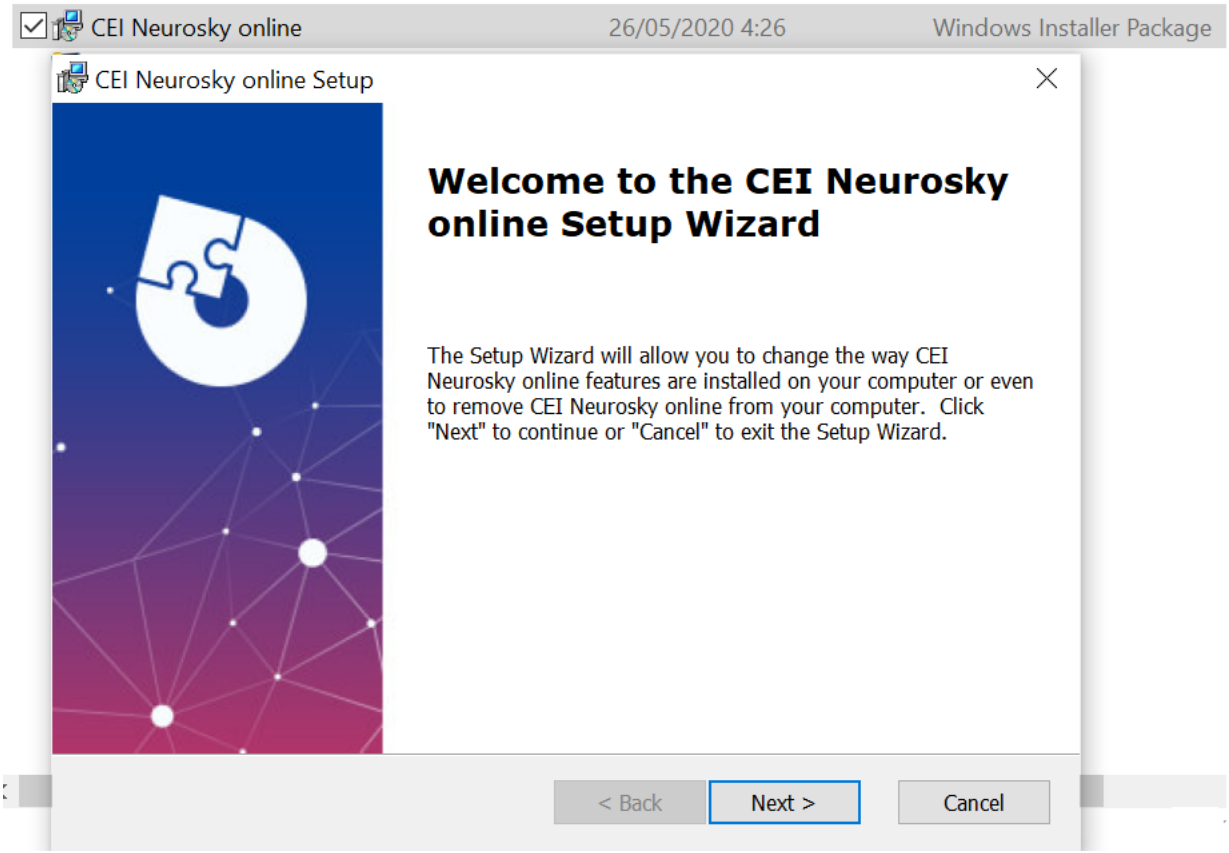
CEI online monitor prototype for NeuroSky – user manual

1. Installation and activation

1.1. Installation



After downloading the software to your PC please activate our standard installer (CEI_Neurosky_online). The default application directory is c:\CEI_NeuroSky_online\. Please select an application directory to which the software can save output files. Once the installation is completed a shortcut to the CEI monitor should appear on the desktop, from which you can activate the software after receiving a key.

1.2. Receiving a key

In the application directory you should find a tool named config. Please run this tool to generate a config.txt file, which includes information on the current date, user, computer, windows version, and user directory. Please send the config.txt file to us (to godeds@gmail.com) and you will receive back a key file. The key is valid for one year.

1.3. Activation

Please place the key file in the application directory. Once the key file is placed in the directory, the application should be ready to activate from the desktop shortcut or by activating the sample_CEI

application in the application directory. Make sure that the headset and the computer are connected first (via Bluetooth).

2. Selecting session type and defining session goals

2.1. Three session types

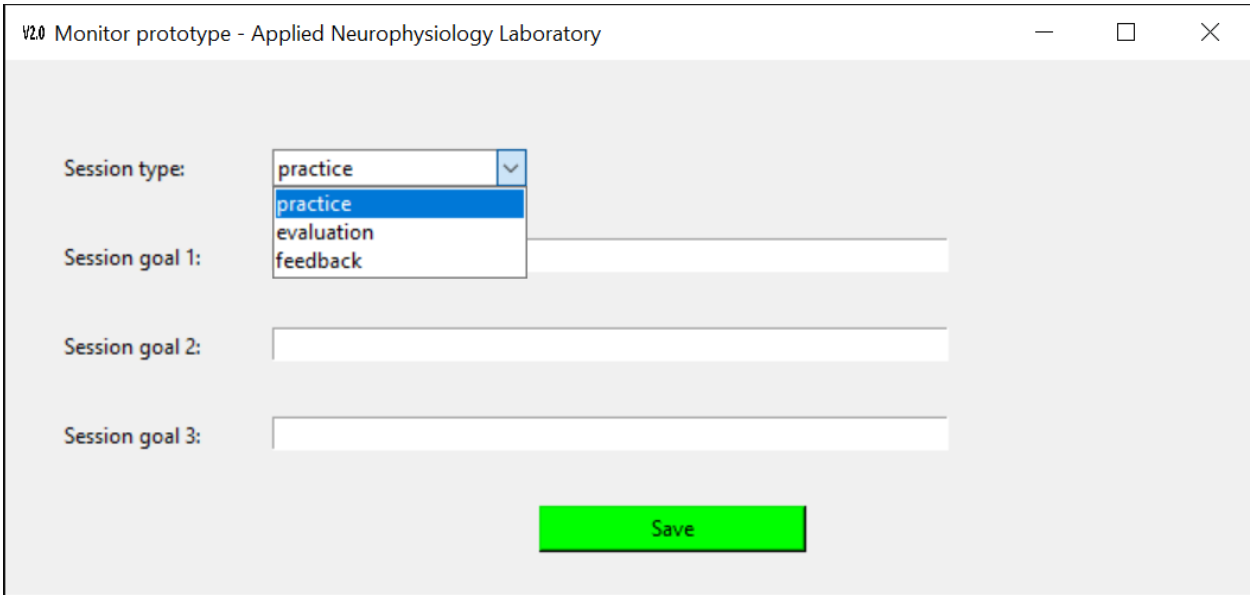
The application provides an interpretation of the index dynamics according to its use context. Thus, interpretation is provided to three types of sessions:

Practice sessions: in which the client is training or exercising and the goal is to ensure an optimal attentional effort and if this is not the case to assist in identifying the cause for the reduced engagement.

Evaluation sessions: in which the client is undergoing a diagnostic test and the goal is to evaluate whether the test results were obtained under optimal attentional effort and if not to assist in identifying the cause for the reduced engagement.

Feedback sessions: in which the client is consuming a certain media or presentation content and the goal is to evaluate whether the content was engaging for the client and if not to assist in identifying the cause.

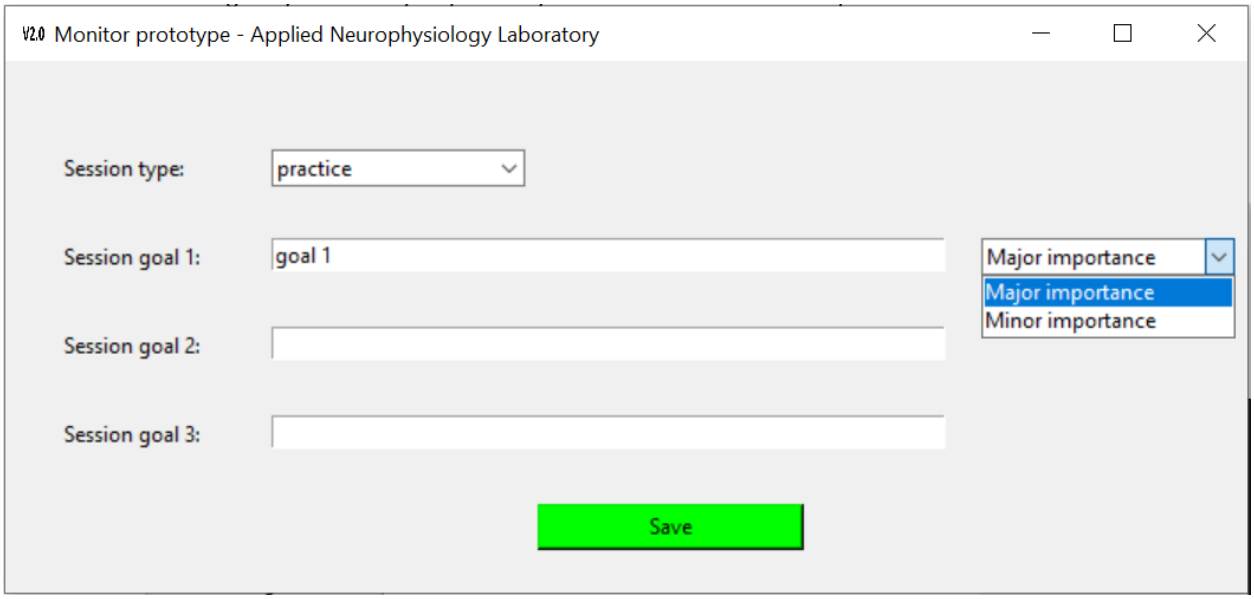
The selection of the session type among these three options is the first step of the opening screen.



