fnirSoft A Quick Start Guide





www.biopac.com

fNIR Systems from BIOPAC

Please refer to fnirSoft in your publications with the following:

Ayaz, H. (2010). "*Functional Near Infrared Spectroscopy based Brain Computer Interface*". PhD Thesis, Drexel University, Philadelphia, PA.

Disclaimer

THIS SOFTWARE IS PROVIDED "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Table of Contents

1.	In	trod	uction	6
	1.1.	F	unctional Near Infrared Spectroscopy	6
	1.2.	N	Nodified Beer Lambert Law	6
2.	Q	uick	Start1	0
	2.1.	0	0verview1	0
	2.2.	Lo	oading Raw Light Intensity (*.nir) Files1	2
	2.3.	Le	oading Event Marker (*.mrk) Files1	6
	2.4.	Р	reprocessing Raw Light Intensity Data1	8
	2.	4.1.	Rejecting Optodes/Channels1	8
	2.	4.2.	Defining Exclude Regions2	0
	2.	4.3.	Applying Low-pass Filter2	3
	2.	4.4.	Applying Motion Artifact Rejection (SMAR)2	6
	2.5.	C	alculating Oxygenation (MBLL)2	9
	2.6.	Lo	oading Oxygenation/Hemoglobin (*.oxy) Files3	2
	2.7.	Р	reprocessing Raw Hemoglobin Data3	4
	2.	7.1.	Rejecting Optodes3	4
	2.	7.2.	Defining Exclude Regions3	7
	2.	7.3.	Applying Low-pass Filter4	0
	2.	7.4.	Applying Detrending4	3
3.	Bl	ock /	Analysis4	6
	3.1.	D	efining Blocks4	6
	3.	1.1.	Defining Blocks using Markers4	8
	3.	1.2.	Define Blocks using Time5	2
	3.	1.3.	Defining Blocks using Markers and Time5	4
	3.2.	U	Ising Blocks	6
	3.	2.1.	Saving Blocks as Variables in Dataspace5	6
	3.	2.2.	Exporting Blocks directly to a Matlab™ File5	9
	3.	2.3.	Exporting Blocks directly to a Text File6	2

fS **2018**

4.	Dat	taspac	e	65
4	4.1.	Savi	ng and loading fnirSoft data (*.fsd) files	65
4	4.2.	View	ving a variable	66
	4.2	.1.	Single variable temporal graph	68
	4.2	.2.	Single variable bar graph	71
	4.2	.3.	Editing axis titles for graphs	72
	4.2	.4.	Editing and moving legend display	73
	4.2	.5.	Saving graphs as image or copying to clipboard	74
4	4.3.	View	ving multiple variables	75
	4.3	.1.	Add/remove variables to the current view	76
	4.3	.2.	Add/remove tabs to the current view	78
	4.3	.3.	Multi-variable bar graph	79
	4.3	.4.	Multi-variable temporal graph	81
	4.3	.5.	Multi-variable aggregate temporal graph	82
	4.3	.6.	Multi-variable aggregate & grouped temporal graph	84
5.	Pro	cessin	g Tool	88
!	5.1.	Sele	ct input variables	89
!	5.2.	Sele	ct actions	89
1	5.3.	Stati	istical comparison and tests	92
!	5.4.	Usin	g MBLL to calculate oxygenation from variables	94
6.	Exp	oort Da	ata Tool	96
7.	Imp	oort Da	ata Tool	99
8.	Org	ganizei	r Tool	. 103
9.	Тор	oograp	bh Tool	. 105
9	9.1.	Visu	alize activations on brain surface image	. 110
9	9.2.	Save	e activations as image	. 112
9	9.3.	Save	e activations as video	. 113
10	. L	ightgr	aph Tool	. 115
11	. (Dxygra	iph Tool	.116
12	. C	Define	Block Automation	. 117
	12.1	Defi	ne Preset	. 117

fS **2018**

12.1	l.1.	Using 'Define Block' dialog	117
12.1	L.2.	Using Automation dialog	118
12.2	Defi	ne Automation	122
12.3	Usin	g Automation	124
Referenc	:es		126

1. Introduction

fnirSoft (fS) is a stand-alone software package designed to process, analyze and visualize functional near infrared (fNIR) spectroscopy signals through a graphical user interface and/or scripting (for automation). This section provides an introduction to the fNIR technology and discusses Modified Beer Lambert Law (MBLL) that is integral to the analysis of fNIR spectroscopy signals. The next chapter provides step-by-step guide for using fS. For information about fnirSoft programming and command line options, please refer to fnirSoft Scripting Manual.

1.1.Functional Near Infrared Spectroscopy

fNIR is an optical brain monitoring technology that monitors changes in hemodynamic response within cortex [1-3] and has been used to assess cognitive and motor task related brain activity [4-11]. fNIR technology uses specific wavelengths of light, introduced at the scalp, to enable the noninvasive measurement of changes in the relative ratios of deoxygenated hemoglobin (deoxy-Hb) and oxygenated hemoglobin (oxy-Hb) in the capillary beds during brain activity. This technology allows the design of portable, safe, affordable, noninvasive, and minimally intrusive monitoring systems.

Our focus here is analysis of continuous-wave fNIR signals collected by the fNIR Devices. The system is composed of two parts: a hardware box and a flexible sensor pad that is placed over the forehead of subjects. With a fixed source-detector separation of 2.5 cm, this configuration generates a total of 16 measurement locations (optodes) with at least two wavelengths each. The sensor pad as shown in Figure 1 below. The hardware box is connected to a computer via a standard universal serial bus (USB) cable for data acquisition and control via Cognitive Optical Brain Imaging (COBI) Studio [6]. The system records two wavelengths and dark current for each 16 optodes, totaling 48 measurements for each sampling period. The sampling rate of the latest generation systems are up to 10Hz.



Figure 1. fNIR sensor pad (fNIRDevices.com)

1.2.Modified Beer Lambert Law

For a medium that contains chromophores (light absorbing molecules) and no scattering, the Beer-Lambert Law states that the ratio of incident and response (detected) light intensity is proportional to the concentration of the chromophore in the unit length of the medium:

$$\log(\frac{I_0}{I}) = \alpha cL \tag{1}$$

where I_0 is incident light intensity and I is the detected light intensity. c is the concentration of the chromophore. L is the distance from where light enters the tissue to where it leaves the tissue. Finally, α is the absorption coefficient of the chromophore.

However, tissue is a highly scattering medium and L does not reflect the true path length. Scattering significantly prolongs the path length of light. To account for that, the modified Beer-Lambert law can be used:

$$\log(\frac{I_0}{I}) = \alpha c L B + G \tag{2}$$

where I_0 , I, c, α and L are the same as in the previous equation. B is an experimentally determined correction factor for L. G is constant attenuation factor related to optical properties and geometry of the tissue. If measurements are made of the changes in attenuation, the Modified Beer Lambert Law can be rearranged as follows:

$$\Delta c = \frac{\Delta OD}{\alpha LB} \tag{3}$$

where
$$OD = \log(\frac{I_0}{I})$$
 (4)

To calculate changes in the concentrations of the chromophores, we need to compare two measurements: one from the subject in a "rest" state as a baseline, and one during the presentation of the stimulus or "test" condition. This comparison can be expressed as follows:

$$\Delta OD = \log(\frac{I_0}{I_{test}}) - \log(\frac{I_0}{I_{rest}})$$

= log(I_{rest}) - log(I_{test})
= log(\frac{I_{rest}}{I_{test}})(5)

where I_{rest} is the measured reflected light intensity in the baseline condition, and I_{test} is the reflected light intensity during the presentation of the stimulus.



Figure 2 Absorption factors of 3 main chromophores in tissue

Brain tissues have three significant chromophores: water, oxy-hemoglobin (oxy-Hb) and deoxy-hemoglobin (deoxy-Hb). In functional brain imaging applications, the main interest is to monitor oxy-Hb and deoxy-Hb concentration changes. Within the 700-900nm range, also called as 'optical window', tissue is relatively transparent because all significant chromophore absorption factors are low. The dominant chromophores in the optical window are oxy-Hb and deoxy-Hb, and their concentration changes can be calculated using Equation 3. Absorption factors of the three main chromophores with respect to wavelength are given in Figure 2. Within the optical window, there is an isosbestic point where the absorption spectra of oxy-Hb and deoxy-Hb cross. Measurements by choosing two wavelengths, one below and one above this isosbestic point, could reveal the individual effects of oxy-Hb and deoxy-Hb.

$$\begin{bmatrix} I_{out} & I_{in} \\ \text{light} \\ \text{detector} \\ \text{source} \\ \text{bight} \\ \text{source} \\ \text{bight} \\ \text{source} \\ \text{Having the same } I_{in} \text{ at two different instances} \\ \text{Having the same } I_{in} \text{ at two different instances} \\ \Delta OD_{\lambda} = \log(\frac{I_{rest}}{I_{text}}) = \varepsilon_{\lambda}^{HB} \Delta c^{HB} d DPF + \varepsilon_{\lambda}^{HBO_{2}} \Delta c^{HBO_{2}} d DPF \\ \text{Measuring at two different wavelengths} \\ \begin{bmatrix} \Delta OD_{\lambda 1} \\ \Delta OD_{\lambda 2} \end{bmatrix} = \begin{bmatrix} \varepsilon_{\lambda 1}^{HB} d DPF & \varepsilon_{\lambda 1}^{HBO_{2}} d DPF \\ \varepsilon_{\lambda 2}^{HBO_{2}} d DPF & \varepsilon_{\lambda 2}^{HBO_{2}} d DPF \end{bmatrix} \begin{bmatrix} \Delta c^{HB} \\ \Delta c^{HBO_{2}} \end{bmatrix} \\ \text{F} \end{bmatrix}$$

Can be solved for Concentrations for non-singular F matrix

2. Quick Start

This section provides a step-by-step tutorial for basic tasks required for data analysis. Each step is illustrated by screen captures. For information about fnirSoft programming and command line options, please refer to fnirSoft Scripting Manual (2018).

2.1.0verview

Below is the main window of fnirSoft with common user elements and tools identified.



fnirSoft includes a scripting engine, so commands written to the "command prompt" at the bottom of the window are executed by pressing "Enter" on your keyboard. The command prompt can also

evaluate algebraic expressions. For more information about syntax, see the fnirSoft Scripting Manual. The rest of this chapter will detail basic steps in fNIR signal processing with graphical user interface elements.

TIP

Type "2 +3" (without quotes) at the command prompt and press enter. You should see the result 5 at the output pane.

TIP

Intellisense is available at command prompt and editor. Try typing fs following by '.' (dot) character to show intellisense dropdown menu. As you continue typing, options are updated. Hover your mouse to see information about the item in a tooltip. Context help windows appear for functions when you type a valid function name followed by '(' open-parenthesis character. This pop-up windows shows information about the command, its parameters and sample usage. For more information, click "Open Command Help Explorer" link.



TIP

Use **Organizer Tool** to keep track of your experiment data files. Organizer Tool visualizes summary information about your data, allows you to sort, view, group, and access all your files.



Change View Type (Details list or i descending and change Group By	icons), change Sorting (by to show all data categorized	experiment features) bot ascending or ed by selected features.
View Type * Sort By * Group By * 21 Details Small Icons Large Icons Large Icons June Point P	View Type • Sort By • Group By • 21 JDH UDH_1020_1_111116 VIEW Top PH 021 VIEW Type VIEW Type VIEW Type VIEW Type VIEW Type Start Time Start Time	ort By • Group By • Experimenter Subject ID Experiment ID Collection Path Ascending Descending Start Time

- 2.2.Loading Raw Light Intensity (*.nir) Files
- 1. Click on the 'Lightgraph' at the toolbar of main window. This will open a new Lightgraph window.



2. In the Lightgraph window, click on the 'Load Data' Button at the lower left corner of the window.



3. A file selection window will appear. COBI data files (*.nir) are filtered and shown by default. Lightgraph tool only recognizes also recognizes event marker (*.mrk) files and also the

associated experiment log (*.log) files. Marker and log files can be automatically loaded with the main NIR file (see next step). Just select one NIR file and click open button.

1 23	Open			×
🛞 🌛 🔻 🕈 퉬 « Docum	ents → fnirSoft → Sample Data	~ Ċ	Search Sample Data	,o
Organize 🔻 New folder				0
★ Favorites	HA_10_2_05310934.nir fnirSoft Light File 45.8 KB	fs Nir	HA_25_1_07301658.nir fnirSoft Light File 345 KB	
This PC	HA_32_1_11191152.nir fnirSoft Light File 282 KB			
Documents Downloads Music Control				
File <u>n</u> ame:	HA_10_2_05310934.nir	~	COBI Studio Nir Data File (*.n Qpen Cance	ir) ∨ tl

4. If the selected file is part of an experiment saved by COBI, it might be accompanied by one or more marker files for time and event information. If 'Skip' button is clicked, these files will be ignored. Click 'Load' to also load the associated marker files with the data file.

lightgraph1 C:\Users\	,Hasan\Documents\fnirSoft\Sample Data\HA_10_2_053109
	Do you want to also load the related marker (event) file?
$\left(\circ \circ \right)$	Current data file has associated marker file:

	Do you want to also load the relate	a marker (eve	nı) me <i>r</i>
	Current data file has associated marker file:		
	C:\Users\Hasan\Documents\fnirSoft\Sample	e Data\HA_10_2_0	5310934_C.mrk
$\langle - Q \rangle$			
		Load	Skip

5. Measurements from all channels in the selected file will be displayed in the graph. If a marker file was loaded, vertical lines corresponding to the markers will be displayed as well. The *'Properties'* pane on the right-hand side provides information about the current data file.



