

-- Manages trials
for i = 1, target_nbr do

-- Start of trial
boxSendStimulation(t, OVTK_GDF_Start_Of_Trial, t, 0)

-- Random time before warning
警示 = math.random(), trials_duration + (answer_wait x 1000 + alex_before_warm_max / time_warm_est) / 1000

-- If warning before stimulus
if warning == "true" then

boxSendStimulation(t, OVTK_StimulationId_Been, t, 0)

end
```
Scenario written for divided attentional tasks with the same number of distractor and target for both visual and auditory tasks.
Divided
- **Keyboard stimulator & Acquisition client:** Retrieve data from keyboard and EEG headset
- **Lua Stimulator:** Manages the timing of the events / stimuli
- **Display cue image & Sound player:** Display the images and play the sounds
- **Stimulation listener:** Display in the logs the events / stimuli
- **CSV File Writer & Generic Stream writer & GDF file writer:** Save the data
Summary of Material & Method.

1 group of participants
   • 16 neurotypical participants

1 session

5 attention-related tasks varying depending on the:
   • Number of targets & distractors
   • Presence of a warning tone
   • Modality of the stimuli
   • Duration of the task

➢ Impact on EEG data analysed
Summary of Results.

Classification accuracy

- Tangent-space classifier [Yger et al. IEEE TNSRE, 2017]
- 5 classes (chance level: ~29%)
- Subject-specific classification
Conclusion & Future research.

- Promising results regarding the measure and differentiation of attentional states
- Results in accordance with the model of van Zomeren & Brouwer
- In the future: test the attentional states involved during BCI training

**International conference:**
- Appriou, Pillette, Cichocki & Lotte. *Int. BCI Meeting*, 2019.

**Journal full paper:**
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Andrzej Cichocki, SKOLTECH, Moscow, Russia

Fabien Lotte, Inria Bdx SO / LabRI, France

Bernard N’Kaoua, HACH, Univ Bdx, France
## Attention – Stimuli

<table>
<thead>
<tr>
<th></th>
<th>Left Ear</th>
<th>Right Ear</th>
</tr>
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<tbody>
<tr>
<td><strong>Target Left - Congruent</strong></td>
<td>2000Hz (+0 dB)</td>
<td>2000Hz (-10 dB)</td>
</tr>
<tr>
<td><strong>Target Left - Incongruent</strong></td>
<td>2000Hz (+0 dB)</td>
<td>1000Hz (-10 dB)</td>
</tr>
<tr>
<td><strong>Target Right - Congruent</strong></td>
<td>2000Hz (-10 dB)</td>
<td>2000Hz (+0 dB)</td>
</tr>
<tr>
<td><strong>Target Right - Incongruent</strong></td>
<td>1000Hz (-10 dB)</td>
<td>2000Hz (+0 dB)</td>
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### Visual Stimuli

- **Square targets**
  - Simple
  - Congruent
  - Incongruent

- **Circle targets**
Attention – Topographies en Theta
Attention – Matrices de confusion en Alpha
Attention – Recorded information

❖ Electroencephalographic data (EEG)

❖ Reaction time (RT)

❖ Accuracy
  ➢ Omission
  ➢ False response
  ➢ Anticipation
  ➢ Late response