2.2. Defining goals

Then you will be asked to specify up to three goals for the session. If you select goals, you will be asked at the end of the session to evaluate whether they were obtained and according to this performance evaluation and the session type you will be able to receive an interpretation of the index dynamics

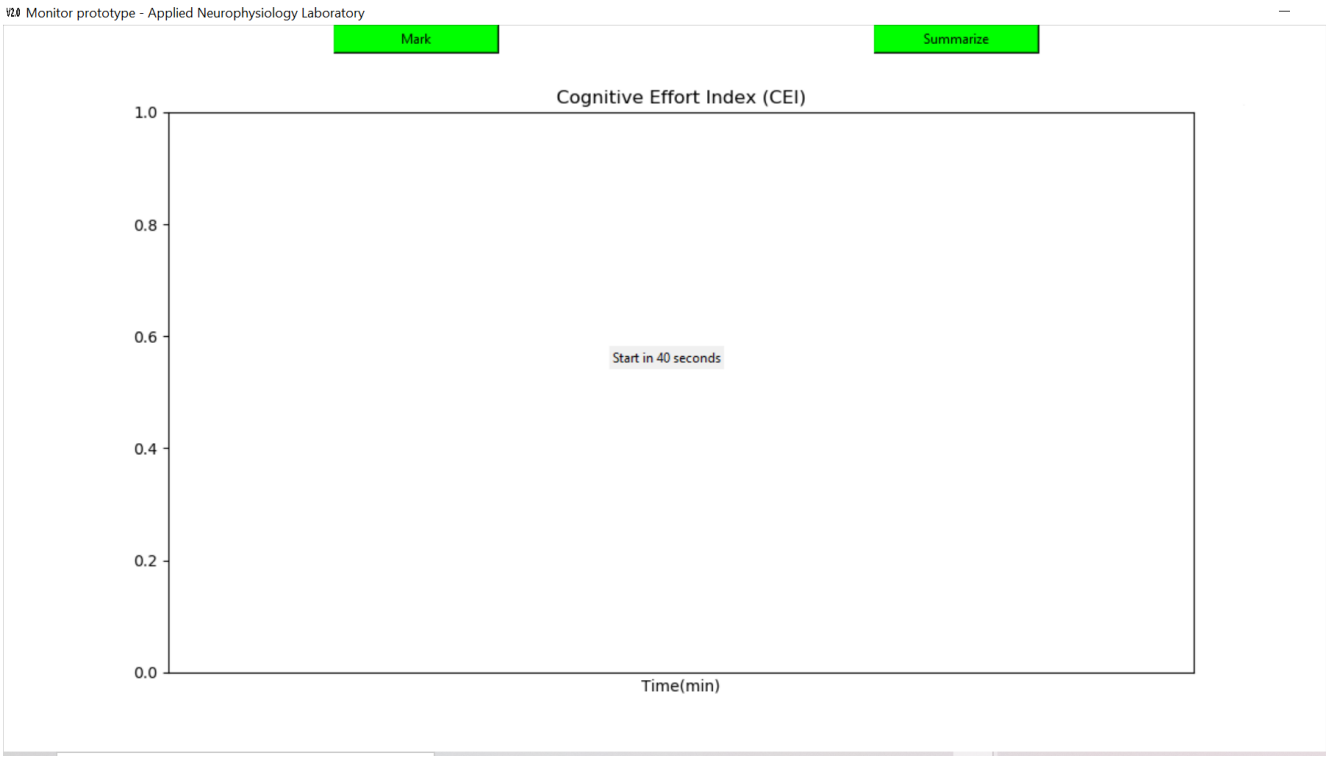
throughout the session and recommendations for possible enhancement. The specification of goals is not obligatory and is only required if you wish to receive the interpretation and recommendations. For every goal you define you will be asked to specify whether it is a major goal for the session or a minor one. If you decide to define goals, it is highly recommended to define them operationally in a measurable way – e.g. a grade in some formal evaluation, or the number of times the client succeeds to perform a task, or the ability of a client to solve a certain challenge. An objective operational definition will reduce the risk of subjective post-session bias regarding the client's success in obtaining the goal.



3. Real-time monitoring

3.1. Waiting for the first marker value

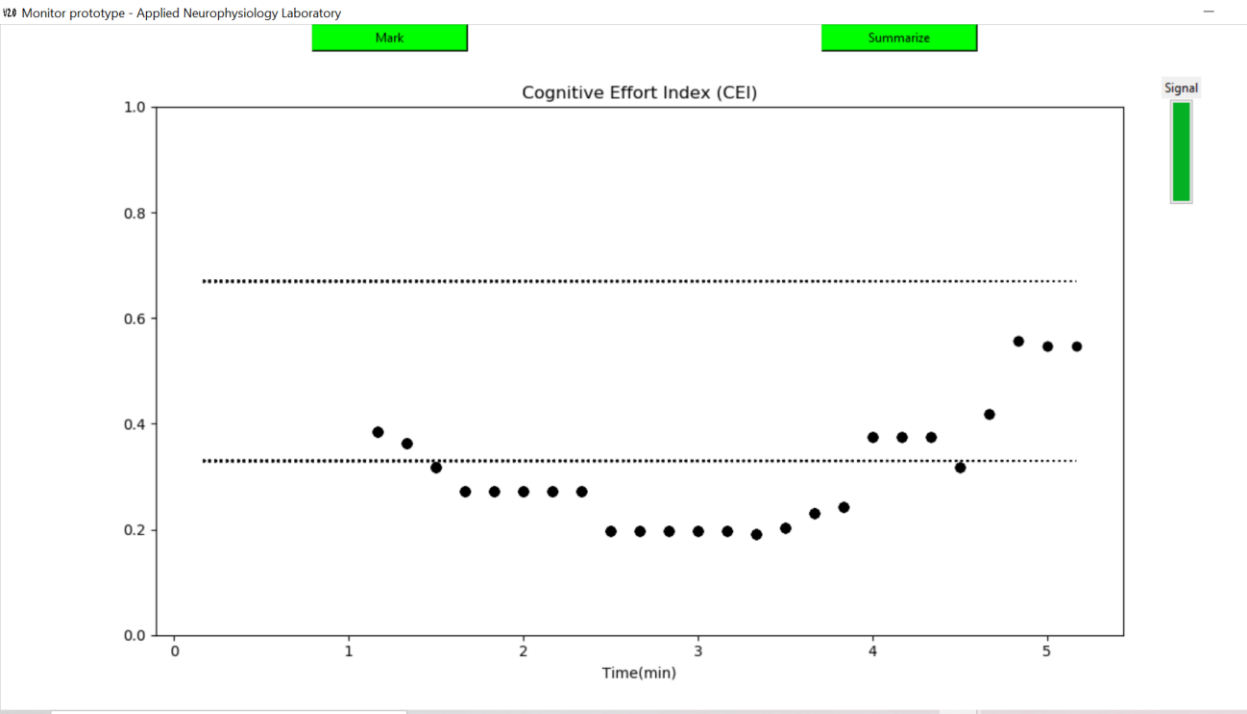
Once you save the session type and goals, the main monitoring screen opens and there is a wait of about 60 seconds to generate the baseline marker. It is recommended to wait for the first marker to appear before starting the session, so as to get marker values from the start of the session.



3.2. The monitor

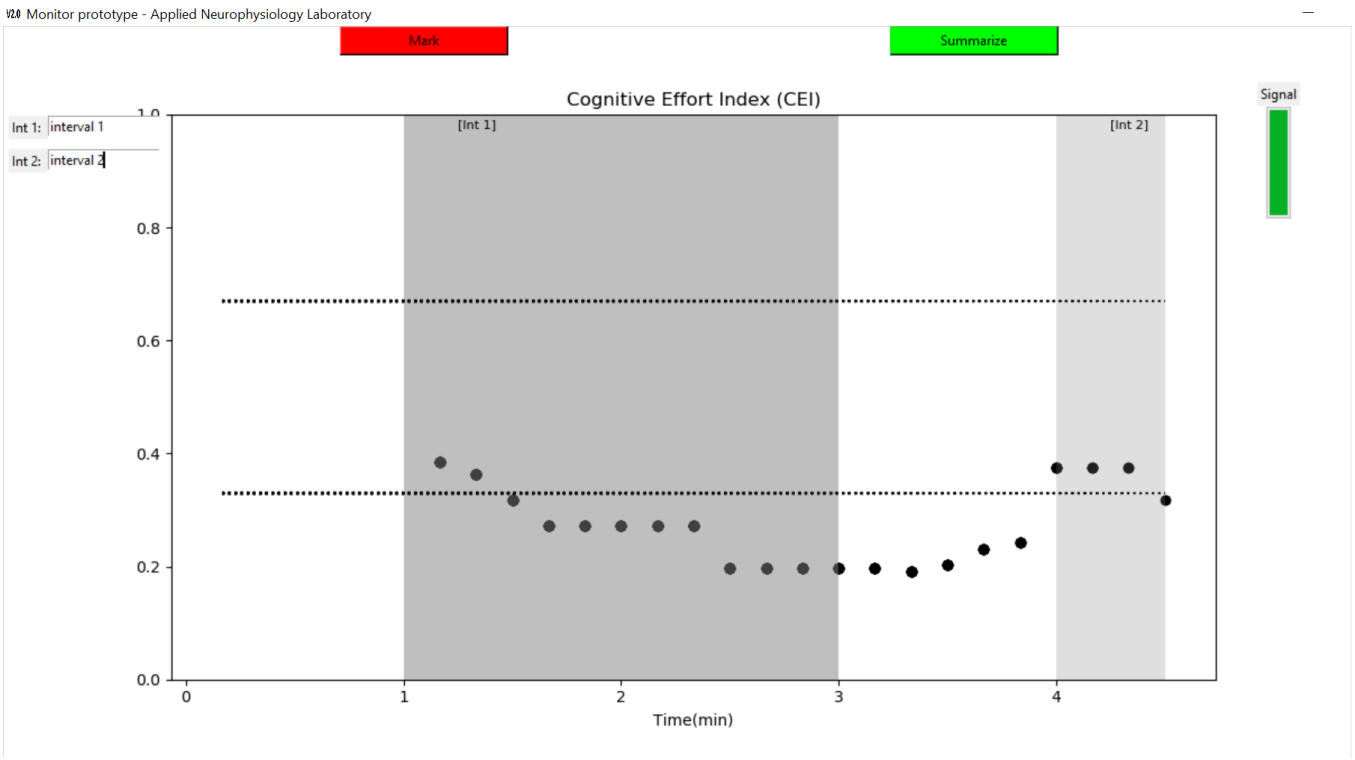
The marker values are provided every ten seconds. Lower and higher thresholds of 1/3 and 2/3 respectively are also presented. Often, if the marker drops below the low threshold for a period of at-least 30 seconds (3 marker points), it may represent an attention drop. If the marker increases to above the high threshold for a period of at-least 30 seconds, it may represent significant discomfort (e.g. anxiety or pain), in which case heightened attention is allocated to the stressor.

A five levels signal quality bar is presented at the top right. If the signal quality bar is emptied (below level 1) no marker will appear due to noisy sample and the quality of the sample needs to be improved first (mostly by better adjustment of the headset).