6. The data can be also displayed in 2-by-8 format (in the sensor's optode layout). This view shows data for each optode and channel individually, in an arrangement corresponding to the actual arrangement of the sensors used. To select this view, right click on the graph and select *Optode Layout View*. This will open the following window.



TIP

Each graph can be enlarged by

- double-clicking on the graph or
- right-click and selecting 'Enlarge' from the context menu of the graph.

Note: Performing the same operation will bring back the 2-by-8 view.

TIP

If you resize the window, the graphs will be automatically refreshed, and this can also be manually initiated by one of the following:

- Click on Update button (lower right-hand side corner) or
- Right-click and select 'Update' from the context menu or
- Left-click on the graph

TIP Left or right click on a graph will highlight the graph (with red borders). Use CTRL+click to unselect or multi-select.

7. When there are many markers, they can occlude the graphs. To hide marker information, right click on any graph and select *Toggle Marker Visibility*. This will update all graphs.

8 8	lightgraph1	Optode Layout	View (Temporal 2x8) C:\Users\Hasan	\Documents\fnirSo	ft\Sample Data\HA	_10_2_05310934.nir	- 🗆 🗙
4400 - 3900 - 3400 - 2900 - 1900 - 1400 - 900 - 400 -		3-	5	7	9-		13	15
-100 - 4400 - 3900 - 2900 - 2900 - 1900 - 1400 -	2	4	6	8		12	14	16
900 400 -100 Save	24.2 91.1 24	1.2 91.1	24.2 91.1 2	4.2 91.1	24.2 91.1	24.2 91.1	24.2 91.1 2	4.2 91.1 Update

2.3.Loading Event Marker (*.mrk) Files

Marker files that are associated with fNIR data files are automatically recognized and will be loaded with the respective fNIR data file if using default settings. However, if data were not recorded in the 'Experiment mode' of COBI, marker files are not associated with the data file. In this case, 'Load File' button can be used to select a marker file to load.



1. Click the 'Load File' button at the bottom of the main graph window.

2. Select the marker file to load.

8 8	Open	×
🔄 🦻 🗉 🕇 🔋	🖁 « Documents 🕨 fnirSoft 🕨 Sample Data	✓ ♂ Search Sample Data
Organize 🔻 No	ew folder	N= ▼ 🔟 🔞
☆ Favorites	A HA_10_2_05310934_C.mrk fnirSoft Marker File 264 bytes	HA_25_1_07301658.mrk fnirSoft Marker File 535 bytes
ConeDrive	HA_32_1_11191152_C.mrk fnirSoft Marker File 252 bytes	Change filter to Marker files
Music	¥	
	File <u>n</u> ame: HA_10_2_05310934_C.mrk	✓ COBI Studio Marker File (*.mrk) ✓ Open Cancel

Once a file is selected and loaded, all markers are displayed on graph immediately. Note that each NIR file by default has the -1 (end of recording), -2 (start of baseline),-3 (end of baseline),-4 (baseline values ready) and -5 (record button is pressed) markers and these are shown in orange

color. Other markers groups have different color. All markers loaded from the same file will have the same color.

Note here that, same marker file is loaded again, and that's why all such markers appear double below. Also,



TIP

You can view a list of all loaded markers click on the "Events/Markers" item in the properties pane (right-hand side) within "Experiment Data" group. A small button ("...") will appear next to it, click on the button to see the collection as below:



2.4. Preprocessing Raw Light Intensity Data

The necessary steps for preprocessing may change depending on the current data and experiment protocol. Also, if oxy files are used light intensity preprocessing would be skipped entirely, but not recommended. If the data is noisy, it is advised to apply a linear phase, low pass filter that attenuates high frequency components of the signal. Furthermore, certain channels, or time periods may need to be excluded due motion artifact, saturation or noise. fnirSoft can be used to design and apply window-based finite impulse response (FIR) filters.

2.4.1. Rejecting Optodes/Channels

To exclude all data from an optode, first, go to "Optode Layout View" window and reject or accept the selected optode from the "Evaluate" option at the context-menu (by right-click).

- _ 🗆 🗙 lightgraph1 | C:\Users\Hasan\Documents\fnirSoft\Sample Data\HA_10_2_05310934.nir -5 1 êi <u>A</u>↓ 🖻 A. Experiment Properties fNIR Device 1. Hardware 2. Software Right-click to open context COBI Studio fnirUSB.dll 3. Tag Update menu and click on 'Optode 4. Date/Time Fri May 31 09:34:20 2 Dis lay Settings 5. Log HA_10_2 Layout View' A B. Experiment Data Optode Layout View 1. Light Intensity 2. Events/Markers (Array of 135x49) View Associated Oxygraph (Collection) 2600 C. Marker Proper Zoom Keyboard/Manual Marker Set1 Evaluate 2150 D. Sensor Setti Total Chann 48 Manage . Total Optodes 16 1700 Load File 10 Current 4. Gains 20 Toogle Marker Visibility 1250 none E. Statistics Copy as image 800 Mean Perio 0.4995 Save as image Period Std 0.0005 350 Properties 1. Hardware 100 Hardware system that has been used to collect data 24.2 91.1 Load File | Display Settings | Optode Layout View | Define Blocks | Refine | Save | Oxy Update
- 1. Right-click on the Lightgraph, and select "Optode Layout View" from the context menu.

2. A new window will appear as shown below. In this "Optode Layout View", you can toggle hide/view markers (by right clicking graphs and selecting *Toggle Marker Visibility*).



18 | Page

 In the Optode Layout View, right-click on the graph of the optode you want to reject, and at the context menu, select *Evaluate > Reject*. Note that optode numbers are written at the lower left corner of each graph.



4. Once rejected, the optode graph is changed to "null" display as shown below for optode 8:



To reverse this action, simply right-click on the graph of the rejected optode and *select Evaluate* > *Accept* from the context menu. The graph will be updated to show the optode data instead of the "null" display.



2.4.2. Defining Exclude Regions

The previous section described how to reject all data for an optode. It is also possible to reject certain time periods within an optode.

 Right-click on the Lightgraph and from context menu, click on *Evaluate > Define Exclude Period* (*For all Channels*). NOTE: For clarity, the following figure is shown with markers hidden (markers can be hidden either through "Display Settings" or right-click context menu.)

1 3	lightgrapl	h1 C:\Users\Hasan\Document	ts\fnirSoft\Sample Data\HA_25_1_07	7301658.nir — 🗖 🗙	
3700	mm _			A Ex Click on "Evalu	iate >
3171	m	Update		> 3. Tag	, Region
2643		Display Settings Optode Layout View		 4. Dat 5. Log Image: For all channe B. Ex 	is)"
	Service Street	View Associated Oxygraph		1. Light intensity (Array or 1063x43 2. Events/Marke (Collection)	
2114		Zoom +		C. Marker Properties	
	Station of the second	Evaluate >	Define Exclude Period (For all chann	els) Ctrl+E	
1586	- And a start and a start a st	Manage 🕨	Define Exclude Period (Only for char	nnels on display) Ctrl+W	
	and the second s	Load File	Clear All Exclusions	Ctrl+Shift+E	
1057		Toogle Marker Visibility		4. Gains 7 5. Other none	
		Copy as image		4 E. Statistics	
		Save as image		1. Mean Period 0.51	
529	· · · · · · · · · · · · · · · · · · ·	Properties		2. Tehod Stu 0.0002	
03	1.9		573.5	1. Hardware Hardware system that has been used to collect data	
Load Fi	ile Display Settings Optode	Layout View Define Blocks Refi	ine Save Oxy	Update	

2. Once "Define Exclude Region" is selected, two mouse left-clicks are required to identify **start** and **end** times for the exclude region. After the first click, a vertical red line will appear at the location under the mouse pointer. The next click will identify the end time and finalize the procedure.

🕵 lightgraph1 C:\Users\Ha	san\Documents\fnirSoft\Sample Data\HA_25_1_07	7301658.nir 🗕 🗖 🗙
3700	The second vertical red line is updated with mouse location. And	A. Experiment Properties A. Experiment Properties A. Experiment Properties A. Experiment Properties Software COBI Studio A. Tage A t
The first vertical red line is start time of this new exclude block	will indicate the end time when clicked	Marker Set1 Serial Port D. Sensor Settings 1. Total Channe 48 2. Total Optode: 16 3. Current 20 4. Gains 7 5. Other none 4. E Statistice
529 0	573.5 fine Blocks Refine Save Oxy	E. Statusues I. Mean Period 0.51 2. Period Std 0.0002 2. Tatel Time ET2 E2 Hardware Hardware system that has been used to collect data Update

3. Once the start and end times are selected, the graph is immediately updated to exclude the selected region. NOTE: Selecting exclude regions do not delete/remove data. This is just masking the data.



 All exclude regions can be deleted by right-clicking the Lightgraph and selecting *Evaluate > Clear* All Exclude Regions in the context menu. Selecting this is option will update the graph immediately and all user-defined exclude-regions will be deleted.

	ligh		ocum		
0		Update Display Settings Optode Layout View View Associated Oxygraph Zoom	* ***		A. Experiment Properties 1. Hardware fNIR Device 2. Software COBI Studio 3. Tag fnir/USB.dll 4. Date/Time Mon Jul 30 16:5 5. Log HA_4_1 B. Experiment Data 1. Light Intensit, (Array of 1063x4 2. Events/Marke (Collection) 4. C Marker Properties
4		Evaluate	•	Define Exclude Period (For all channels)	Ctrl+E Port
		Manage Load File		Clear All Exclusions	Ctrl+Shift+E
		Toogle Marker Visibility Copy as image Save as image	-		4. Gains 7 5. Other none ■ E. Statistics 1. Mean Period 0.51
		Properties		Selec	t this to delete all
3 ad Fi	1.9 le Display Settings 0	Dptode Layout View Define Blo	ocks	Refine Save Oxy regio	defined exclude ns and return the

5. You can view a list of all defined exclude blocks by right-clicking the Lightgraph and selecting *Manage > Exclude Regions* in the context menu.

8 8	lig	htgraph1 C:\Users\Hasan\D	ocuments\fnirSoft\Samp	ole Data\HA_25_1_0	7301658.nir — 🗖 🗙
					2↓ □
3700 -	.A.				A. Experiment Properties
	1. M.		_		Hardware fNIR Device
	WW. h			Exclude	Software COBI Studio
3171 -	m	Update			Tag fnirUSB.dll
	marsh		_ /	Region List	Date/Time Mon Jul 30 16:58
	A CHARLES	Display Settings	many have		Log HA_4_1
2643 -	and and the	Optode Layout View	and the second second	and	B. Experiment Data
	Ser Com	View Area sisted Oscernals	And the second second second		1. Light Intensity (Array of 1063x49
	mm	view Associated Oxygraph	Carl Contraction of Contraction		2. Events/Marke (Collection)
2114 -	00000000	Zoom		and the second second	C. Marker Properties
	Contraction of the local division of the loc	5.1.1	CONCERCION OF THE OWNER		Marker Set1 Serial Port
	moun	Evaluate	State Constitutions and state		▲ D. Sensor Settings
1596		Manage	Placks		1. Total Channe 48
1300			BIOCKS	Contraction of the local division of the loc	2. Total Optode: 16
		Load File	Exclude Regions	the second se	3. Current 20
		Toogle Marker Visibility	1		4. Gains /
1057 -		Toogle Marker Visibility			5. Other none
		Copy as image			4 E. Stabsbcs
		Comparison of the second se			1. Mean Period 0.51
529 -		Save as image			2. Period Std 0.0002
		 Properties 			1 Hardware
					Hardware system that has been used to
0 -		I I	1	1	collect data
	31.9			573.5	
Loa	d File Display Settings	Optode Layout View Define Blo	cks Refine Save Oxy		Update

6. This will display the list of all exclude regions. Any or all of them can be deleted.

2018

fS



2.4.3. Applying Low-pass Filter

1) To apply a low-pass filter to the noisy data, first, click on the Refine button at the toolbar.



2) A popup windows will appear that displays the first step: selection of input. Either 'Raw Data' or 'Refined Data' can be selected as input for processing.

[Note: At first, only 'Raw Data' is available and 'Refined Data' is empty (as there's no processing done). After processing, output data is placed in 'Refined Data'.]

Just keep default selections and click Next button to go to step 2.



 Finally at 'Step 2', method to be applied is selected. By default FIR Filtering tab and also "System1200S_2Hz" filter is selected. This default filter is a low pass FIR filter with an order of 20. Just keep default selections and click Next button to apply the filter.

	sing Meth	od	
FIR Filtering	Ambient	SMAR	Median Filtering
Finite	Impulse A	lesponse	Digital Filter
Select F	ilter Sy	stem1200	S_2Hz ∨
Details			
LowPass	Order:20	Hammin	9
	Filter D	esigner 1	Fool
This method ena impulse response	Filter D	esigner 7	g a variety of finite erately:

4) The filter will be applied and the graph will be updated immediately, as shown below:

_ 🗆 15 lightgraph1 | C:\Users\Hasan\Documents\fnirSoft\Sample Data\HA_25_1_07301658.nir 8 2↓ 🖻 3700 A. Experiment Properties **fNIR Device** 1. Hardware 2. Software COBI Studio 3. Tag fnirUSB.dll 3171 Mon Jul 30 16:58 4. Date/Time 5. Log HA 4 1 B. Experiment Data 2643 1. Light Intensity (Array of 1063x49 2. Events/Marke (Collection) C. Marker Properties 2114 Serial Port Þ Marker Set1 D. Sensor Settings Total Channe 48 1586 2. Total Optode: 16 20 3. Current 7 4. Gains 1057 5. Other none E. Statistics 1. Mean Period 0.51 2. Period Std 0.0002 529 Total T 1. Hardware Hardware system that has been used to 0 collect data 573.5 31.9 Load File | Display Settings | Optode Layout View | Define Blocks | Refine | Save | Oxy Update

5) Filtered data do not replace original (raw/unfiltered) data. Both are accessible with functions to be exported or used for oxygenation calculation.