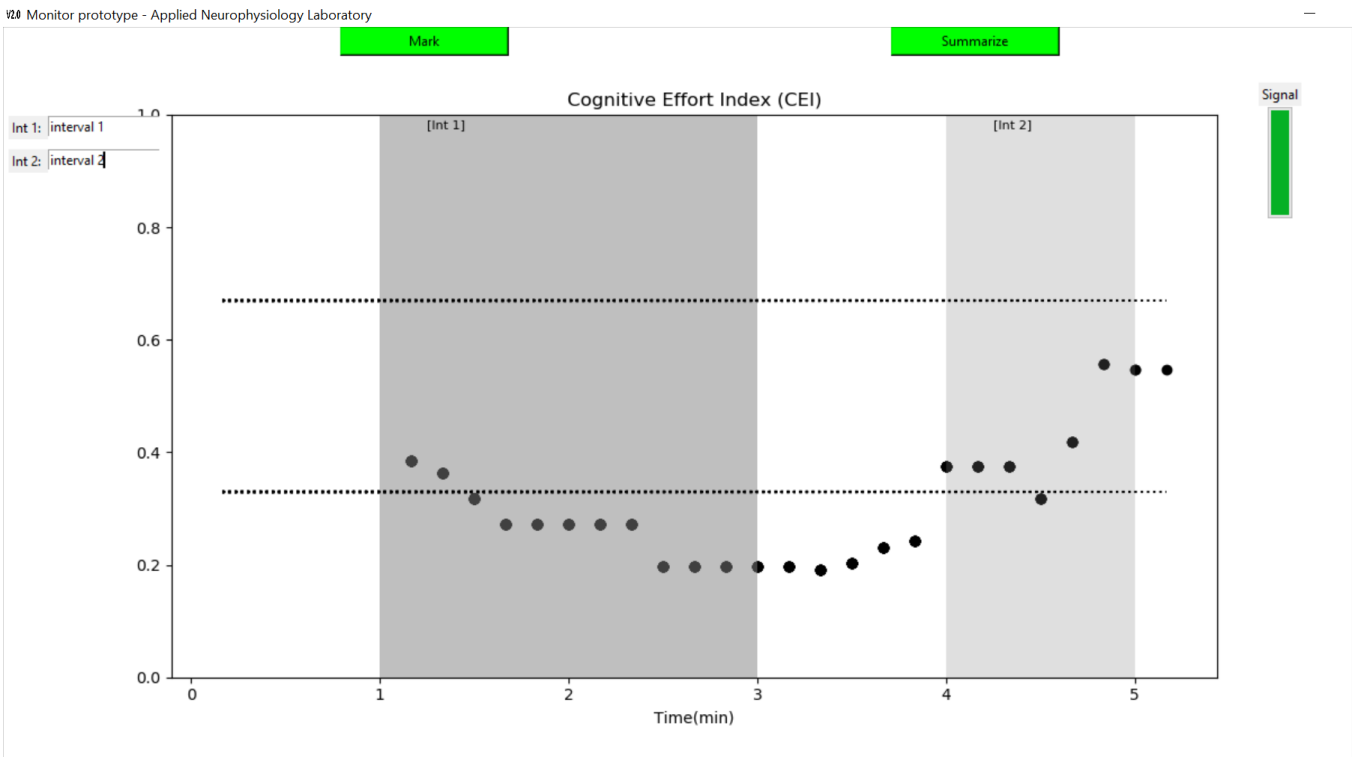


3.3. Marking intervals

It is possible to mark intervals in the sample for further analysis. Pressing the green Mark key at the top left opens a new interval and the key color is switched to red to denote an active interval. The interval is marked in grey on the graph (two shades of grey are used intermittently to differentiate between intervals). It is possible to name the interval on the left for documentation.

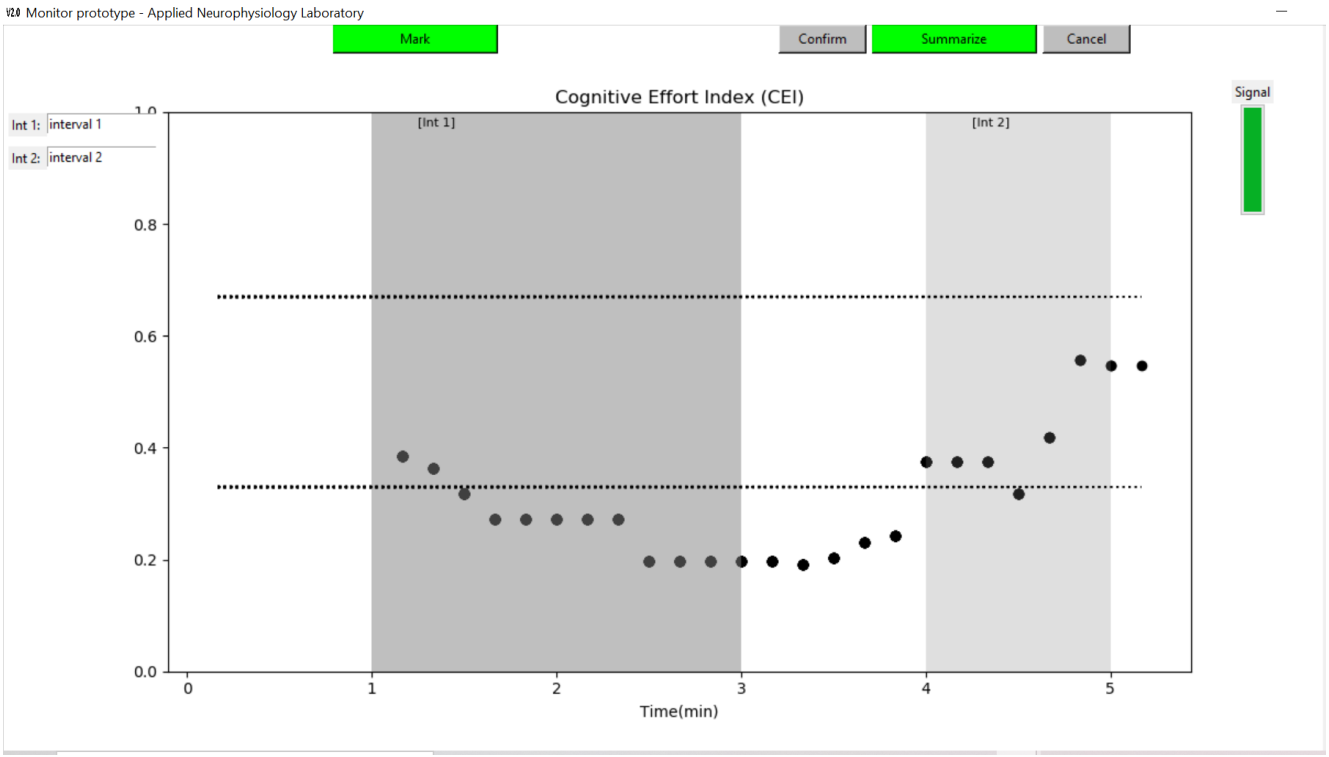


Once the red Mark key is pressed the interval is ended and the Mark key is turned green again.



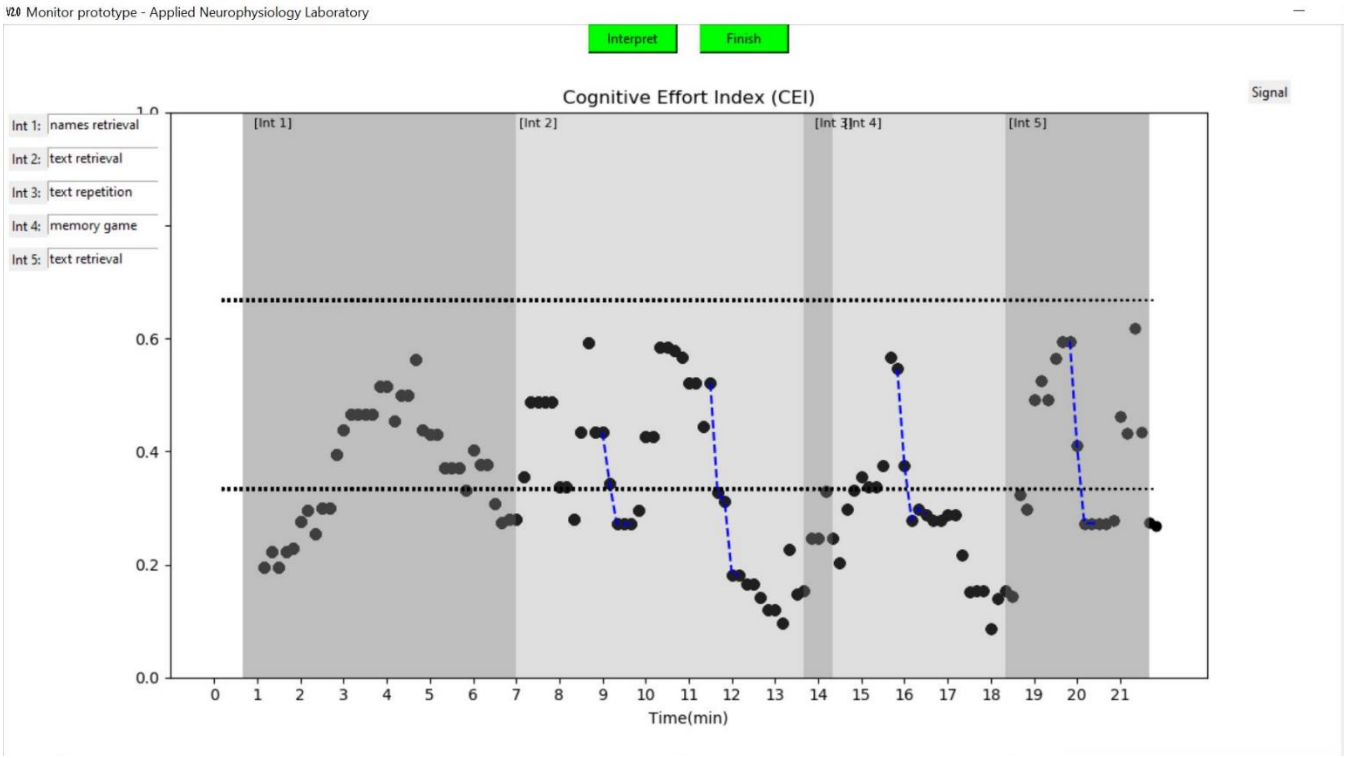
4. Session summary: marking the dominant pattern

Once you wish to end the session you can press the summarize key at the top right and then confirm summary. Alternatively, if the sampling stops for more than one minute (signal stops arriving from the headset) the session is also summarized.



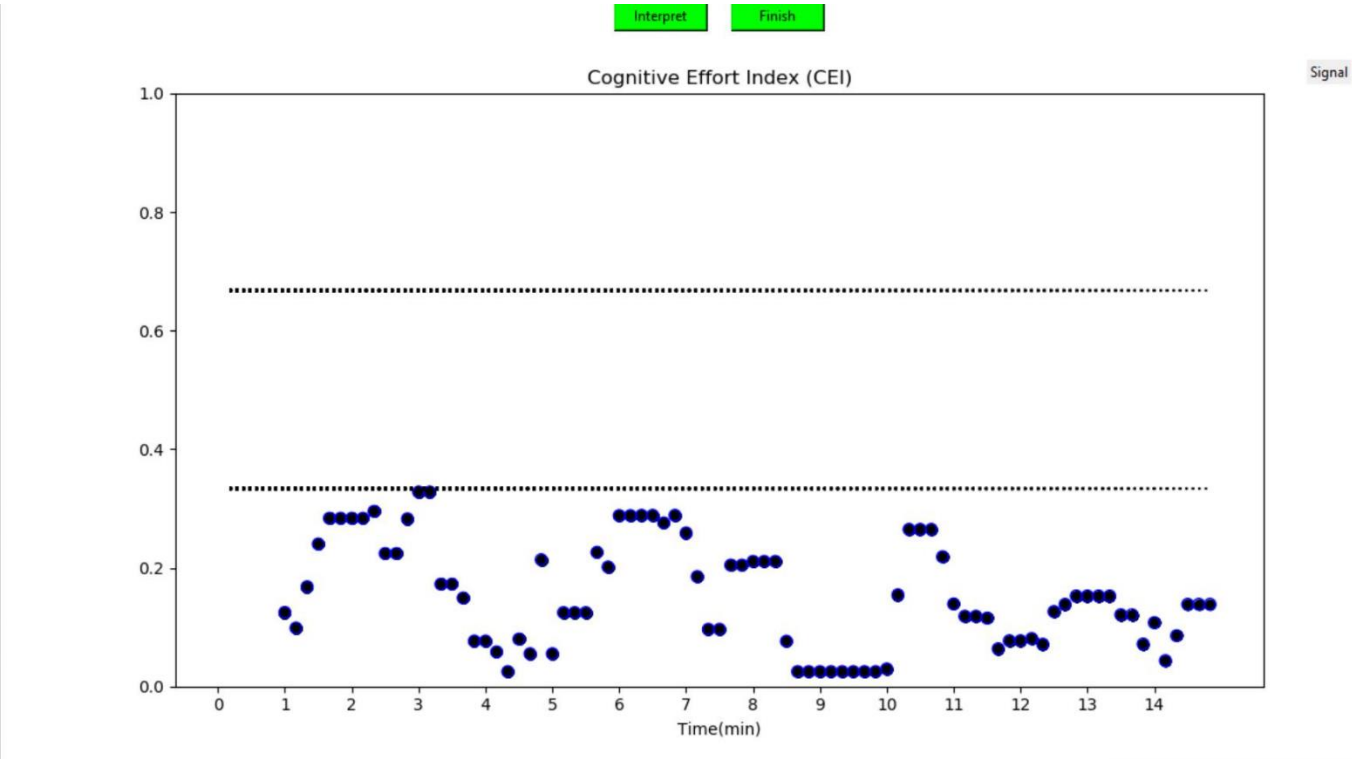
If the sample involves at-least 5 minutes of valid marker points (30 points), and assuming the majority of sampling points are valid, it will include an automatic identification of the prevailing pattern of marker dynamics in the session out of three possibilities:

An Affective pattern: if the marker tends to descend rapidly and temporarily to below the low threshold or ascend rapidly to above the high threshold, in a repetitive manner, we interpret it as patterns of avoidance or anxiousness respectively, if performance is lacking or moderate, and as relaxation after overcoming the challenge, if performance is good. Also, if the marker tends to be consistently above the high threshold we interpret it as a tendency to anxiousness, if performance is lacking or moderate, and as being in “high focus” if performance is good. All these patterns are summarized as affective.



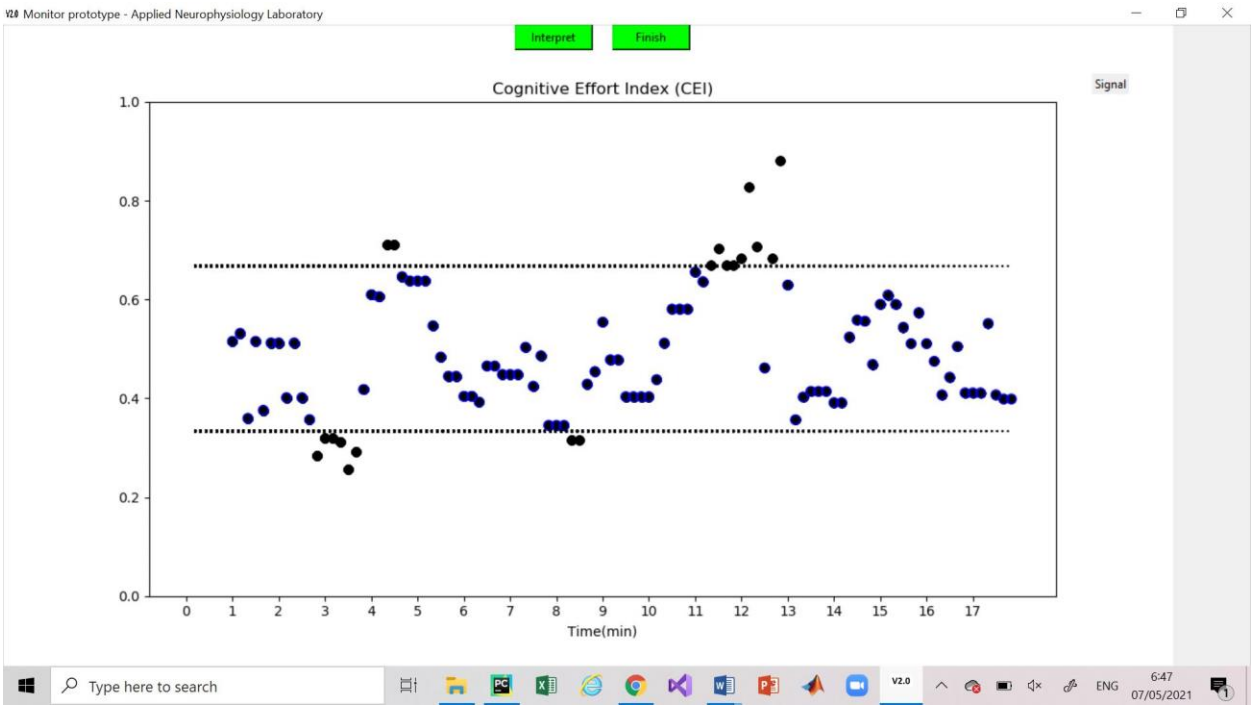
The sharp decreases and increases are then marked on the graph with blue lines. Also, sequences of points above the high threshold are encircled in blue (not shown in the example above).

The low cognitive engagement pattern: if the marker is mainly below the low threshold, we interpret it as an indication that the client was not cognitively engaged during the session.



The low range points (below the low threshold) are encircled in blue.

The effective cognitive engagement pattern: if the marker is mainly in the middle range (between the low and high thresholds) and there are no prevalent sharp descends or ascends out of this range, the pattern is interpreted as an effective attentional effort.



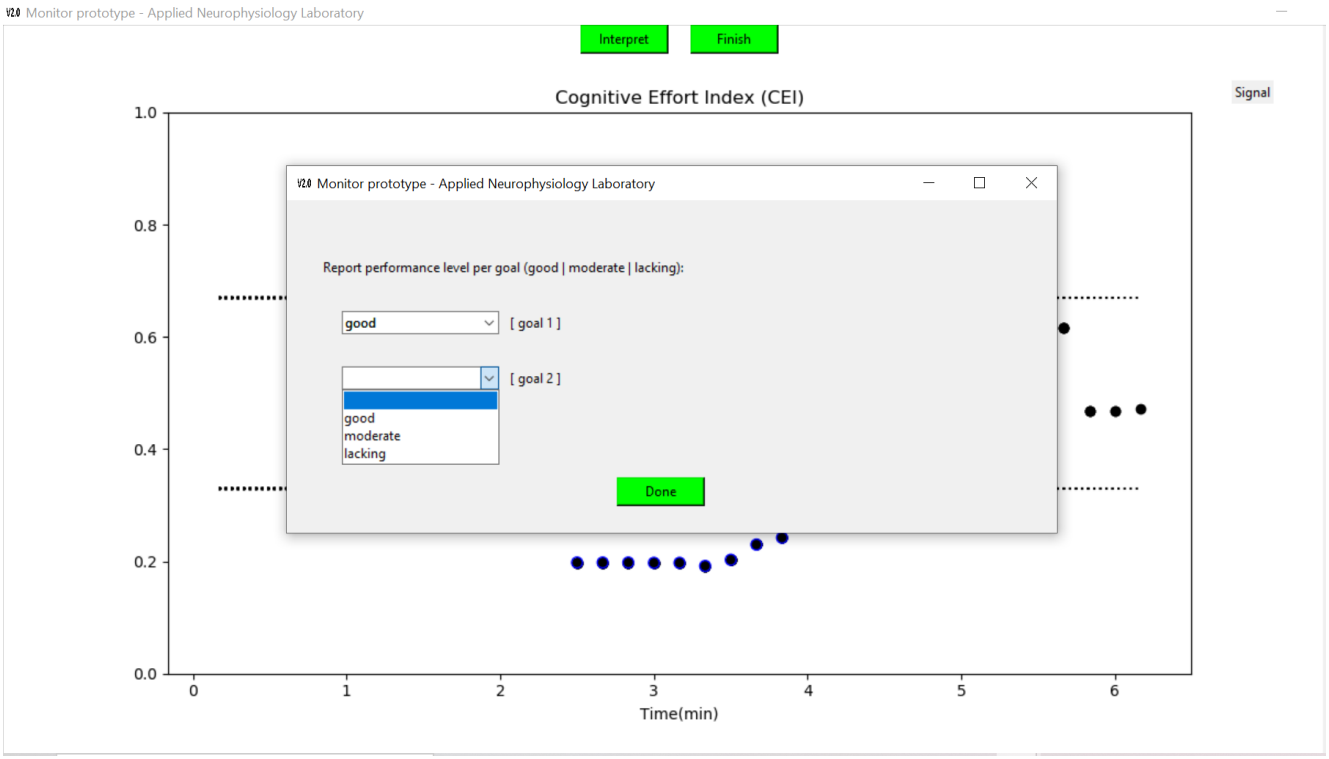
The middle range points (between the two thresholds) are encircled in blue.

5. Session interpretation

5.1. Reporting performance per goal

Thereafter, if you defined goals to the session, it is possible to select session interpretation, by pressing on the top left Interpret key. The interpretation of the marker dynamics throughout the session depends upon the client's performance. For one example, if CEI is consistently low (reduced cognitive engagement), but performance is good, it probably means that the exercises are easy for the client, however, if CEI is similarly low, but performance is lacking, it probably means that the client was not engaged by the session, either because the exercises may have been too demanding for the client's ability, or because the client may have been uninterested.

Therefore, if goals were defined at the beginning of the session, you will be prompted to report whether they were obtained. For each goal you will be asked to select whether the client reached a good level of success, a moderate level of success or whether the performance was lacking. We recommended above to select goals which are as objectively and quantifiably defined as possible. For each such goal, it is also advisable to select these three ranges of performance (good, moderate and lacking) a-priori, so as to reduce post-session subjective bias.