6) Also, now that a filter applied, 'Refine Data' is available again. Click on 'Refine' button on Lightgraph that will step 1 again as below. This time, 'Refine Data' is available and can be clicked. And, the history list shows it contains 'FIR' filtered version of 'raw data'. If more than one operation is performed, they will be listed here.

2018

fS



2.4.4. Applying Motion Artifact Rejection (SMAR)

 Motion artifacts and saturation can be detected automatically by a Sliding-window Motion Artifact Rejection (SMAR) algorithm. See Ayaz et. al. [12] for more information about the algorithm. To apply, click "Refine" button at the toolbar.



2) Refine window will appear, as below. Just click next to proceed.

😟 lightgraph1 - Refine L	ightgraph D 🔀	
Step 1 of 2: Input Plea	ase select data source!	
Raw Data Use raw/unfiltered data	Refined Data Use refined/filtered data Histroy of current Refined Data: Empty/None!	
Process Data (Select Methods at the next step)		
Refined Data* After processing, output will be placed in Refined Data		

3) Click on 'SMAR' tab to select this method. Configuration options are within this tab and allow changing algorithm parameters. Just keep default settings. Click the "Apply" button to accept current parameters and apply the algorithm.

ID Eltarina Ambient	SMAR Median Eltering
Sliding window Ma	tion Artifact Rejection
Silaing-winaow Mo	ion Aninact Rejection
Window Size	10
Upper Threshold	25
Lower Threshold	3
Perform global chai This method uses a statistical a roblematic data regions for eac aparately.	nnel check oproach to identify and reject h optode and channel
elected method: SMA	R

 Segments identified as motion artifacts and saturated channels will be excluded automatically. Compare the following graph with the one in step 1 above. Also, see the command output pane (at the main window) for a brief report. The graph will be updated immediately.



5) Rejected regions can be seen easier at 'Optode Layout View'. As shown below, optodes 8 and 10 were rejected.



2.5.Calculating Oxygenation (MBLL)

 fnirSoft calculates oxygenation by applying the Modified Beer Lambert Law (MBLL) described in the previous chapter. To start the process, click the "Oxy" button on the toolbar.



2) The following parameter window will appear. Under the General tab, there two main selections: Baseline and Data to enable use of different baselines (reference point), and specify filtered or unfiltered data. The Coefficients tab allows modifying the absorption spectrum coefficients of oxy-Hb and deoxy-Hb of MBLL. The "Refined Data" option will be disabled if no processing has been applied to the current data. The default baseline is the "COBI Baseline". Click the "Calculate Oxygenation" button to accept current settings and continue.



 Once oxygenation data is calculated, a new Oxygraph window will appear as below. By default, all markers and exclude regions are transferred. The graphs displays HbR (deoxyhemoglobin), HbO (oxy-hemoglobin), HbT (total-hemoglobin) and Oxy (difference between oxyand deoxy-hemoglobin).



4) Oxygraph has options and menu items similar to Lightgraph, for example, Optode Layout View. Open Optode Layout View in Oxygraph and double-click on optode two to see it in full-window as below.



5) Also, Oxygraph, by default displays oxygenated-Hemoglobin (HbO) and deoxygenatedhemoglobin (HbR) data. To change display options, right click on the main window of Oxygraph and select "Display Settings" from the context menu. A new dialog box will appear as shown below.





6) Uncheck oxygenated-hemoglobin (HbO) and deoxygenated-hemoglobin (HbR) click on Oxy (difference in hemoglobin). Click "Update" to refresh the graphs as shown below.



7) You can apply various filters using filters using Refine tool available on the toolbar. To save and/or export data and apply block analysis, see the next chapter.

2.6.Loading Oxygenation/Hemoglobin (*.oxy) Files

An experiment data saved from COBI Studio includes oxy file in addition to nir, mrk and log files. Oxy file contains hemoglobin concentration changes and can be completely recalculated from nir file by using the default (COBI) baseline. If oxy file is used (as shown in this section), light intensity preprocessing steps would be skipped (in Lightgraph). See previous section for information on loading nir file and then calculating oxygenation data.

1. Click on the 'Oxygraph' at the toolbar of main window. This will open a new Oxygraph window.



2. In the Oxygraph window, click on the 'Load Data' Button at the lower left corner of the window.

fS **2018**

4	oxygraph1	- • ×
		A Experiment Properties A Experiment Properties A Experiment Properties A Experiment Pata A Experiment Data A Date/Time A Date/Ti
	Click 'Load Data' button to select file	D. Sensor Settings 1. Total Optodes 2. Current 3. Gains 4. Other E. Statistics 1. Mean Period 0 2. Period Std 0 3. Total Time 0
Load File Display Settings Opt	ode Layout View Define Blocks Refine Save	1. Hardware Hardware system that has been used to collect data Update

3. A file selection window will appear. COBI Oxy data files (*.oxy) are filtered and shown by default. Oxygraph tool only recognizes also recognizes event marker (*.mrk) files and also the associated experiment log (*.log) files. Marker and log files can be automatically loaded with the main NIR file (see next step). Just select one NIR file and click open button.

6	Ope	n ×
⊕ ⋺ - ↑ 🛽	🛛 « Documents 🕨 fnirSoft 🕨 Sample Dat	a v C Search Sample Data $ ho$
Organize 🔻 🛛 N	ew folder	
\land OneDrive	A HA_10_2_05310934.oxy fnirSoft Oxygenation File 41.6 KB	e HA_25_1_07301658.oxy fnirSoft Oxygenation File 319 KB
This PC Desktop Documents Downloads Music Pictures Videos	HA_32_1_11191152.oxy fnirSoft Oxygenation File 367 KB	e
	File name: HA_25_1_07301658.oxy	COBI Studio Oxy File (*.oxy) Open Cancel

4. If the selected file is part of an experiment saved by COBI, it might be accompanied by a marker file for time and event information. Click 'Yes' to also load the associated marker file with the data file.

oxygraph1 C:\Users\H	lasan\Documents\fnirSoft\Sample Data\HA_25_1_07301
?	Do you want to also load the related marker (event) file? Current data file has associated marker file: C:\Users\Hasan\Documents\fnirSoft\Sample Data\HA_25_1_07301658.mrk
	Load Skip

5. Measurements from all optodes in the selected file will be displayed in the graph. If a marker file was loaded, vertical lines corresponding to the markers will be displayed as well. The '*Properties*' pane on the right hand side provides information about the current data file. NOTE: This graph is identical to the calculated-oxygenation from raw light intensity (see the graph in 2.5 step 4).



6. You can apply various filters using filters using Refine tool available on the toolbar. To save and/or export data and apply block analysis, see the next section.

2.7.Preprocessing Raw Hemoglobin Data

The necessary steps for preprocessing may change depending on the current data and experiment protocol. Also, if oxy files are used from raw files, light intensity preprocessing have been skipped entirely, but not recommended. If the data is noisy, it is advised to apply a linear phase, low pass filter that attenuates high frequency components of the signal. Furthermore, certain channels, or time periods may need to be excluded due motion artifact, saturation or noise. fnirSoft can be used to design and apply window-based finite impulse response (FIR) filters.

2.7.1. Rejecting Optodes

To exclude all data from an optode, first, go to "Optode Layout View" window and reject or accept the selected optode from the "Evaluate" option at the context-menu (by right-click).

1. Right-click on the Oxygraph, and select "Optode Layout View" from the context menu.



2. A new window will appear as shown below. In this "Optode Layout View", you can toggle hide/view markers (by right clicking graphs and selecting Toggle Marker Visibility).



3. In the Optode Layout View, right-click on the graph of the optode you want to reject, and at the context menu, select *Evaluate > Reject*. Note that optode numbers are written at the lower left corner of each graph.

fS **2018**



4. Once rejected, the optode graph is changed to "null" display as shown below for optode 8:



To reverse this action, simply right-click on the graph of the rejected optode and *select Evaluate* > *Accept* from the context menu. The graph will be updated to show the optode data instead of the "null" display.


2.7.2. Defining Exclude Regions

The previous section described how to reject all data for an optode. It is also possible to reject certain time periods within an optode.

 Right-click on the Oxygraph and from context menu, click on *Evaluate > Define Exclude Period* (*For all Channels*). NOTE: For clarity, the following figure is shown with markers hidden (markers can be hidden either through "Display Settings" or right-click context menu.



8. Once "Define Exclude Region" is selected, two mouse left-clicks are required to identify **start** and **end** times for the exclude region. After the first click, a vertical red line will appear at the



location under the mouse pointer. The next click will identify the end time and finalize the procedure.

 Once the start and end times are selected, the graph is immediately updated to exclude the selected region. NOTE: Selecting exclude regions do not delete/remove data. This is just masking the data.



10. All exclude regions can be deleted by right-clicking the Oxygraph and selecting *Evaluate > Clear* All Exclude Regions in the context menu. Selecting this is option will update the graph immediately and all user-defined exclude-regions will be deleted.



11. You can view a list of all defined exclude blocks by right-clicking the Oxygraph and selecting *Manage > Exclude Regions* in the context menu.



12. This will display the list of all exclude regions. Any or all of them can be deleted.



2.7.3. Applying Low-pass Filter

1) To apply a low-pass filter to the noisy data, first, click on the Refine button at the toolbar.



2) A popup windows will appear that displays the first step: selection of input. Either 'Raw Data' or 'Refined Data' can be selected as input for processing.

[Note: At first, only 'Raw Data' is available and 'Refined Data' is empty (as there's no processing done). After processing, output data is placed in 'Refined Data'.]

Just keep default selections and click Next button to go to step 2.



3) Finally at 'Step 2', method to be applied is selected. By default FIR Filtering tab and also 'System1200S_2Hz' filter is selected. This default filter is a low pass FIR filter with an order of 20. Just keep default selections and click Next button to apply the filter. (Note that available processing methods are different in Oxygraph then in Lightgraph).

Select Proces	sing Metho	d	
FIR Filtering	Detrending	g Median Filtering	• •
Finite	Impulse Re	sponse Digital Fili	ler 🛛
Select F	ilter Sys	tem1200S_2Hz	~
Details	-		
LowPass	Order:20 H	Hamming	
	Filter De	signer Tool	
This method ena impulse response	bles designing s filters to each	and applying a variety of : opticite seperately:	linite

4) The filter will be applied, and the graph will be updated immediately, as shown below:



5) Filtered data do not replace original (raw/unfiltered) data. Both are accessible with functions to be exported or used for oxygenation calculation.



6) Also, now that a filter applied, 'Refine Data' is available again. Click on 'Refine' button on Oxygraph that will step 1 again as below. This time, 'Refine Data' is available and can be clicked. And, the history list shows it contains 'FIR' filtered version of 'raw data'. If more than one operations are performed, they will be listed here.



History list of '*Refined Data*' contains FIR filtering.

This contains more than one item if *'Refined Data'* is selected again for another processing.

NOTE: When '*Raw data*' is selected, any previous value in '*Refined data*' is deleted and new processed data is loaded.

2.7.4. Applying Detrending

 Signal drifts global trends can be automatically removed by linear detrending. See Ayaz et. al. [7] for more information about the algorithm. To apply, click "Refine" button at the toolbar. In this example, FIR filtered data (as described in previous section but using another filter of size 100, and cutoff 0.03 created in filter designer tool) is used. Detrending will applied to refined data (filtered data).

fS **2018**



2) Refine window will appear, as below. Select 'Refined Data' and click next to proceed.

Note that if FIR filtered was not applied, 'Refined Data' option here will be disabled as there won't be any processed data.



3) Click on 'Detrending' tab to select this method. Configuration options are within this tab and allow changing algorithm parameters. Just keep default settings. Click the "Apply" button to accept current parameters and apply the algorithm.

💿 oxygraph1 - Refine Oxygraph Data 💌
Step 2 of 2: Apply Select method and apply!
Select Processing Method
FIR Filtering Detrending Median Filtering
Linear Detrending
✓ Auto-select parameters
This method applies first order linear detranding to each optode by finding the slope of the overall vector time-series and eliminating that.
Selected method: Detrending
Previous Apply

4) Detrending will be applied to each optode separately, and global trend will be removed automatically. Compare the following graph with the one in step 1 above. Also, see the command output pane (at the main window) for a brief report. The graph will be updated immediately.



3. Block Analysis

This section describes the most common analysis approach. Here, a "block" refers to an epoch/segment of data, defined by a start time and end time; and contains all channels (i.e. with full-forehead sensor: 48 for raw data blocks and 16 for oxygenation data blocks).

Block analysis allows comparing data periods that corresponds to different task conditions or stimuli effects (pre/post events), etc. For example, blocks before and after events can be compared across trials, within subjects or across groups. The remainder of this section describes various ways to define blocks using the "Define Blocks" tool, available in both Lightgraph and Oxygraph windows. Once blocks are defined, block data or block times (start/end) can be saved to Dataspace and further processing or can be exported to text or other output files using the Export Tool.