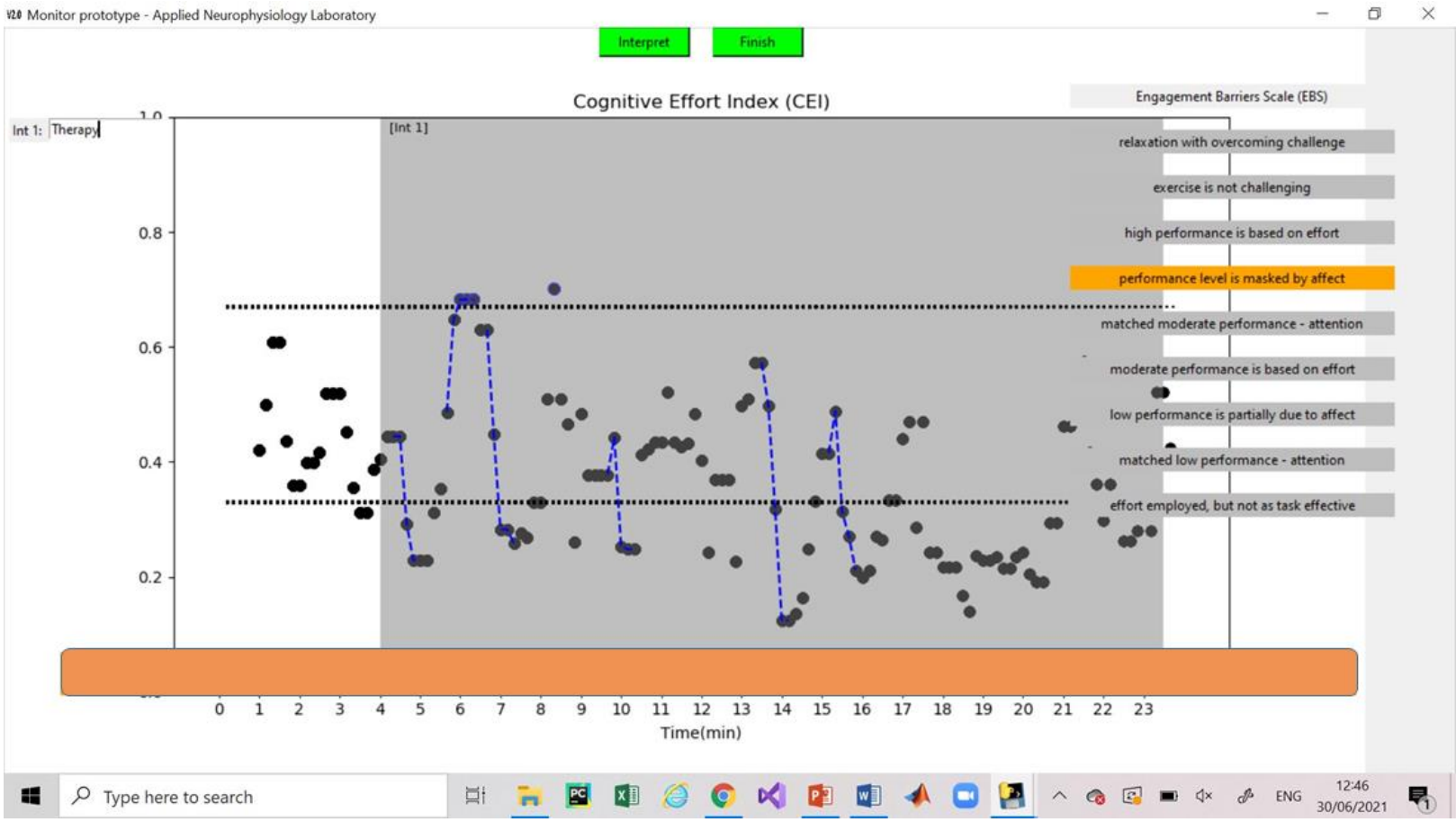


If no goals were defined at the beginning of the session and interpretation is requested, the message "Interpretation requires goals evaluation" will be presented.

5.2. The engagement barriers scale (EBS) – based on both performance and the CEI pattern

The session level of performance is computed based on weighting the importance ascribed to each goal (major or minor) in the beginning of the session and the performance of this goal (good, moderate, lacking). This overall level of session performance is again either good, moderate or lacking.

Then this level of performance is intersected with the dominant pattern, which was identified in the session (affective, low cognitive engagment or effective cognitive engagement – as described above) to generate the nine ranks of the engagement barriers scale (EBS), presented on the right. The rank, which accords with the current session results is highlighted in orange.



The bottom orange bar will contain recommendations as will be presented below (ignore it for now).

Interpretation is only provided if the sample session is long enough, with at-least 5 minutes of valid markers (30 points) and if the majority of the sampled points were valid (not noisy). If the session is too short or too noisy the message “Not enough valid points for EBS calculation” is presented.

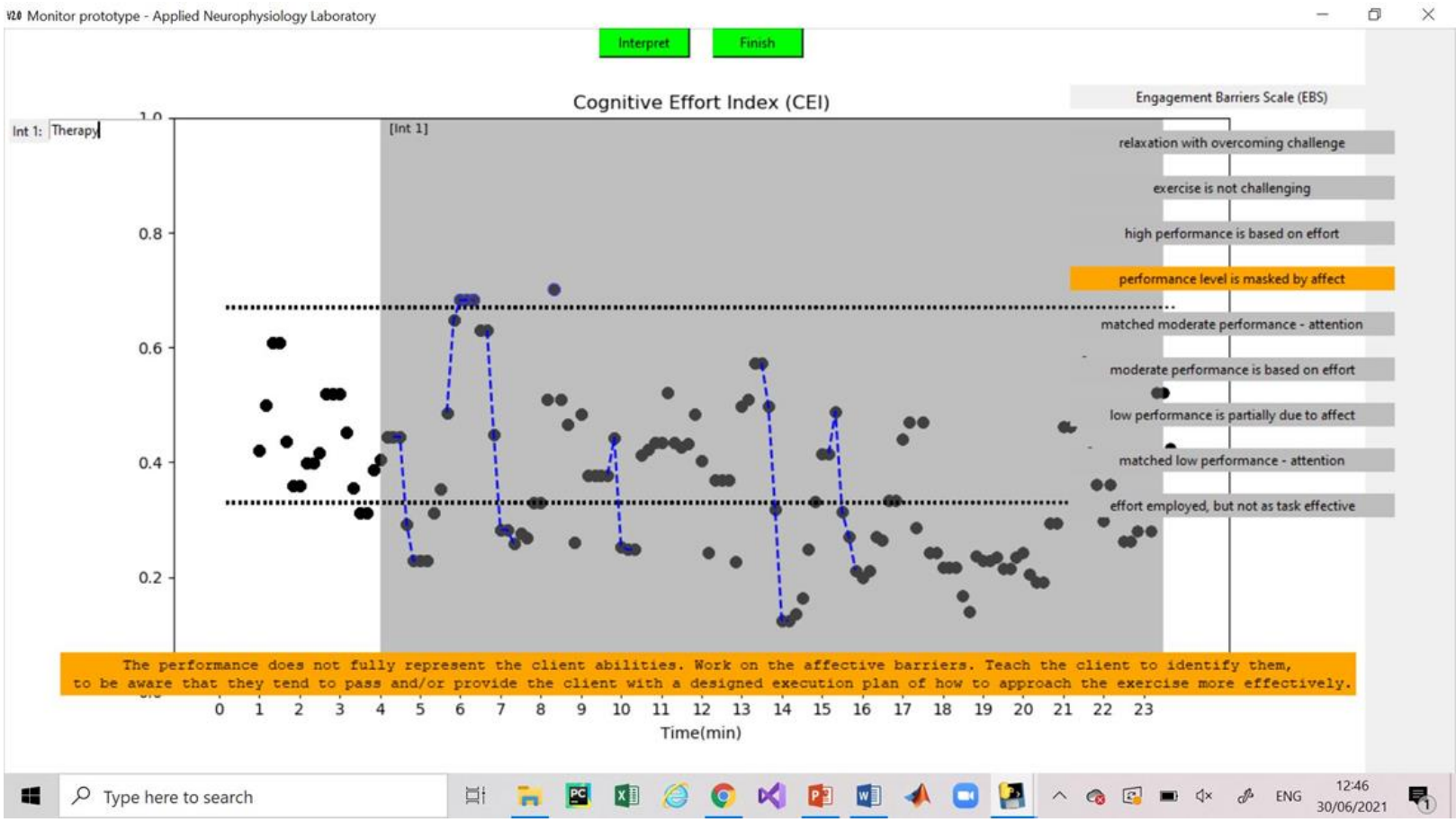
The table below shows how the nine ranks of the EBS are derived from the interaction between overall session performance and the CEI dominant pattern.

Performance: **Pattern:**	High	Moderate	Low
Affective	R1. relaxation with overcoming challenge	R4. performance level is masked by affect	R7. low performance is partially due to affect

Low cognitive	R2. exercise is not challenging	R5. true moderate performance ability	R8. true low performance ability
Effective cognitive	R3. high performance is based on effort	R6. moderate performance with effort	R9. effort employed, but not as task effective

5.3. Session type dependent interpretation and recommendation

According to the calculated EBS rank and to the session type (practice/evaluation/feedback) recommendations are generated and presented at the bottom (in the orange bar).



Below are the recommendations for each session type according to EBS rank.

<u>For practice sessions</u>

Rank 1: The exercise demands were easy for the client, but the client felt success. It is recommended to consider a higher level of demands, while maintaining the success.

Rank 2: The exercise demands were easy for the client. It is recommended to consider a higher level of demands, with increasing interest.

Rank 3: The current exercise level meets current peak ability and thus seems appropriate.

Rank 4: The performance does not fully represent the client abilities. Work on the affective barriers. Teach the client to identify them, to be aware that they tend to pass or provide the client with a designed execution plan of how to approach the exercise more effectively.

Rank 5: Consider reducing the exercise demands first, to improve the performance and only then to re-increase the demands.

Rank 6: The client is highly engaged, but consider reducing the exercise demands slightly first, to improve the performance and only then to re-increase the demands.

Rank 7: The performance does not fully represent the abilities, yet the exercise is at-least somewhat beyond the current ability. First, consider reducing the exercise demands, to improve the performance. Also, work on the affective barriers. Teach the client to identify them, to be aware that they tend to pass and/or provide the client with a designed execution plan of how to approach the exercise more effectively.

Rank 8: Consider reducing the exercise demands significantly first, to improve the performance and only then to re-increase the demands.

Rank 9: Check whether the client was engaged with some other task or may have misunderstood the exercise and the way to perform it effectively.

<u>For evaluation sessions</u>

Rank 1: The current evaluation reached a ceiling effect for the client. The client felt success solving the exercises.

Rank 2: The current evaluation reached a ceiling effect for the client.

Rank 3: The high performance represents maximal ability based on high effort and attention allocation.

Rank 4: The performance level is an under-diagnosis of the client due to affective barriers.

Rank 5: There is a matching moderate reduction in the ability.