1) The following data file and event file are loaded for the reminder of the section:

2) There are two main colored markers (vertical lines) available: Green colored markers were recorded from serial port in this case (as indicated on the right-hand side properties pane) are 40, 45, 46, 50, 81, 82, 90 and 92, each appearing various times. Orange colored markers are system events and includes -5 (Recording Started) and -1 (Device Stopped). Actually there are additional system markers such as -2 for baseline start and -4 for baseline end. However, these markers are not active and visible as they all are earlier then marker -5 that indicates start of recording.

3.1.Defining Blocks

The "Define Blocks" tool is available in both the Lightgraph and Oxygraph windows by clicking the "Define Blocks" button on the toolbar. The following window will appear, allowing you to define blocks separately by using marker(s), absolute time or relative time.

lightgraph1	Define Blocks
Start of a block: Check	End of a block: Check
Use Markers Use Time All available event markers	Use Markers Use Time All available event markers
Start pattern Sort By Time By Value -2 (Baseline Start ^ -3 (Baseline value) -4 (Baseline value) -5 (Recording Sta Up Up 45 (Marker) 90 (Marker) 90 (Marker) V	End pattern Sort: By Time By Value -2 (Baseline value -3 (Baseline value -4 (Baseline value -4 (Baseline value -4 (Baseline value -5 (Recording Sta Up 45 (Marker) -50 (Marker)
Block start includes outer border Only check within block: Use all combinations of start and end times Ready	Block end includes outer border
Run (Step 1) Save (Step 2)	Manage Clear All Close

There are 5 steps in creating blocks. Multiple blocks or a single block can be created with each run. The steps are as follows; details of each step are provided in the next sections.

- 1) Define "Start of a block"
- 2) Define "End of a block"
- 3) **Run** current settings
- 4) See the report at the output pane.
- 5) Save the new found blocks to current list



TIP To see current list of

blocks, click **manage** button. A new window with list of blocks will appear.

3.1.1. Defining Blocks using Markers

- 1) In this section, we will create two types of blocks: one type is between markers '40' and '45', and another between the '45' marker and the '50' marker.
- 2) Both "Start of a block" and "End of a block" sections has two lists: one empty and the other one with all available marker types as source. Transfer any type and number of markers from these lists on the right to the left to create a pattern that specifies start and end of blocks.
- 3) For the first type:
 - a. Load 'HA_25_1_07301658.nir' sample file and accept to load its associated marker file to a Lightgraph window. Open 'Define Blocks' tool. On the "Start of a block" side: On the right list, click to select the '40 (Marker)' item and then the '<' button to transfer it to the left-most list.



ТІР
Double-clicking on list
items transfer them to
the next list.

b. On the "End of a block" side: On the right list, click on the '45 (Marker)' and then the '<' button to transfer it to the left-most list. The window should appear as follows:

Use Markers Use T	ìme		Use Markers Use Tim	ne	
	All available	event markers		All available e	event marker
Start pattern	Sort: By Time	By Value	End pattern	Sort: By Time	By Value
40 (Marker)	 < -2 (Baseli -3 (Baseli -3 (Baseli -4 (Baseli -5 (Recording) -5 (Recording) -6 (Market -6 (Mar	ne State ne value ne end) rding Sta er) er) er) v	45 (Marker)	 -2 (Baselin -3 (Baselin -3 (Baselin -5 (Record 40 (Marke 40 (Marke 90 (Marke 50 (Marke) 	e Starte ^ e value e end) ding Sta r) r) r) r) ~
Ignore the first	markers		Ignore the first	markers	
Block start incl	ludes outer border		Block end includ	es outer border	
Only check with the onl	thin block:	~	Apply the following	ng label:	
Use all combin	ations of start and end	times	Blocks can overl	lap or touch neighbors	
> Ready					

c. Now that we have identified the start and end of the block, click the 'Run (Step 1)' button at the bottom of the window. fnirSoft will search the data for all blocks that can be defined as beginning and ending marker patterns. All found blocks will be listed in the text box just above the buttons, as indicated below:

iignigiaphi i	Define Blocks	×
start of a block: Check	End of a block: Check	
Jee Markers Use Time All available event markers Start pattern Sott By Time By Value 2 (Baseline Start + 3 (Baseline Value 3	Use Markers Use Time All available event on the End pattern Sort: By Time of Value 45 (Marker) 2 (Barline Statt + 3 distine value 2 (Barline Statt + 3 distine value 3	Indicates how many blocks have been found with the current settings. Stat and end times for each found block are within parentheses.

d. Click the "Save (Step 2)" button at the bottom of the window to save the blocks. In this example, three blocks were found. On the Lightgraph window, the blocks will be shown by a colored (in this case blue, pink and yellow) bars drawn between the start and end times, just below the X axis.



TIP

You can apply labels (that are simply strings) to tag blocks you have created. To do that, add any string (separate by comma for multiple labels) to "Apply following label" field in the define blocks dialog (see next item for more info).

If you use # within the label, block index numbers will be added to the label. For example, with "sample#" temple, and if 3 blocks are created, they will have "sample1", "sample2" and "sample3".

- 4) For the second type:
 - a. At the "Start of a block" side: On the right list, click on '45 (Marker)' and '<' button to transfer it to the left-most list.



Any text entered here will be used as label when new blocks are identified using 'Run' button and then saved using 'Save' button.

b. At the "end of a block" side: On the right list, click on '50 (Marker)' and '<' button to transfer it to the left-most list. Also, type 'task#' next to the



c. Click 'Run' button. This will use current settings to identify any available blocks. The output pane indicates 3 new block found.

Start of a block:		Check	End of a block:	Check
Use Markers Use Time	All available	event markers	Use Markers Use Time	e All available event markers
Start pattem 45 (Marker)	Sort: By Time < -2 (Baselin -3 (Baselin -3 (Baselin -4 (Baselin -5 (Recond) -5 (Recond) -5 (Recond) Up 40 (Market Down 90 (Market 50 (Market 50 (Market)	By Value he Statt€ ∧ he value he end) ding Sta sr) sr) sr) ✓	End pattern 50 (Marker)	Sort By Time By Value -2 (Baseline Statt A -3 (Baseline value > 4 (Baseline end) -5 (Recording Sta 40 (Marker) -50 (Marker) -9 Up 40 (Marker) -50 (Marker) -9 Down 50 (Marker) -50 (Marker) ->
gnore the first	markers		Ignore the first	markers
Block start include Only check within Use all combination	es outer border block: ons of start and end t	↓ times	Block end include Apply the followin Blocks can overla	es outer border ng label: task# ap or touch neighbors
>> Start Pattern Count: 3, >> Run: (136.66,180.7)+ta: >> Saved! (Total Blocks:	End Pattern Count: 6 sk0 (247.68,291.29) 6)	task 1 (358.3,40	1.91)-task2 Found 3 block	·:5

d. Click 'Save' button to add this new block to the available blocks list. The Lightgraph window will be updated immediately to show the all 6 blocks (3 short blocks from first execution, and 3 long blocks from second execution).



5) All currently available blocks can be listed by right clicking on the graph, and from the contextmenu, selecting *Manage > Blocks*. Here, it displays all 6 blocks in order of creation. They can be sorted in order of their start or end times. Any one of them can be deleted and the whole list can be re-sorted. Note that the last three blocks contain a label (task0, task1 and task2).



3.1.2. Define Blocks using Time

- 1) In this section, we will create two blocks, the first one with start and end times as 40 sec and 110 sec. And the second block, with 460 sec and 570 sec.
- 2) For the first block:
 - Load 'HA_25_1_07301658.nir' sample file and accept to load its associated marker file to a Lightgraph window. Open 'Define Blocks' tool. At the "start of a block" side: click on "Use Time" Tab. Under fixed time, enter 40 for 'block starts at' field.

Use Markers Use Time	Use Markers Use Time	
All entries are in seconds	All available	event marken
Fixed time Single	End pattern Sort: By Time	By Value
Block starts at: 40	 < -2 (Base -3 (Base -4 (Base -5 (Reco 	line Starte A line value line end) ording Sta
Relative to End of block Difference between start and end:	Up 44 (Man 5 (Mark Down 50 (Mark 50 (Mark	ter) ter) ter) V
Block start includes outer border	Block end includes outer border	
Only check within block:	Apply the following label:	
Use all combinations of start and end times	Blocks can overlap or touch neighbor	s
> Ready		

b. At the "End of block" side, click on "Use Time" tab and enter 110 at the within fixed time group, for "block ends at" as shown below.

Start of a block:	Check	End of a block:	Check
Use Markers Use Time		Use Markers Use Time	
All entries are in seconds	0	All entries are in seconds Fixed time Single Block ends at:	110
Relative to End of block Difference between start and end:		O Relative to Start of block	rt:
Block start includes outer border		Block end includes outer border	
Only check within block:	~	Apply the following label:	
Use all combinations of start and end t	imes	Blocks can overlap or touch neig	ghbors
> Ready			

- c. Click "Run (Step 1)" button to apply these settings to identify blocks. Pane will indicate that it found 1 block.
- d. Click on "Save (Step 2)" button to add this block to current block list. The Lightgraph window will be updated immediately to visualize the block.



- 3) For the second block:
 - a. At the "start of a block" side: under "Use Time" Tab. Under fixed time group, enter 460 for 'block starts at' field.
 - b. At the "end of a block" side: under "Use Time" Tab. Under fixed time group, enter 570 for 'block ends at' field.
 - c. Click "Run (Step 1)" button to apply these settings to identify blocks. Pane will indicate that it found 1 new block.

		_
Use Markers Use Time	Use Markers Use Time	
All entries are in seconds Fixed time Single Block starts at: 460.000	All entries are in seconds Fixed time Single Block ends at: 570.000	
Relative to End of block Difference between start and end:	Relative to Start of block Difference between end and start:	
Block start includes outer border	Block end includes outer border	
Only check within block: V	Apply the following label:	
Use all combinations of start and end times	Blocks can overlap or touch neighbors	
> Saved! (Total Blocks: 1) > Start Pattern Count: 1, End Pattern Count: 1 > Bun: (460, 570), Found 1 block		^

d. Click "Save (Step 2)" button to add this new block to current block list.



4) All blocks can be removed by the "Clear All" button at the "Define Blocks" tool window. Or, by right-clicking the graph and from the context menu, selecting, *Manage>Blocks* and "Delete All" at the new window.

3.1.3. Defining Blocks using Markers and Time

- 1) In this section, we will create two blocks that start with marker '92' and ends 25 seconds after that.
- Load 'HA_25_1_07301658.oxy' sample file and accept to load its associated marker file to an Oxygraph window. Open 'Define Blocks' tool. At the "Start of a block" side, at the "Use Marker" tab, add only one marker '92' to the list as shown below.

	oxygraph	Define Blocks	5	×
Start of a block:	Check	End of a bl	ock:	Check
Use Markers Use Time		Use Markers	Use Time	2
4	II available event marke	s	All	available event markers
Start pattern Sort:	By Time By Value	End pattern	Sort:	By Time By Value
92 (Marker) <	-5 (Record started A		<	-5 (Record started A
>	45 (Marker) 90 (Marker)		>	45 (Marker) > 90 (Marker) >
Up	50 (Marker)		Up	50 (Marker)
Down	81 (Marker) 92 (Marker)		Down	81 (Marker) 92 (Marker)
gnore the first m	arkers	Ignore the	e first ma	irkers
Block start includes outer	border	Block end	d includes outer bo	order >
Only check within block:		 Apply the 	following label:	2
Use all combinations of st	art and end times	Blocks ca	an overlap or touch	n neighbors >
>> Ready				~ ~
Run (Step 1) Save (St	ap 2)	1	Manage Cle	ear All Close

3) At the "End of a block" side, click on "Use Time" tab, within "Relative to Start of block" group, enter 25 for 'difference between end and start' field.

start of a	block:		Check	Endofat	olock:		Check
Use Markers	Use Time All n Sort:	available e By Time	vent markers By Value	Use Markers All entries	Use Time are in seconds d time Singl	e	
92 (Marker)	<	-5 (Record 40 (Marker 45 (Marker 90 (Marker	started A	Block e	nds at:		
Ignore th	e first ma	50 (Marker 46 (Marker 81 (Marker 92 (Marker rkers)))	 Rela Different 	tive to Start of bl	ock I and start: 25	1
Block sta	art includes outer b	order		Block e	nd includes oute	r border	
Only che	ck within block:		~	Apply th	ne following labe	t:	
Use all o	ombinations of sta	rt and end ti	mes	Blocks	can overlap or to	ouch neighbors	
Ready							

4) Click on "Run (Step 1)" button to use these settings to identify blocks. Output pane will indicate 2 blocks are found and their start & end times.

start of a l	DIOCK:		Check	End of a block:		Check		
Use Markers	Use Time	All		Use Markers Use Time				
Start pattern 92 (Marker)		All available Sort: By Time < -5 (Reco 40 (Mart > 45 (Mart	By Value By Value ord started A ker) ker)	All entries are in seconds Fixed time Single Block ends at				
] Ignore the	e first	Up 50 (Mar 50 (Mar 46 (Mar 81 (Mar 92 (Mar markers	ker) ker) ker) ker)	 Relative to Start on Difference between 	f block end and start: 25	.000		
Block sta	rt include:	s outer border		Block end includes	outer border			
Only che	ck within I	block:	~	Apply the following I	abel:			
Use all c	ombination	ns of start and end	times	Blocks can overlap	or touch neighbors			
> Ready > Run: (247.68	,272.68) (3	02.97,327.97) Fo	und 2 blocks					

5) Click "Save (Step 2)" button to add these blocks to current blocks list. The graph will be updated immediately to visualize them. The two blocks are have identical length and start with a marker '92'.