Rank 6: The moderate performance represents maximal ability based on high effort and attention allocation.

Rank 7: The ability is at-least somewhat hindered, but the performance level might be overly reduced due to affective barriers.

Rank 8: There is a matching reduction in the ability.

Rank 9: Check whether the client was engaged with the evaluation or may have misunderstood it and the way to perform it effectively.

<u>For feedback sessions</u>

Rank 1: The media is interesting and enjoyable (first there is an increase of attention with the media induced challenges and then relaxation with overcoming the induced challenges).

Rank 2: The media is too simple for the client.

Rank 3: The media is challenging, but within reach, for the client.

Rank 4: The media induces discomfort, which moderately hinders its understanding.

Rank 5: The media is somewhat under-recruiting for the client.

Rank 6: The media is complex for the client, despite effort.

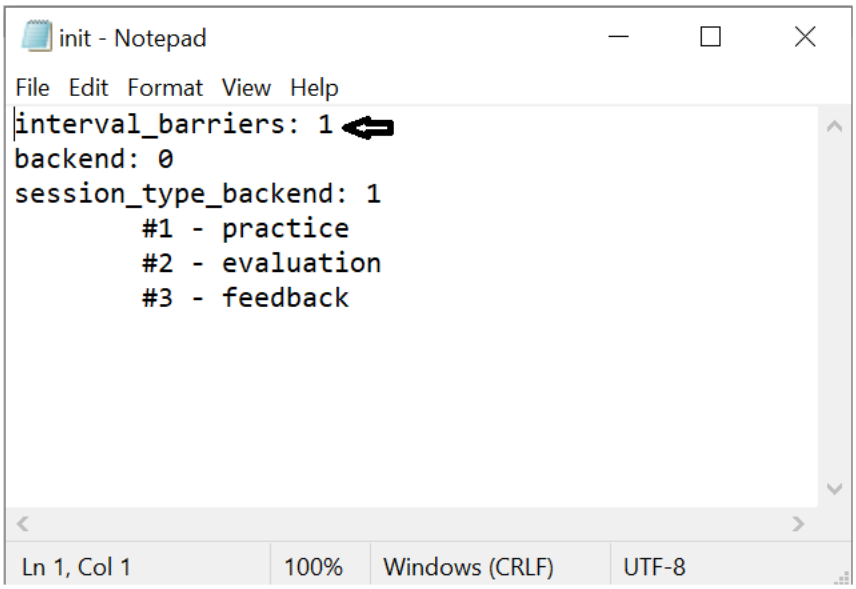
Rank 7: The media is somewhat under-recruiting for the client and also induces discomfort.

Rank 8: The media is under-recruiting for the client.

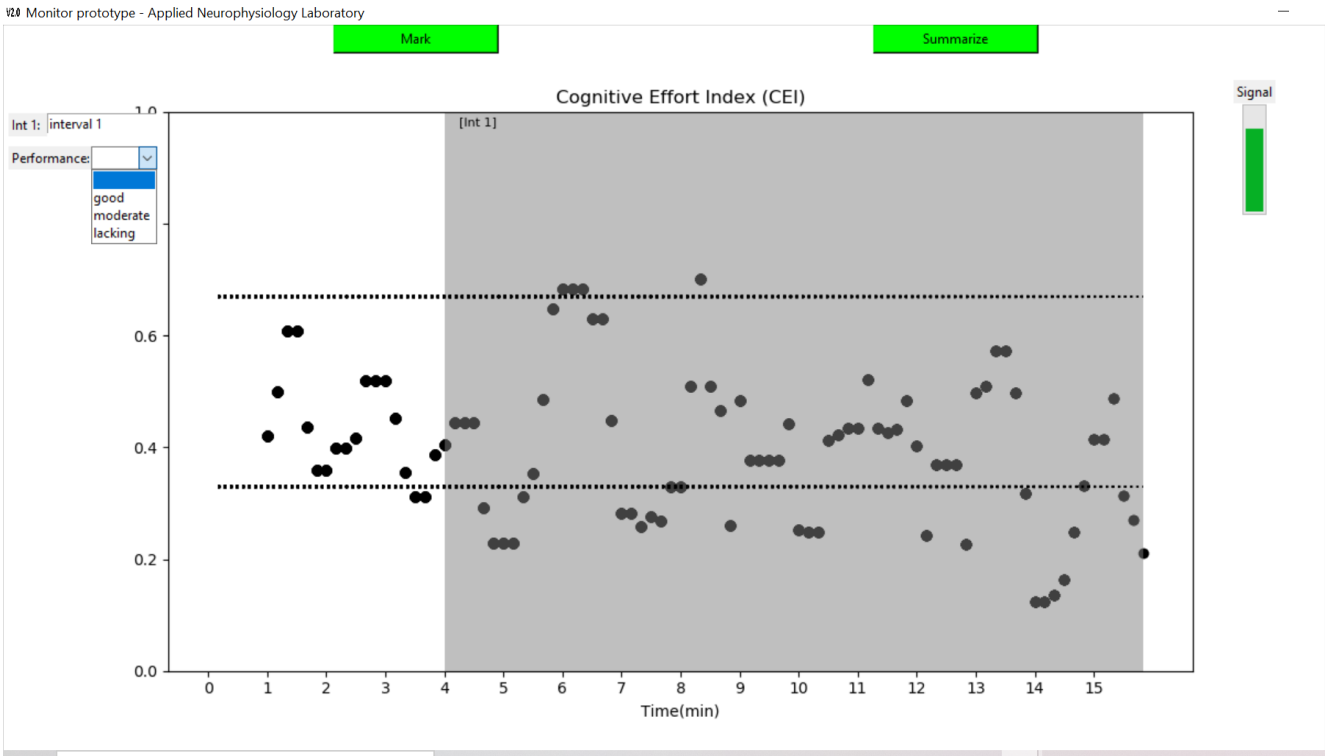
Rank 9: Check whether the client was engaged with the media.

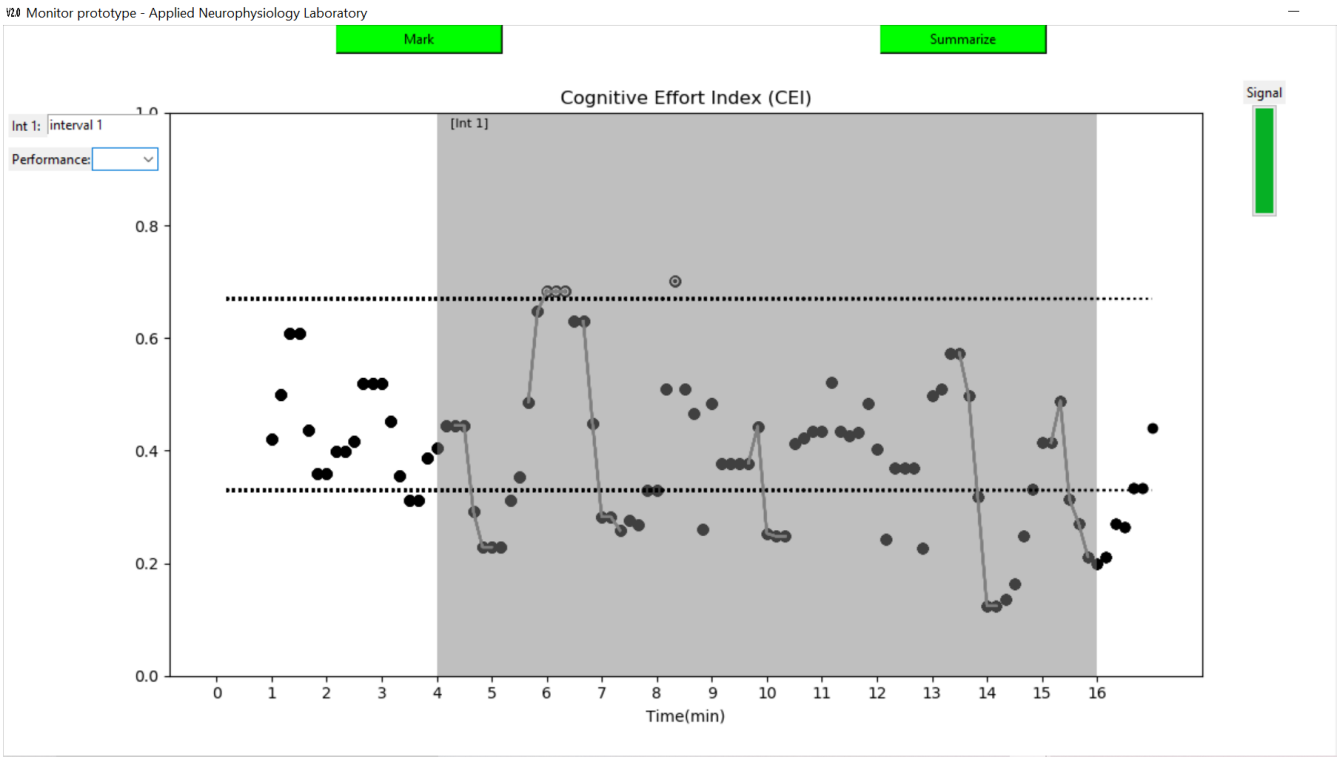
6. Real-time and interval-based marking of dominant pattern and its interpretation

In the application directory there is an init file, in which the parameter interval_barriers is 0 by default. Changing this parameter to 1 as marked below with an arrow, and saving the file before activating the application, enables real-time feedback regarding the dominant pattern at the level of single intervals, provided they contain at-least 5 minutes of mainly valid sample points. Shorter intervals might be grouped together for the analysis of the dominant pattern.

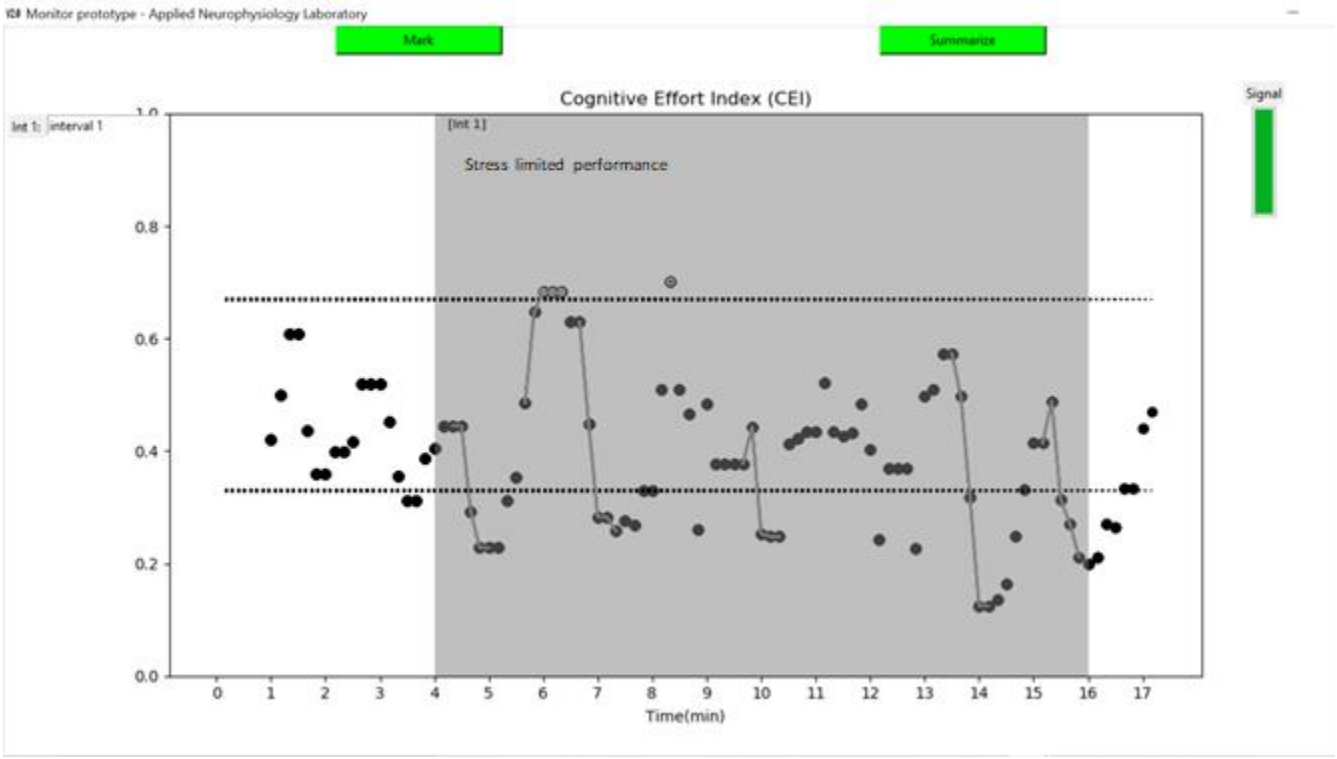


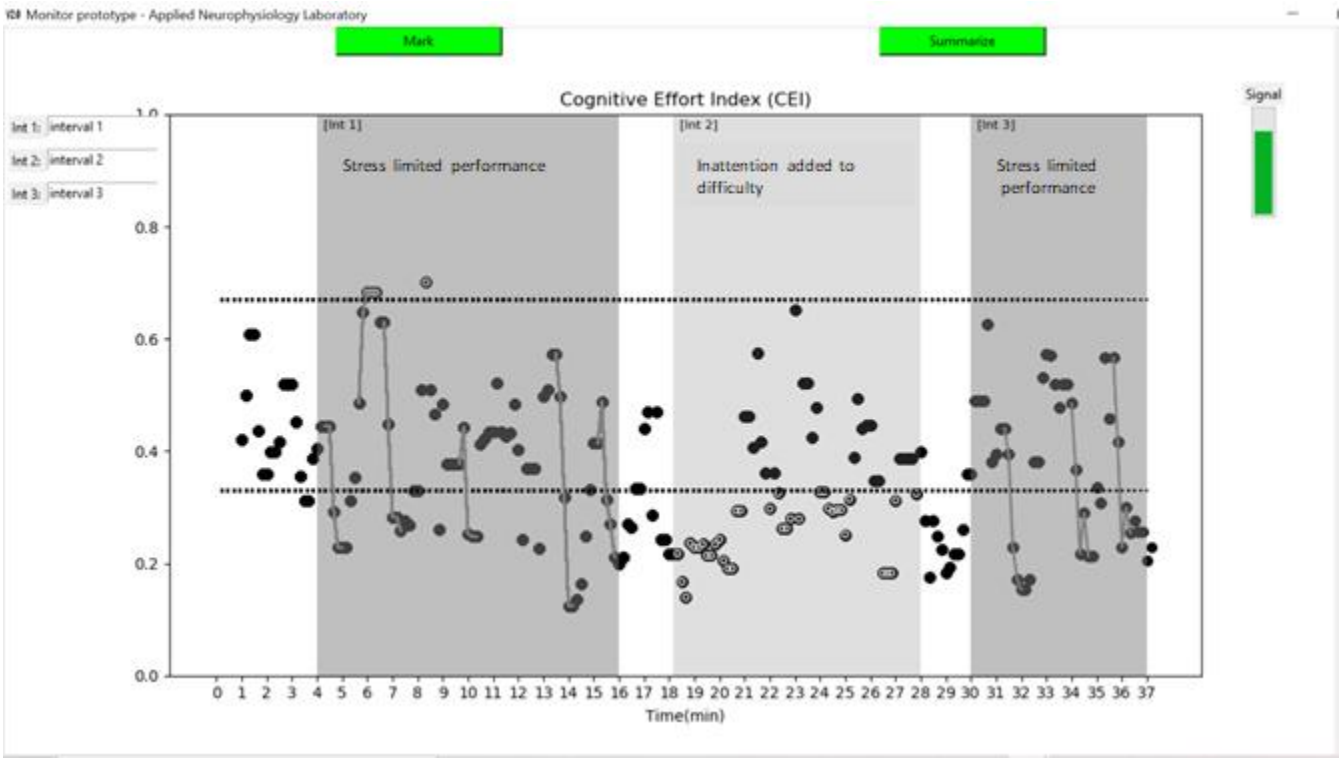
During the run, whenever the end of the target interval is marked, a scroll-down menu is opened in order to enable the reporting of the client's performance during the interval among the options of good/moderate/lacking. Simultaneously the prevalent pattern of the interval is marked in grey as the either sharp changes which characterize affective dynamics, the prevalent low values which characterize reduced cognitive engagement, or prevalent middle range values which characterize cognitive effort.


Monitor prototype - Applied Neurophysiology Laboratory
Mark
Summarize
Cognitive Effort Index (CEI)
Signal
Int 1: interval 1
Performance:
good
moderate
lacking
[Int 1]
1.0
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Time(min)

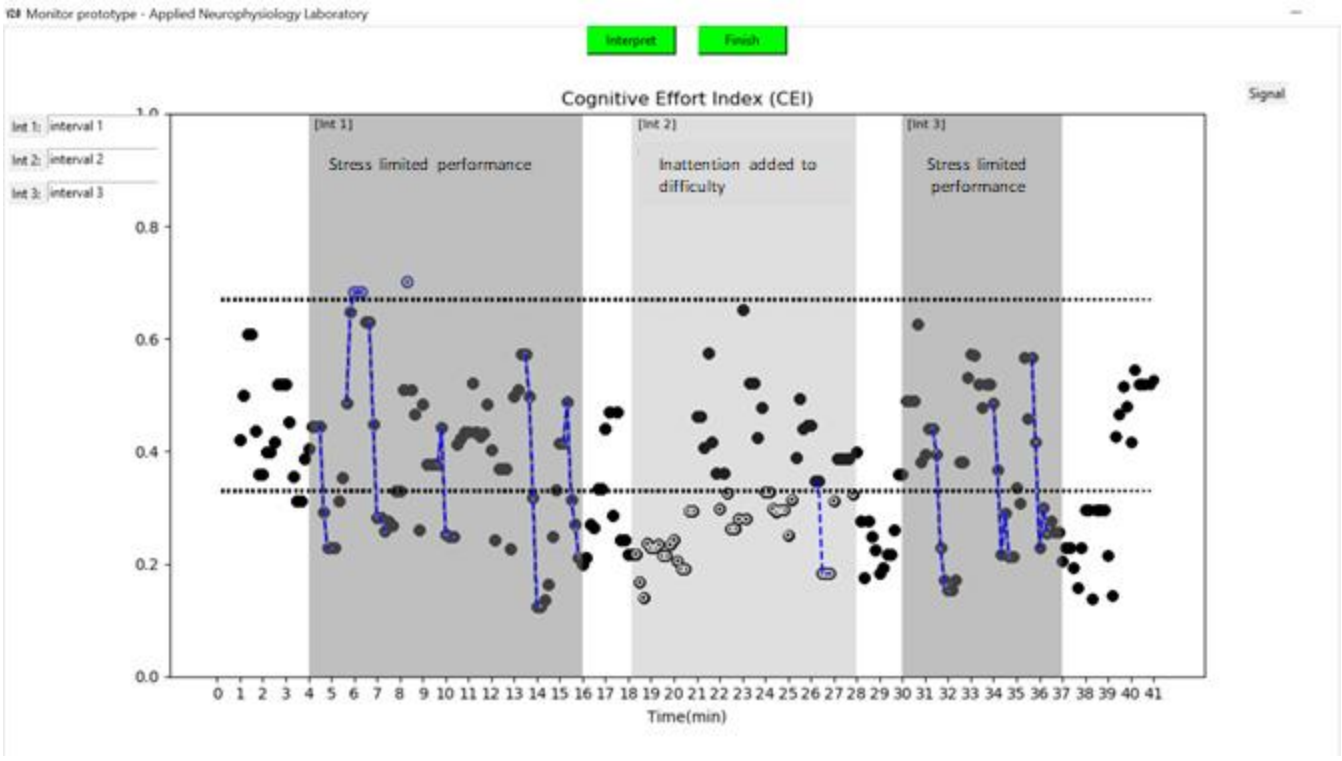

Monitor prototype - Applied Neurophysiology Laboratory
Mark
Summarize
Cognitive Effort Index (CEI)
Signal
Int 1: interval 1
Performance:
[Int 1]
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Time(min)

Once the level is performance is reported, the rank [1-9] is computed by combining the prevalent pattern, which was recognized and the performance, as is explained above. The rank derived brief description is then presented near the top of the marked interval.