3.2.Using Blocks

This section describes how to utilize the data or time information in defined blocks. In a typical experimental data analysis, block data from many task conditions and subjects are acquired after preprocessing steps are applied (refined data), and next, feature extraction or data reduction is applied to each and aggregate list from all conditions or subjects are formed. All these steps can be done in Dataspace tool which will be described in the next chapter. This section describes procedures to save block data to Dataspace or to external files. Also, data in Dataspace can be saved to external files and can also be processed through scripting.

This section uses the raw data in Lightgraph for illustration, but the same interface and options are available for the Oxygraph.

3.2.1. Saving Blocks as Variables in Dataspace

 Load 'HA_25_1_07301658.nir' sample file to a Lightgraph. Click the "Save" button on the toolbar. A popup dialog appears and first step is to identify what to save. Select "All Recorded Data", this option saves all data as a single block from marker (-5) to marker (-1).

Use all data from beginnin	g (marker -5) to end (marker -1).
All Blocks Use all available blocks cu	mently in memory.
Selected Blocks	
Use only selected blocks a	is shown below.
none!	

2) In step 2, select type of data to be save. By default, raw data (unfiltered) original data loaded from file is selected. If processing is applied, refined data is also available. Block times option just saves start and end times for blocks.



3) Finally, in step 3, outcome is previewed (how many blocks will be generated) and if any postsaving actions should be triggered such as opening Dataspace window. Keep default options and hit 'Save' button to actually save the data to Dataspace.

🖆 lightgraph1 - Save Lightgraph Data	×
Step 3 of 3: Final Please select final options and save!	
Target Location Targe	
Ater saving/transfer Open Dataspace See all variables in Dataspace Open Export Tool Use Export Tool to export selected data to external file	
4 variables (1 data, 1 time, 1 marker, 1 info) from raw data will be saved to DataSpace.	
Previous	/e

4) A success message is displayed as below. After, pressing "Ok" the messagebox and the previous dialog is closed.



5) Dataspace window appears and lists the two blocks as shown below. Note that Lightgraph object is also listed (as first item) in the list. The following four items are the new variables that were just created with types of 'Light intensity', 'Time', 'Marker' and 'Composite' (metadata information about the variable).

			fnirSoft Proc	essing Tool		_ 🗆 🗙
Dataspace Directory Process Cor	mpare MBLL					
Enter text to filter						
Name	Туре	Content	Size	Date/Time	₽ 2 ↓ □	
lightgraph1	Lightgraph	{Lightgraph}	1063 x 16 x 3	6/6/2015 2:54:37 PM	⊿ Identity	
lightgraph1.raw.Block1	Numeric	Light	1063 x 48	6/6/2015 2:55:54 PM	Name	lightgraph 1
lightgraph1.raw.Time1	Numeric	Time	1063 x 1	6/6/2015 2:55:54 PM	Date/Time	6/6/2015 2:54:37 PM
lightgraph1 raw Marker1	Numeric	Marker	29 x 2	6/6/2015 2:55:54 PM	⊿ Data	
Hightgraph1 row lafe1	List	Composito	25 x z	C/C/2015 2:55:54 DM	l lype Contont	Lightgraph (Lightgraph)
H lightgraph I.raw.into I	List	Composite	20 Variables	6/6/2015 2:55:54 PM	Size	(Ugntgraph) 1062 × 16 × 2
					A Supplementary	1003 × 10 × 3
					Notes	lightgraph1 C:\Users\Hasan\Do
						2 2 1
					Name	
<				>		
Load Save - Delete - Impo	ort Export			1 item selected. Total: 5,	4 vars, 1 lightgraph, 0 o	cygraphs, 0 topographs Refresh

6) Also, on the main window a brief report about the operation is printed in command output pane.





- 3.2.2. Exporting Blocks directly to a Matlab[™] File

2) Click the "Save" button in the toolbar and select "All Blocks" in step 1.

Next



Additional Marker Data Sava all Data Info

Previous

4) At step 3, check "Open Export Tool" option, this will upload saved blocks (from Dataspace) directly to Export Tool.

🖻 oxygraph1 - Save Oxygraph Data	
Step 3 of 3: Final Please select final options and save!	
Target Location	
Dataspace Save data to findSoft Dataspace in findSoft Processing Tool. Many other tools can avoid and process the data. After saving/transfer Open Dataspace See all variables in Dataspace	This option loads currently saved blocks to Export Tool for
Open Export Tool Use Export Tool to export selected data to external file A variables (2 data 2 time) from raw data will be exceed to DataScane	exporting as different file formats
Previous Save	ine formats.

5) A success message will be shown as below, just click "Ok" to continue.



6) A new dialog, Export Tool with all block data will appear as below. Click 'Next' to continue.



7) In Step 2, select the type of output file format. Select "Matlab' from the drop down menu. This will automatically enable "single aggregate file' option. This way, all blocks will be saved to a single output file.



8) At Step 3, output file names are set. Various properties of block variables such as name, index, count, current date or time, etc can be used in output names. Click on the properties to add them to the name template or just type them with curly parenthesis. A preview list of output filenames is displayed at the lower part of the window. In this example a single file will be generated 'fs_Exported.m''. Click next to continue.

		<u> </u>		_
5		Export Data	Tool	×
Step 3 of	f 4: Output F	ilename(s)	Add placeholde	ers to use values
Filename Te	molate:			
fS_Exported	inpiato.			
{name}	{index}	{count}	{file count}	{type}
{size}	{label}	{width}	{height}	{date}
{time}	{year}	(month)	{day}	{hour}
{minute}	{second}			
Preview: fS_Exported.	m			
Previous				Next

9) At step 4, output folder can be changed. The default folder is shown and also a brief summary of operation number of input block variables, number and type of output file is listed. Click "Export" button perform the operation.

ŕ	Export Data Tool
Step 4 o	f 4: Location Please select location of output files!
	Select Output Folder
C:\Users\H	asan \Desktop
After Expor	t
Show Open V	output files in folder Indows File Explorer
16 variable Type of the	s will be exported to one file. file is Matlab File(".m),Matlab compatible
Previous	Export

10) A confirmation Messagebox will appear to indicate success. Also, main window command output pane will show a summary report line about the operation.



From windows explorer, the output file can be used:

慉 fS_Exported.m



3.2.3. Exporting Blocks directly to a Text File

2) Click the "Save" button in the toolbar and select "All Blocks" in step 1.



nhes properties of the data

Next

4) At step 3, check "Open Export Tool" option, this will upload saved blocks (from Dataspace) directly to Export Tool.

Previous



5) A success message will be shown as below, just click "Ok" to continue.



6) A new dialog, Export Tool with all block data will appear as below. Click 'Next' to continue.



7) In Step 2, select the type of output file format. Select 'Text file' from the drop down menu. This will by default enable "Separate files' option. This way, each blocks will be saved to a separate output file and the number of output files is the same as the number of input blocks.



8) At Step 3, output file names are set. Various properties of block variables such as name, index, count, current date or time, etc can be used in output names. Click on the properties to add them to the name template or just type them with curly parenthesis. By default '{name}' is

added so filename template is 'fS_Exported_{name}'. With this template, when processing each block, name of that block is used to create its respective output file. A preview list of all output filenames is displayed at the lower part of the window. Click next to continue.

Ilename I e 6_Exported	mplate: _{name}				
(name)	{index}	{count}	{file count}	{type}	
size}	{label}	{width}	{height}	{date}	
(time)	{year}	{month}	{day}	{hour}	
(minute)	{second}				
Exported Exported Exported Exported Exported Exported Exported Exported	_oxygraph1.hbo _oxygraph1.hbo _oxygraph1.hbo _oxygraph1.hbo _oxygraph1.hbr. _oxygraph1.hbr.	Block1.txt Block2.txt Time1.txt Time2.txt Block1.txt Block2.txt Time1.txt			< ×

9) At step 4, output folder can be changed. The default folder is shown and also a brief summary of operation number of input block variables, number and type of output file is listed. Click "Export" button perform the operation.



10) Files will be created at the selected folder and main window command output pane will show a summary report line about the operation.

From explorer, the output files can be used:

- fS_Exported_oxygraph1.hbo.Block1.txt
 fS_Exported_oxygraph1.hbo.Block2.txt
 fS_Exported_oxygraph1.hbo.Time1.txt
 fS_Exported_oxygraph1.hbr.Block1.txt
 fS_Exported_oxygraph1.hbr.Block2.txt
 fS_Exported_oxygraph1.hbr.Block2.txt
 fS_Exported_oxygraph1.hbr.Time1.txt
 fS_Exported_oxygraph1.hbr.Time2.txt
 fS_Exported_oxygraph1.hbt.Block1.txt
 fS_Exported_oxygraph1.hbt.Block2.txt
 fS_Exported_oxygraph1.hbt.Block2.txt
 fS_Exported_oxygraph1.hbt.Block2.txt
 fS_Exported_oxygraph1.hbt.Time1.txt
 fS_Exported_oxygraph1.hbt.Time1.txt
 fS_Exported_oxygraph1.hbt.Time2.txt
 fS_Exported_oxygraph1.hbt.Time2.txt
 fS_Exported_oxygraph1.hbt.Time2.txt
 fS_Exported_oxygraph1.nbt.Time2.txt
 fS_Exported_oxygraph1.nbt.Time2.txt
- fS_Exported_oxygraph1.oxy.Block2.txt
- fS_Exported_oxygraph1.oxy.Time1.txt
- fS_Exported_oxygraph1.oxy.Time2.txt

4. Dataspace

fnirSoft global memory is called Dataspace. All data variables (numeric, string, lists) and all objects (Lightgraph, Oxygraph, Topograph) are created and stored in Dataspace. Processing Tool allows applying various functions/processing methods through user interface. All these functions are also available as commands through fnirSoft scripting.

4.1.Saving and loading fnirSoft data (*.fsd) files

fnirSoft data variables can be saved to and re-loaded from 'fsd' files. Once a data file is saved or loaded, a brief report is included in the command output pane at the main window. fnirSoft Processing Tool, variable tab options are explained below.



To select variables click on them, to select multiple variables, keep ctrl button (on the keyboard) pressed and click (with mouse) on the variables listed.

Note: When saving or clearing variables, all variables (which are either numeric, string or list) in the Dataspace list are saved or cleared except objects (which are either Lightgraph, Oxygraph or Topograph) as indicated in the 'Type' column. Objects can be deleted by right-clicking and selecting *Delete* from the context menu.

4.2.Viewing a variable

 All available variables are listed in "Dataspace" tab of *fnirSoft Processing Tool*. This list can be re-sorted by clicking on any column header. *fnirSoft Processing Tool* can be accessed from the main window by clicking on the "Dataspace" toolbar button. Load data_3.2.2_refined.fsd file as below.

B			fnirSoft	Processing Tool		_ 🗆 🗙
Dataspace Directory Process Comp	pare MBLL					
Enter text to filter						
Name	Туре	Content	Size	Date/Time	Labels	2↓
oxygraph1.ref.hbo.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	
oxygraph1.ref.hbo.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	
oxygraph1.ref.hbo.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	
oxygraph1.ref.hbo.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	
oxygraph1.ref.hbr.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR,DATA	
oxygraph1.ref.hbr.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR,DATA	
oxygraph1.ref.hbr.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	
oxygraph1.ref.hbr.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	
oxygraph1.ref.hbt.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT, DATA	
oxygraph1.ref.hbt.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT,DATA	
oxygraph1.ref.hbt.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT, TIME	
oxygraph1.ref.hbt.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT,TIME	
oxygraph1.ref.oxy.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY,DATA	
oxygraph1.ref.oxy.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY,DATA	
oxygraph1.ref.oxy.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	
oxygraph1.ref.oxy.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	
<					>	
Load Save - Delete - Import	t Export			Total: 1	6, 16 vars, 0 lightg	raphs, 0 oxygraphs, 0 topographs Refresh

2) Any selected (by clicking with left mouse button) variable will be highlighted.

JILEI LEAL TO TILEI							
Name	Туре	Content	Size	Date/Time	Labels	2 ↓ 🖾	
oxygraph1.ref.hbo.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	⊿ Identity	
oxygraph1.ref.hbo.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	Name	oxygraph1.ref.hbt.Blo
oxygraph1.ref.hbo.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	Date/Time	6/7/2015 10:50:12 A
oxygraph1.ref.hbo.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	Type	Numeric
oxygraph1.ref.hbr.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR, DATA	Content	Hemoglobin
oxygraph1.ref.hbr.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR, DATA	Size	49 x 16
oxygraph1.ref.hbr.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	⊿ Supplementa Notes	Tatal barra alabia aan
oxygraph1.ref.hbr.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR,TIME	Labels	HBT DATA
oxygraph1.ref.hbt.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT,DATA	Log	
oxygraph1.ref.hbt.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT,DATA	⊿ Value	
oxygraph1.ref.hbt.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT, TIME	Preview	1.0421 0.2171 0.695
oxygraph1.ref.hbt.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT,TIME		
oxygraph1.ref.oxy.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY,DATA		
oxygraph1.ref.oxy.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY,DATA		
oxygraph1.ref.oxy.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME		
oxygraph1.ref.oxy.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	Name	
oxygraph1.ref.oxy.Block2 oxygraph1.ref.oxy.Time1 oxygraph1.ref.oxy.Time2	Numeric Numeric Numeric	Hemoglobin Time Time	49 x 16 49 x 1 49 x 1 49 x 1	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	OXY,DATA OXY,TIME OXY,TIME	Name	

3) Double click on a variable to open detail-view for that variable. Alternatively, right click on any variable in the list and click on 'view'. Detail-view allows viewing variable in graph or array formats. A new window that displays all channels of the selected variable will appear. Graph view is shown by default.

fS **2018**



4) Click on 'Array View' tab at the top. Contents of the variable are shown in a grid with rows and columns. All cells of the data can be viewed. Note that, each column caption contains optode number and content type of the data in that column.

			V	view1 - oxyg	graph1.ref.h	bt.Block1 //	Showing 1	variable			_ □	×
iraph View	Array View: o	xygraph1.ref.hb	ot.Block1 Note	es: oxygraph1.n	ef.hbt.Block1	+						
	1 Optode1 (Hemoglobin)	2 Optode2 (Hemoglobin)	3 Optode3 (Hemoglobin)	4 Optode4 (Hemoglobin)	5 Optode5 (Hemoglobin)	6 Optode6 (Hemoglobin)	7 Optode7 (Hemoglobin)	8 Optode8 (Hemoglobin)	9 Optode9 (Hemoglobin)	10 Optode10 (Hemoglobin)	11 Optode11 (Hemoglobin)	(H
1	1.042114	0.217150	0.695905	1.224248	2.392591	1.512627	2.638559	5.022568	1.296566	5.265872	1.358595	1.1
2	1.094290	0.239339	0.719867	1.260177	2.455597	1.535864	2.707992	5.056011	1.329112	5.255593	1.355703	1.1
3	1.141668	0.249259	0.732014	1.285602	2.499484	1.534878	2.761412	5.046281	1.339457	5.203595	1.327303	1.1
4	1.180681	0.244905	0.729849	1.298538	2.518244	1.507831	2.792903	4.990211	1.328569	5.115302	1.276620	1.0
5	1.208385	0.225855	0.712289	1.298692	2.509023	1.456563	2.799304	4.891537	1.300551	5.001667	1.210020	1.0
6	1.222713	0.193201	0.679727	1.287444	2.472589	1.386242	2.780625	4.760337	1.261436	4.876757	1.135598	1.0
7	1.222363	0.148961	0.633836	1.267397	2.413183	1.304393	2.740077	4.611070	1.217911	4.755015	1.061514	0.9
8	1.206839	0.095775	0.577370	1.241887	2.337636	1.219224	2.683282	4.459850	1.175631	4.648044	0.994084	0.9
9	1.176742	0.036528	0.514021	1.214688	2.254521	1.138488	2.617723	4.322033	1.138420	4.563002	0.936822	0.8
10	1.133610	-0.026041	0.447822	1.189346	2.172739	1.068220	2.551472	4.209566	1.107851	4.501817	0.890035	0.
11	1.080092	-0.089340	0.382879	1.169015	2.100184	1.011816	2.492075	4.129580	1.083155	4.461480	0.851201	0.
12	1.019767	-0.150988	0.322757	1.156010	2.042666	0.969996	2.445586	4.083690	1.062116	4.435836	0.816125	0.1
13	0.956424	-0.209035	0.269871	1.151302	2.002944	0.940768	2.415526	4.068150	1.041906	4.417467	0.780246	0.1
14	0.893836	-0.261853	0.225261	1.154608	1.980501	0.920243	2.402632	4.075083	1.019762	4.399580	0.740038	0.1
15	0.835148	-0.308349	0.188504	1.164297	1.971810	0.903544	2.404843	4.094100	0.993978	4.377704	0.694004	0.
16	0.782332	-0.348127	0.157844	1.177707	1.971000	0.885675	2.417635	4.114292	0.964075	4.350246	0.643059	0.
17	0.736306	-0.381268	0.130803	1.191786	1.971194	0.862706	2.435162	4.126204	0.930965	4.318509	0.590583	0.
									1		1	>

5) Click on Notes tab. This tab displays a string text that is metadata of the variable. You can view or edit descriptive information about the variable here. Any changes can be saved by using the 'save' button at the lower left corner.

 View
 view1 - oxygraph1.ref.hbt.Block1 // Showing 1 variable
 —
 —
 X

 Graph View
 Array View: oxygraph1.ref.hbt.Block1
 +

 Total-hemoglobin concentration changes refined data saved by Oxygraph from file C:\Users\Hasan\Documents\fnirSoft\Sample Data\HA_25_1_07301658.oxy

4.2.1. Single variable temporal graph

6) Click on "Graph View" tab to go back to the graph view. By default all channels are shown in a single graph, this is called Temporal (All in 1) type graph. In this example, our variable has 16 columns, and is a variable collected with 16 optode sensor. We can change the graph type to sensor optode layout format using the graph type toolbar button at the bottom of the screen. The dropdown menu from the button will list compatible options with the currently loaded data as shown below.



7) Select 'Temporal-(2 by 8)' as graph type. The window will be updated immediately and individual optodes will be displayed in separate graphs.





8) Right-click on one of the graphs and context menu will appear as below.

9) Select 'Enlarge' from the right-click context menu (alternatively double-click on the graph). This make the graph to the size of the window and enables viewing in more detail.



10) Similar to Lightgraph and Oxygraph windows, single-click on the graph displays a tip-window that shows x and y coordinate (time and signal value) at the clicked location.



11) Enlarged graph can be changed from right hand side properties pane, within Style>Enlarged Graph item



12) To go back, right-click and select 'Enlarge' from context-menu again (Or double-click on the graph).



4.2.2. Single variable bar graph

13) Select "Bar- All in 1" at the "Graph Type" button at the toolbar. In this case, all 16 optodes are shown as rectangular bars at the length of their mean and standard deviation/error is shown at the tip of the bars.



14) Select "Temporal (All in 1)" graph type from the toolbar to go back to original view. Right click on the graph and select "Properties" from the context menu to hide the right-hand side properties pane. The properties pane allows modifying various parameters to further customize the graph view, such as from background panel color to removing grid lines to arranging axis ranges but can be hidden to extent graph display area.



4.2.3. Editing axis titles for graphs

15) Display properties pane again by right-click and selecting properties from dropdown menu. At the right-hand side properties pane, under "Y-Axis", for "Axis title" field, enter "Activation throughout task" and hit enter. The text will be displayed as y-axis title.



16) Similarly, enter "Time (sec)" for Axis title under "X-axis" group. Both titles will be displayed as below.


4.2.4. Editing and moving legend display

17) This font type/size/color and place of legend can be modified for best fit to the current graph. At properties pane, under legend section, change text color to black and font size to 12 as shown below. The legend box might need to be re-sized to display all (enlarged) text by placing the mouse cursor at the border of the legend box.



18) Move the legend box by clicking inside legend and keeping the left mouse window while moving cursor. Once you reach the desired location, release the left mouse button.



4.2.5. Saving graphs as image or copying to clipboard

19) At any time, graph can be saved as an image or copied to clipboard to be pasted into other applications (such as Microsoft Word, Powerpoint, etc) when preparing report. When more than one graph is visible (such as temporal 2by8 view), single graph or all can be saved/copied.



4.3.Viewing multiple variables

- The Detail-view window described in previous section can also display two or more variables simultaneously in one window other than opening two separate windows for each. This is usually needed for comparison of variables such as different conditions of an experiment or different groups from a study.
- 2) Load sample file 'data_3.2.2_refined.fsd' file as below. And, select two (or more can be selected) at "Dataspace" tab of "fnirSoft Processing Tool" open them together in variable View Tool. To do that, keep 'ctrl' button (at the keyboard) and click on variables to select more variables. In the figure below, two variables (oxygraph1.ref.hbo.Block1 and oxygraph1.ref.hbr.Block1) are selected.

intertext to filter						
Namo	Type	Contont	Sizo	Date/Time	Labola	
oxygraph1.ref.hbo.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	⊿ Identity
oxygraph1.ref.hbo.Block2 oxygraph1.ref.hbo.Time1 oxygraph1.ref.hbo.Time2	Numeric Numeric Numeric	Hemoglobin Time Time	49 x 16 49 x 1 49 x 1	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	HBO,DATA HBO,TIME HBO,TIME	Date/Time 6/7/2015 10:50:12 Data Type Numeric
oxygraph1.ref.hbr.Block1 oxygraph1.ref.hbr.Block2 oxygraph1.ref.hbr.Time1	Numeric Numeric Numeric	Hemoglobin Hemoglobin Time	49 x 16 49 x 16 49 x 1	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	HBR,DATA HBR,DATA HBR,TIME	Content Hemoglobin Size 49 x 16 Supplementary
oxygraph1.ref.hbr.Time2 oxygraph1.ref.hbt.Block1	Numeric Numeric	Time Hemoglobin	49 x 1 49 x 16	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	HBR, TIME HBT, DATA	Labels Log
oxygraph1.ref.hbt.Time1 oxygraph1.ref.hbt.Time2	Numeric Numeric	Time Time	49 x 1 49 x 1 49 x 1	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	HBT,TIME HBT,TIME	Preview
oxygraph1.ref.oxy.Block1 oxygraph1.ref.oxy.Block2	Numeric Numeric	Hemoglobin Hemoglobin	49 x 16 49 x 16	6/7/2015 10:50:12 AM 6/7/2015 10:50:12 AM	OXY,DATA OXY,DATA	
oxygraph1.ref.oxy.Time1 oxygraph1.ref.oxy.Time2	Numeric	Time	49 x 1 49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	
						Name

3) Right-click on one of the selected variables and click on "View" from the context-menu.

	_	-			^			
ame	Туре	Conten	t	Size	Date/Time	Labels	2 ↓ □	
oxygraph1.ref.hbo.Block1	Numeric	Hemog	lobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	⊿ Identity	
oxygraph1.ref.hbo.Block2	Numeric	Hemog	lobin	49 x 16	6/7/2015 10:50:12 AM	HBO,DATA	Name	0.0015 10-50-10 /
oxygraph1.ref.hbo.Time1	Numeric	Time		49 x 1	6/7/2015 10:50:12 AM	HBO,TIME	Date/Time	6/7/2010 10:00:127
oxygraph1.ref.hbo.Time2	Numeric	Time		49 x 1	6/7/2015 10:50:12 AM	HBO,TIME	Туре	Numeric
oxygraph1.ref.hbr.Block1	Numorio	Homes	pbin	49 x 16	6/7/2015 10:50:12 AM	HBR,DATA	Content	Hemoglobin
oxygraph1.ref.hbr.Block2	View		bin	49 x 16	6/7/2015 10:50:12 AM	HBR, DATA	Size	49 x 16
oxygraph1.ref.hbr.Time1	Labels	•		49 x 1	6/7/2015 10:50:12 AM	HBR,TIME	⊿ Suppleme	ntary
oxygraph1.ref.hbr.Time2	Content	+		49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	labels	
oxygraph1.ref.hbt.Block1	Copy Name	es	bbin	49 x 16	6/7/2015 10:50:12 AM	HBT,DATA	Log	
pxygraph1.ref.hbt.Block2	Invest Color		bbin	49 x 16	6/7/2015 10:50:12 AM	HBT,DATA	⊿ Value	
oxygraph1.ref.hbt.Time1	invert selec	uon		49 x 1	6/7/2015 10:50:12 AM	HBT, TIME	Preview	
oxygraph1.ref.hbt.Time2	Save			49 x 1	6/7/2015 10:50:12 AM	HBT, TIME		
oxygraph1.ref.oxy.Block1	Delete		bbin	49 x 16	6/7/2015 10:50:12 AM	OXY.DATA		
oxygraph1.ref.oxy.Block2			bbin	49 x 16	6/7/2015 10:50:12 AM	OXY.DATA		
oxvaraph1.ref.oxv.Time1	 Properties 			49 x 1	6/7/2015 10:50:12 AM	OXY.TIME		
oxygraph1.ref.oxy.Time2	Numeric	Time		49 x 1	6/7/2015 10:50:12 AM	OXY, TIME		
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,								
							Name	

4) Comparison of means of all optodes (columns) are shown with bar graph type by default. Error bars at the tip are Standard Error of the Mean (SEM) by default.



4.3.1. Add/remove variables to the current view

5) To add or remove more variables, click on the "Variables" button at the bottom toolbar. This will show "Select Variables" window as below. On the left hand side, all available variables are listed and on right-hand side, those already selected (loaded) to the current detail-view window are listed. You can move variables from one to the other and select "Save" to commit the changes to update the graph.



6) From the left list locate 'oxygraph1.ref.hbt.Block1' variable and move it to the right-hand side by double-clicking or highlighting and using right-arrow button. See the tip at the end of this section for filtering the list by name.