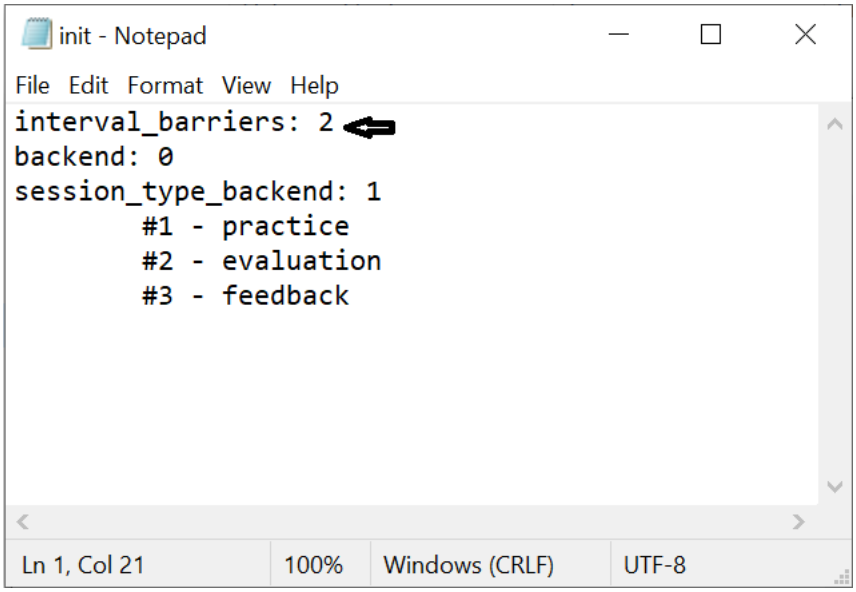




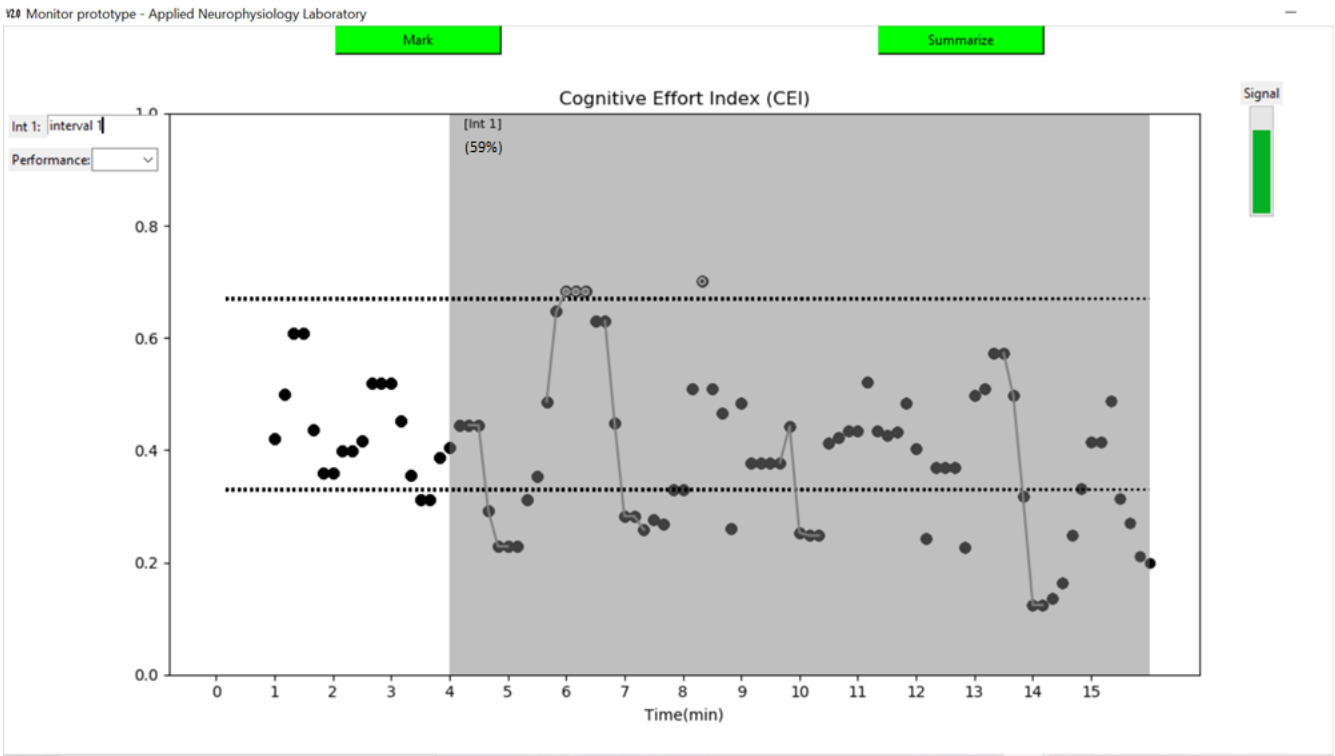
By the end of the session, the blue marks denote the prevalent overall pattern for the entire session, while the grey marks denote the interval patterns. Note that in case of overlap the pattern will be marked in blue.



Changing the interval_barriers parameter in the init file to 2 will generate a score for each interval of at-least 2 minutes of valid sample.

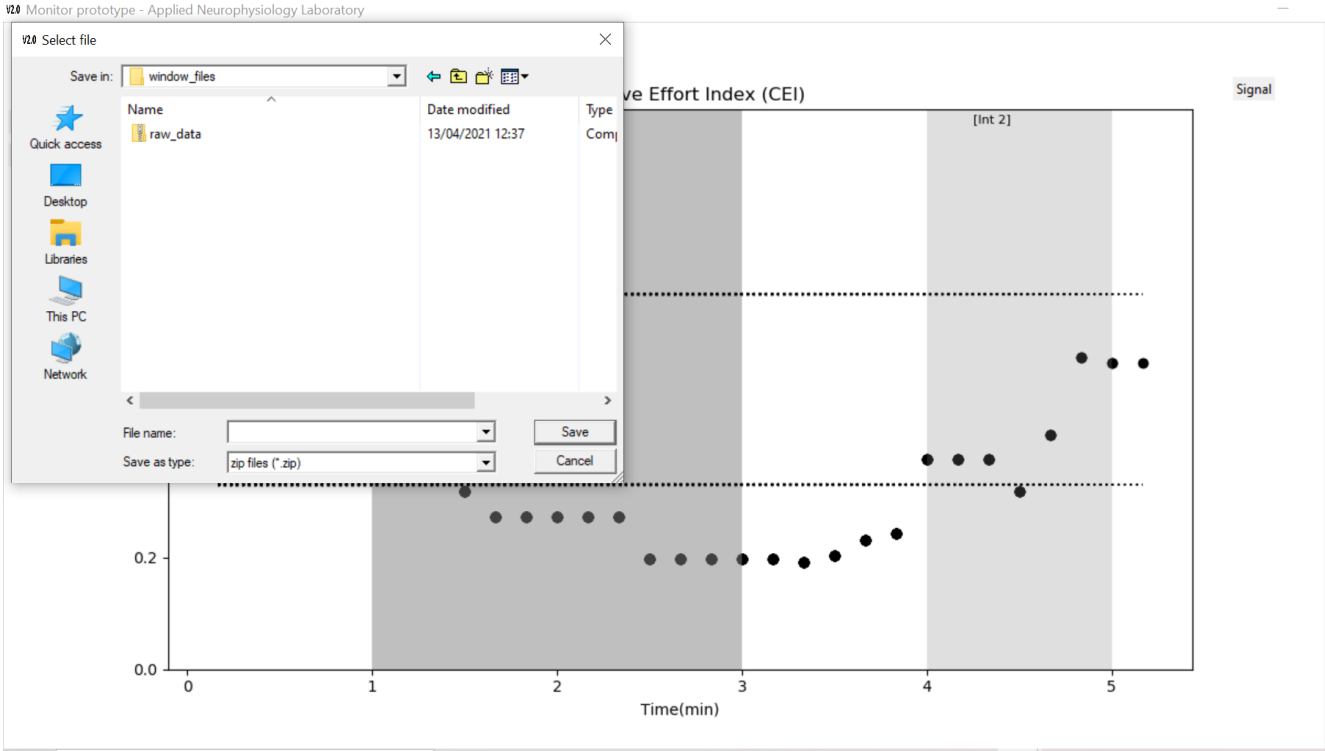


The score denotes the percentage of CEI values within the middle (effective) range out of the total valid CEI values, and is also presented near the top of the marked interval.



7. Saving session data:

Once you press the top right finish key you are prompted to save the session results.



The files that are saved are:

- the goals file, which presents the session goals and the degree to which each goal was obtained

- the intervals file, which specifies the intervals and their start and end point

- The markers file, which presents the CEI value every 10 seconds (-2 denotes a noisy point)

- The screenshot of the graph without interpretation

- The screenshot of the graph with interpretation

- The raw electrophysiological 10 second window files (numbered by file order) chunked as raw_data

- The global barriers file, which marks the positions of the barrier (1 – affect | 2 – cognitive | 3 - none)

- The global outcome file, which includes the global barrier and the rank no.

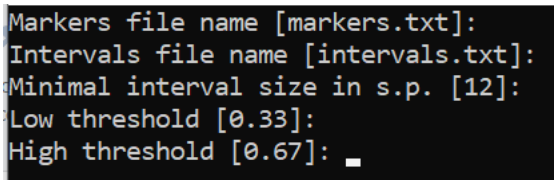
- The int barriers file, which marks the values and positions of the different interval barriers

8. Availability of an Application Programming Interface (API)

The application supports a basic API which enables getting the CEI values, as well as indications regarding the prevailing patterns in intervals (affective dynamics, low cognitive enagement or effective cognitive effort), in real-time, for the development of desired tools. If you are interested in using the API, please send us a detailed request, in which you present yourself, your organization and the proposed tool for which you are interested in the API. Requests should be addressed to godeds@gmail.com. The decision whether to enable API would be done at a project basis as it requires further effort on our side.

9. Basic offline quantitative analysis

Multiple types of analysis could be performed with the sampled data and it is important to select the analysis, which is most appropriate for your research question. A basic analysis, which is relevant in multiple types of studies involves the percent of marker points within the effective range, between the low and high thresholds out of the overall valid sample points. To support this option and to enable it also by intervals, we provide the offline tool – analyze_CEI_sample, which could be found in the application directory. This tool receives as an input the markers file, the intervals file, the minimal interval size in sampling points, and the defining values for the effective range (low threshold and high threshold). Pressing <enter> for each parameter would select the default values, presented in square parentheses.



It then generates the CEI_statistics file, which shows the distribution of points below the low threshold, between the low and high thresholds and above the high threshold. It also shows the overall distribution of marker points and the distribution of all points, and of all points within and outside intervals. On the right, the low and high thresholds, and the minimal interval size in sampling points, are presented.

Int#	Desc	Start (sec)	End (sec)	Length (pts)	Invalid (pts)	Low (%)	Middle (%)	High (%)	Lthresh [0.33]	Hthresh [0.67]	Mint [12]
1	interval 1	250	960	71	0	39	55	6			
	All	0	2460	246	5	48	50	2			
	Intervals	0	2460	71	0	39	55	6			
	Unmarked	0	2460	175	5	52	48	0			

10. Troubleshooting

When the application is activated, a backend (black) window is also opened. During a normal run this window is empty. However, if CEI values are not presented consistently in the graph of the main window, it is of value to view potential messages in the backend window for the purpose of debugging.

The following causes for missing values could be considered:

- If the message in the backend window is “Cannot connect to device”, it means that the NeuroSky headset is not connected with the computer. Please consult with NeuroSky recommendations for device communication problems.

- If the message in the backend window is “Poor signal”, it either means that the electrodes are not placed tightly on the skin, or that the battery is not sufficiently charged.

- If CEI values are missing and the backend window remains empty, it might mean that the client contracts strongly the frontalis muscle which could be corrected with a little relaxation, or alternatively that there is an insolating layer, which could be washed with a wet paper towel.

Contact for additional queries

Goded Shahaf

Please send email to godeds@gmail.com, or call 972-50-2062334