Available variables Enter text to filter oxygraph1.ref.hbo.Block oxygraph1.ref.hbo.Time1 oxygraph1.ref.hbo.Time2	Selected variables oxygraph1.ref.hbo.Block1 oxygraph1.ref.hbr.Block1	Available variables Enter text to filter	Selected variables
Enter text to filter oxygraph1.ref.hbo.Block oxygraph1.ref.hbo.Time1 oxygraph1 ref.hbo.Time2	oxygraph1.ref.hbo.Block1	Enter text to filter	oxygraph1 ref bbo Block1
oxygraph1.ref.hbr.Block2 oxygraph1.ref.hbr.Block2 oxygraph1.ref.hbr.Time1 oxygraph1.ref.hbt.Block1 oxygraph1.ref.hbt.Block2 oxygraph1.ref.hbt.Time1 oxygraph1.ref.hbt.Time2 oxygraph1.ref.hbt.Time2 oxygraph1.ref.hbt.Block1 × oxygraph1.ref.hbt.Block1 (49x 16) (HBT DATA)	 € ↓ 	oxygraph1.ref.hbo.Block ^ oxygraph1.ref.hbo.Time1 ^ oxygraph1.ref.hbr.Time2 ^ oxygraph1.ref.hbr.Time1 ^ oxygraph1.ref.hbr.Time2 ^ oxygraph1.ref.hbr.Time1 ^ oxygraph1.ref.hbr.Time2 ^ oxygraph1.ref.hbt.Time1 ^ oxygraph1.ref.hbt.Time2 ^ oxygraph1.ref.oxy.Block1 ^ oxygraph1.ref.oxy.Block2 ×	oxygraph1.ref.hbr.Block1 oxygraph1.ref.hbt.Block1 v

7) Click "Save" button to accept changes. The dialog will close and the graph will be updated. Also, note the title that lists all variable names.



8) It is also possible to add/remove tabs on the detail-view window for different views. In this example, other than graph view, array view of two variables are listed because they were loaded together initially. To add/remove tab, click on the small "+" tab button or, right click on the tab name and select "edit visible tabs".

X	view1 - oxygraph1.ref.hbo.Block1, oxygraph1.ref.hbr.Block1, oxygra	aph1.ref.hbt.Block1 // Shov	ving 3 variables 🗕 🗖	x
Graph	View Array View: oxygraph1.ref.hbo.Block1 Array View: oxygraph1.ref.hbr.Block1 +			
5.0	📕 oxygraph1.ref.hbo.Block1 (HBO,DATA) 🛛 oxygraph1.ref.hbr.Block1 (HBR,DATA) 📕 oxygraph1.ref.hbt.Bloc	Edit Selected Variables	 2 ↓ ■	
		Edit Visible Tabs	1. Input Data	^
4 25			1.1 Variables 3 variables	
1.20			1.2 Groups 1 group	
			1.3 Columns 1	
3.5			1.4 Rows 1	
			a 2. Types	

4.3.2. Add/remove tabs to the current view

9) Similar to "Select variables" window, a "Select tabs" window will appear as below. Available but invisible tabs are listed on the left and already visible tabs are listed on the right-hand side.

2	Select ta	ibs	×
Available tabs Note: oxygraph1.ref.hbo.Block1 Note: oxygraph1.ref.hbr.Block1 Array View. oxygraph1.ref.hbt.Block1	€	Selected tabs Graph View Array View: oxygraph1.ref.hbo.Block1 Array View: oxygraph1.ref.hbr.Block1	7
Note: oxygraph1.ref.hbt.Block1	¢		
Array View: oxygraph1.ref.hbt.Block1	V		
Cancel		Save	

10) Select "Array View: oxygraph1.ref.hbt.Block1" and move it to the right-hand side list: either by double-clicking on it, or by highlighting it with single click and using "right-arrow" button.

	Select tabs
Available tabs Note: oxygraph1.ref.hbo.Block1 Note: oxygraph1.ref.hbr.Block1 Note: oxygraph1.ref.hbt.Block1	Selected tabs Graph View Array View: oxygraph1.ref.hbo.Block1 Array View: oxygraph1.ref.hbr.Block1 Array View: oxygraph1.ref.hbtBlock1
Cancel	Save

11) Click "Save" to accept changes and close the dialog. The detail-view window will be updated to include the new tab. Click on the new tab to display contents as below.

	view	1 - oxygrap	h1.ref.hbo.E	Block1, oxyg	graph1.ref.h	br.Block1, c	xygraph1.re	ef.hbt.Block	1 // Showin	g 3 variable	es — 🗆	^
Graph View	Array View: o 1 Optode 1 (Hemoglobin)	2 Optode2 (Hemoglobin)	3 Optode3 (Hemoglobin)	4 Optode4 (Hemoglobin)	5 Optode5 (Hemoglobin)	6 Optode6 (Hemoglobin)	7 Optode7 (Hemoglobin)	8 Optode8 (Hemoglobin)	9 Optode9 (Hemoglobin)	10 Optode10 (Hemoglobin)	11 Optode11 (Hemoglobin)	с (Н
1	1.042114	0.217150	0.695905	1.224248	2.392591	1.512627	2.638559	5.022568	1.296566	5.265872	1.358595	1.1
2	1.094290	0.239339	0.719867	1.260177	2.455597	1.535864	2.707992	5.056011	1.329112	5.255593	1.355703	1.1
3	1.141668	0.249259	0.732014	1.285602	2.499484	1.534878	2.761412	5.046281	1.339457	5.203595	1.327303	1.1
4	1.180681	0.244905	0.729849	1.298538	2.518244	1.507831	2.792903	4.990211	1.328569	5.115302	1.276620	1.0
5	1.208385	0.225855	0.712289	1.298692	2.509023	1.456563	2.799304	4.891537	1.300551	5.001667	1.210020	1.0
6	1.222713	0.193201	0.679727	1.287444	2.472589	1.386242	2.780625	4.760337	1.261436	4.876757	1.135598	1.0
7	1.222363	0.148961	0.633836	1.267397	2.413183	1.304393	2.740077	4.611070	1.217911	4.755015	1.061514	0.9
8	1.206839	0.095775	0.577370	1.241887	2.337636	1.219224	2.683282	4.459850	1.175631	4.648044	0.994084	0.9
9	1.176742	0.036528	0.514021	1.214688	2.254521	1.138488	2.617723	4.322033	1.138420	4.563002	0.936822	0.8
10	1.133610	-0.026041	0.447822	1.189346	2.172739	1.068220	2.551472	4.209566	1.107851	4.501817	0.890035	0.8
11	1.080092	-0.089340	0.382879	1.169015	2.100184	1.011816	2.492075	4.129580	1.083155	4.461480	0.851201	0.8
12	1.019767	-0.150988	0.322757	1.156010	2.042666	0.969996	2.445586	4.083690	1.062116	4.435836	0.816125	0.8
13	0.956424	-0.209035	0.269871	1.151302	2.002944	0.940768	2.415526	4.068150	1.041906	4.417467	0.780246	0.8
14	0.893836	-0.261853	0.225261	1.154608	1.980501	0.920243	2.402632	4.075083	1.019762	4.399580	0.740038	8.0
15	0.835148	-0.308349	0.188504	1.164297	1.971810	0.903544	2.404843	4.094100	0.993978	4.377704	0.694004	0.7
16	0.782332	-0.348127	0.157844	1.177707	1.971000	0.885675	2.417635	4.114292	0.964075	4.350246	0.643059	0.7
17	0.736306	-0.381268	0.130803	1.191786	1.971194	0.862706	2.435162	4.126204	0.930965	4.318509	0.590583	0.7 🗸
<										1	1	>
Select All	Deselect All	Copy Form	nat • Decim	al Digits 🔻								

4.3.3. Multi-variable bar graph

12) Open "Graph View" tab to see the graph from all variables. To edit graph properties such as range, error bar type, etc, use Properties Pane. If it is closed, can be opened again, by right clicking on the graph and selecting on "Properties" from the dropdown context-menu.



13) Change the error bars to "standard deviation" at item "2.4 Variance Type" and Y-axis range maximum to 6 at item "5.2 Range"





14) Next, change background color to 'Beige' at item "7.1 Background Color".



15) Change Graph Type to 'Bar (2 by 8)' to see each optode data (from all variables) in separate subgraphs. And hide properties by right-clicking on the graph and unselecting Properties from the context menu. The color legend is still available as small squares at the top left corner and can be moved by clicking & dragging.



4.3.4. Multi-variable temporal graph

16) Change Graph Type to "Temporal All in 1" to see all optodes from all variables in a single time series graph. Also change background color back to "GhostWhite".



17) The above type of graph can be hard to evaluate with many number of optodes and variables. Instead, each optode can be graphed separately. From the bottom toolbar, change graph type to "Temporal 2 by 8".



4.3.5. Multi-variable aggregate temporal graph

18) In this case, there are three time-traces in each optode graph (one for each variable). Another useful option is to draw aggregate (average time-series). To do that, change "Draw Type" at the bottom toolbar to "Aggregate".



- 19) With the aggregate draw type, an average time-series (in blue) and also error (plus and minus) to this average is also drawn as a shaded area. The error area, similar to error bar, can be standard error, standard deviation or 95% confidence interval. Also note that the legend is changed when the draw type was changed.
- 20) It is possible enlarge one of the optode graphs to cover all window by double-clicking or selecting view from right-click-context menu.



TIP

Use name filtering in "Select Variables" window:

When there are large number of variables are loaded in Dataspace, finding specific variable can be challenging in "Select Variable(s)" window. Use "filter by name" to list only variables that contain a specific string in their names as shown below.

	Select Variable(s)	×
Available variables (Filtered) hbt oxygraph1.ref.hbt.Block2 oxygraph1.ref.hbt.Time1 oxygraph1.ref.hbt.Time2	x Selected variables x Oxygraph1.ref.hbo.Block1 oxygraph1.ref.hbr.Block1 oxygraph1.ref.hbt.Block1 image: the second se	

TIP

Data and Time variable coupling/association is by name.

Data variables contain only optode (for hemoglobin data) or channel (for light intensity data). The time information is kept in a separate variable that has only one column but has the same number of rows as the data variable.

Name association: The time variable for any time variable is found by the following:

- 1. Start with the name of data variable (i.e. "oxy1.hbo.Block1")
- 2. Replace the term "Block" with "Time" (i.e. "oxy1.hbo.Time1")
- 3. If there are any variable with the above string, use that as time variable.
- The keywords are "Block", "Time", "Marker" are special within names, fnirSoft replaces them in name templates to find associated variables.

4.3.6. Multi-variable aggregate & grouped temporal graph

21. From Dataspace, select the following 4 variables: (oxygraph1.ref.hbo.Block1 oxygraph1.ref.hbo.Block2 oxygraph1.ref.hbr.Block2).

			fnirSoft Pro	cessing Tool		_ 🗆 🗙
Dataspace Directory Process Compa	re MBLL					
Enter text to filter						
Name	Туре	Content	Size	Date/Time	Lab ^	2 I 🖻
oxygraph1.ref.hbo.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBC	⊿ Identity
oxygraph1.ref.hbo.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBC	Name
oxygraph1.ref.hbo.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBC	Date/Time 6/7/2015 10:50:12 AM
oxygraph1.ref.hbo.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBC	Type Numeric
oxygraph1.ref.hbr.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR	Content Hemoglobin
oxygraph1.ref.hbr.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR	Size 49 x 16
oxygraph1.ref.hbr.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR	Supplementary
oxygraph1.ref.hbr.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR	Labels
oxygraph1.ref.hbt.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT	Log
oxygraph1.ref.hbt.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT	⊿ Value
oxygraph1.ref.hbt.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT	Preview
oxygraph1.ref.hbt.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT	
oxygraph1.ref.oxy.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY	
oxygraph1.ref.oxy.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY	Name
oxygraph1.ref.oxy.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY	
<					>	
Load Save - Delete - Import	Export			4 items selected. Total: 16, 16 vars,	0 lightgrap	hs, 0 oxygraphs, 0 topographs Refresh

22. Next, right-click and select "view" to open them in view tool.



23. Change Graph Type to "Temporal 2x8" and Draw Type to "Aggregate".



24. Click "Groups" button on the bottom toolbar. The Grouping Editor will be shown with only one group that all variables are in.

fS

		Grouping Editor		>
	Group 1			
oxygraph1.ref.hbo.Block1	•			
oxygraph1.ref.hbo.Block2	✓			
oxygraph1.ref.hbr.Block1	-			
oxygraph1.ref.hbr.Block2	-			
Add Group Group Typ	e: None	•	Cancel & Quit	Save & Quit

25. Click on "Add Group" button at the bottom toolbar to add a new group.

	Grouping Editor							
	Group 1	Group 2						
oxygraph1.ref.hbo.Block1	-							
oxygraph1.ref.hbo.Block2	-							
oxygraph1.ref.hbr.Block1	•							
oxygraph1.ref.hbr.Block2	-							
Add Group Group Typ	e: Manu	ial	 Cancel & Quit 	Save & Quit				

26. Next, to move 'oxygraph1.ref.hbr.Block1' and 'oxygraph1.ref.hbr.Block2' variables, click on the checkboxes under the Group 2 column. Note that, group type is now changed to 'manual'.

Group 1 Group 2 oxygraph1 ref hbo.Block1 Image: Complete the second	Grouping Editor ×								
oxygraph1.ref.hbo.Block1		Group 1	Group 2						
oxygraph1.ref hbo.Block2	oxygraph1.ref.hbo.Block1	-							
oxygraph1.ref.hbr.Block2	oxygraph1.ref.hbo.Block2	•							
oxygraph1.ref.hbr.Block2	oxygraph1.ref.hbr.Block1		✓						
	oxygraph1.ref.hbr.Block2		✓						
Add Group Group Type: Manual Cancel & Quit	Add Group Group Typ	e: Manu	al	✓ Cancel & Quit	Save & Qui				

27. It is possible to rename the groups. Right click on the column headers that say "Group 1" and "Group 2" to enter HBO and HBR respectively.

			Grouping Editor		×
oxygraph 1 ref.hbo.Block 1 oxygraph 1 ref.hbo.Block 2 oxygraph 1 ref.hbr.Block 2 oxygraph 1 ref.hbr.Block 2	Group 1	Gr	Rename Group Delete Group Check all		
Add Group Group Typ	e: Manu	ual	•	Cancel & Quit	Save & Quit
			Grouping Editor		×
	HBO	HBR			
oxygraph1.ref.hbo.Block1	•				
oxygraph1.ref.hbo.Block2	•				
oxygraph1.ref.hbr.Block1		-			
oxygraph1.ref.hbr.Block2		✓			
Add Group Group Tv				Coursel B. Out	

28. Click "save and quit" button the lower right corner. Accept manual changing of the groups to this will return to the graph view.



29. Graph view will be updated to show the two groups time-traces (each are product of multiple variables). Note also that, the legend displays the names of the groups with color coding.



5. Processing Tool

Processing tools provides a quick and visual interface to apply various predefined action(s) to the selected input variables. See the previous chapter on Dataspace to get more information on variables. Processing tool is available at the "Process" tab next to "Dataspace" tab. To open, click on "Dataspace" toolbar button of the main window. The following window will appear.

	fnirSoft Pr	rocessing Tool	- 🗆 ×
Dataspace Directory Process Compa	re MBLL		
Output Variable(s)	Action(s) to perform	Input Variable(s)	
Use '# as placeholder for index number. For example writing 'test# with two input files will produce test1 and test2	none/	none!	
Type in label, seperate multiple labels by comma (°, 7			
Execute	Clear Add/Remove Actions	Clear Add/Remove Variables	
>> Ready			

There are 3 steps needed to perform an operation:

- 1) Select input variable(s)
- 2) Select action(s) to perform
- 3) Execute

The outcome will be displayed at the output pane at the bottom of the window. And, new variable(s) will be added to the current variables' list.

C	B	fnirSoft Processing Tool	- - ×
	Dataspace Directory Process Compare MBLL		
	Use If as placeholder for index number. For example writing best?" with two input files will produce test t and test?	Action(s) to perform Input (ariable(s) none/ (none!)
3	sce in label, seperate multiple Sale by comma (;)		-
	Execute	Clear Add/Remove Actions Ci r A d/Remove Va	riables
	>> Ready		

5.1.Select input variables

 Click on "Add/Remove Variables" button, a new window will appear that lists all available variables. On the left hand side, all available variables are listed and on right-hand side, those already selected (loaded) to the current detail-view window are listed. You can move variables from one to the other and select "Save" to commit the changes to update the graph. Use "filter by name" to list only variables that contain a specific string in their names as shown below that filters by "Block", so only data variables are listed and not time variables (that has 1 column)

	Select Variable(s)
Available variables (Filtered)	Selected variables
Block oxygraph1.ref.hbr.Block1 oxygraph1.ref.hbr.Block2 oxygraph1.ref.hbt.Block1 oxygraph1.ref.hbt.Block2 oxygraph1.ref.oxy.Block1 oxygraph1.ref.oxy.Block2	x D
Cancel	Save

2. Select one or more variables of interest and click 'right-arrow' button to move them to the list on the right hand side. Selected variables' name and size is also shown at the bottom of the list. Click "Save" button to accept the selected list and close the window. The "Process" screen will change to indicate selected variables. Also, a name template will be added to the output variable name section.

					fnirS	oft Processing	g Tool			_ [ĸ
Dataspace	Directory	Process	Compare	MBLL							
0	utput Varia	ble(s)		Ac	tion(s) to perform		11 01) oro	nput Variable(s) voraph1 ref bbo Block1			
proce	ss1.result#		=		none!	(02) ox	vgraph1.ref.hbo.Block			
Use '#' numbe with tw and tes	as placeholder r. For example to input files wil t2	for index writing 'test I produce te] # st1			(,		
Type in labels t	n label, seperati by comma (", ')	e multiple					۲	>			
	Execute	•		Clear	Add/Remove Action	8	Clear	Add/Remove Variable	S		
>> Ready											-

5.2.Select actions

 Click "Add/Remove Actions" button to display all available actions as shown below. The list on the left is categorized by processing type (Temporal/Spatial/Cell by Cell). Temporal processing operation is performed across rows. So, for Temporal Mean, the result variable has the same number of columns with the input and only one row that is the mean values. Spatial processing is performed across columns, so for Spatial Mean, the resultant variable has same number of rows with input variable but one column that contains mean values.

	Select Action(s	.) 🗙
Available actions		Selected actions
Temporal Processing & Averaging & Fasture Extraction & Outline Conditioning & Misc Spatial Processing & Averaging & Feature Extraction & Conditioning & Misc & Cell by-Cell Processing & Averaging		
Cancel		Save

2) Select *Temporal Processing > Averaging > Mean Within Blocks* and click right arrow button.



 Click "Save" button to accept changes and close the window. Note that "Process" tab is updated immediately with selected settings and output variable name is automatically entered. This can be changed if necessary.

		fnirSoft	Processing Tool	- 🗆 🗡
Dataspace Directory Process	Compare MBLL			
Output Variable(s)	01) T.	Action(s) to perform	Input Variable(s)	
process1.result#	= 01) Ter	mporal_Mean_Within	02) oxygraph1.ref.hbo.Block2	
Use '#' as placeholder for index number. For example writing 'test# with two input files will produce test and test2	r tî			
Type in label, seperate multiple labels by comma (°, 7			۲	
Execute] [Clear Add/Remove Actions	Clear Add/Remove Variables	
>> Ready				

4) Finally, click on Execute button to perform the actions on the selected variables. The outcome will be posted at the bottom pane as shown below. For the selected operations, temporal means of the two input variables are created as new variables with names 'process1.result1' and 'process1.result2'. These are single row (1x16) variables and each cell in the row is the mean of the corresponding column of the corresponding input variable.

					fnirSc	oft Processing	g Tool			- 🗆 🗙
Dataspace	Directory	Process	Compare	MBLL						
Q	utput Varia	<u>ble(s)</u>			ction(s) to perform	,	01) oxy	nput Variable(s) vgraph1.ref.hbo.Block	k1	
proce	ess2.result#		=	or) rempo		(02) oxy	graph1.ref.hbo.Block	2	
Use '# numbe with tw and tes	' as placeholder vr. For example v vo input files will st2	for index writing 'test produce te	u# st1			,			,	
Type it labels i	n label, seperate by comma (", ")	multiple					۲		>	
	Execute			Clea	Add/Remove Actions	(and the second s	Clear	Add/Remove Variab	les	
>> Ready >> Succes	s: Created 2 v	variables [process1.	esult1 process1	result2]					

Directory Process Comp	are MBLL					
Enter text to filter						
Name	Туре	Content	Size	Date/Time	Lab ^ 🔡 24 🖾	
oxygraph1.ref.hbo.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBC	
oxygraph1.ref.hbr.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBF	
oxygraph1.ref.hbr.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBR	
oxygraph1.ref.hbr.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR	
oxygraph1.ref.hbr.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBR	
oxygraph1.ref.hbt.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT	
oxygraph1.ref.hbt.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	HBT	
oxygraph1.ref.hbt.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT	
oxygraph1.ref.hbt.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	HBT	
oxygraph1.ref.oxy.Block1	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY	
oxygraph1.ref.oxy.Block2	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	OXY	
oxygraph1.ref.oxy.Time1	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY	
oxygraph1.ref.oxy.Time2	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	OXY	
process1.result1	Numeric	Hemoglobin	1 x 16	6/7/2015 8:16:35 PM		
process1.result2	Numeric	Hemoglobin	1 x 16	6/7/2015 8:16:35 PM	¥	
<						

5.3.Statistical comparison and tests

Statistical comparison methods can be applied at the "Compare" tab of "fnirSoft Processing Tool" window as shown below.

	fnirSoft Pr	ocessing Tool		_ 🗆 🗙
Dataspace Directory Process Compare 1 Output Variable(s)	IBLL Group By		Input Variable(s)	
Use '# as placeholder for index number. For example writing 'tesd' with two input files will produce test f and test2	Action(s) to perform	} {	none! }	
Execute		~	Clear Add/Remove Variables	

Similar to Process Tool, there are 3 steps:

- 1) Select input variable(s)
- 2) Select action to perform
- 3) Execute

The outcome will be displayed at the output pane at the bottom of the window. And new variable(s) will be added to the current variables list.

Selection of 'input variables' are same using the variable selection window interface. However, "Actions to perform" are selected from a drop-down menu as shown below.



Once the input variable and the action to perform are selected, output variable names are automatically filled. Also, description of selected action is added to the pane at the bottom of the screen.



Finally, clicking "Execute" button performed the analysis and creates new variables depending on the analysis type. In this case, for ANOVA, two new variables are created: one for F and the other for p values.

-	2			mirson	Processing 1001	
	Dataspace Directory Process (Compare MBLL				
	Enter text to filter					
١	Name	Туре	Content	Size	Date/Time ^	21 0
H	oxygraph1.ref.hbr.Blo	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbr.Ti	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbr.Ti	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbt.Blo	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbt.Blo	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbt.Tim	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
	oxygraph1.ref.hbt.Tim	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
	oxygraph1.ref.oxy.Blo	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	
	oxygraph1.ref.oxy.Blo	Numeric	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	
	oxygraph1.ref.oxy.Ti	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
	oxygraph1.ref.oxy.Ti	Numeric	Time	49 x 1	6/7/2015 10:50:12 AM	
Ы	process1.result1	Numeric	Hemoglobin	1 x 16	6/7/2015 8:16:35 PM	
7	process1.result2	Numeric	Hemoglobin	1 x 16	6/7/2015 8:16:35 PM	
	compare1.result1.f	Numeric	Statistics	1 x 16	6/7/2015 8:24:06 PM	
Π	compare1.result1.p	Numeric	Statistics	1 x 16	6/7/2015 8:24:06 PM	
	<				>	
15	Lond Course Delate - Llas	and Diment			T . 1 20 20	

As any other variable, clicking on one of the statistics type variables will open them in View Tool. And at the 'Array View' tab, individual values can be observed.

	1						view1 ·	compar	e1.result1	.p // Sho	wing 1 va	ariable						
G	iraph View	Array Viev	v: compare1	.result1.p	Notes: comp	lotes: compare1.result1.p +												
ſ		1 Optode 1 (Statistics)	2 Optode2 (Statistics)	3 Optode3 (Statistics)	4 Optode4 (Statistics)	5 Optode5 (Statistics)	6 Optode6 (Statistics)	7 Optode7 (Statistics)	8 Optode8 (Statistics)	9 Optode9 (Statistics)	10 Optode10	11 Optode11	12 Optode12	13 Optode13	14 Optode14	15 Optode15	16 Optode16	
IE	1	0.007458	0.007458	0.007816	0.007458	0.017728	0.007458	0.011386	0.007458	0.108586	0.007458	0.765875	0.007458	0.007458	0.007458	0.007458	0.007458	

5.4.Using MBLL to calculate oxygenation from variables

Programmatic oxygenation calculation from variables can be performed at the "MBLL" tab of "fnirSoft Processing Tool" window as shown below. This tool provides more flexibility and additional features for oxygenation calculation.

		fnirSoft Processing Tool		- 🗆 🗡
Dataspace Directory Process Comp. Output Variable(s) Une Was above for inder Probler. For example which base with non-proof files will produce test and test2	Modified Beer Lambert Law Settings	Baseline Variable(s)	Input Variable(s) none!)
Execute	с	lear Add/Remove Variables	Clear Add/Remove Variables	

Similar to Process Tool, there are 3 steps:

- 1) Select input variable(s)
- 2) Select **baseline variable(s)** (optional)
- 3) Execute

All input variables should be light intensity content type. Any number of input variables can be used. If no baseline variable is provided, first 20 rows of each input variable will be used for that variable as a baseline. Otherwise, same number of baseline variables needs to be selected so, through one to one matching, first baseline variable will be used for first input variable, etc. If only one baseline variable is selected or at the MBLL settings dialog, 'use single baseline' is enabled, all input baseline variables will be averaged and the same baseline will be used for each input variable.

Once the input variable is selected,	output variable names are automatically filled.
--------------------------------------	---

		fnirSoft Processing Tool		- 🗆 🗡
Dataspace Directory Process Compare Output Variable(s)	MBLL Modified Beer Lambert Law Settings	seline Variable(s) none!	Input Variable(s) lightgraph1.raw.Block1 (DATA))
Execute	Clear	Add/Remove Variables	Clear Add/Remove Variables	

When, 'Execute' is clicked, all variables (names by default starts with mbll as they are created by mbll tool) are calculated. Also, time variables are generated for each corresponding data variable.

	fnirSoft Processing Tool	_ 🗆 🗙
Dataspace Directory Process Compare Output Variable(s)	MBLL)
Execute	Clear Add/Remove Variables Clear Add/Remove Variables	
>> Success: Created 8 variables [mbl1.result mbl1.result1.cxy.Time]	hbo.Block mbil 1 result 1 hbr.Block mbil 1 result 1 hbt.Block mbil 1 result 1 .oxy Block mbil 1 result 1 hbo.Time mbil 1 result 1 hbr.Tin	e mbil 1.result 1.hbt. Time

			fnirSoft Pro	cessing Tool		_ 🗆 🗙
Dataspace Directory Process Co	mpare MBLL					
Enter text to filter						
Name	Туре	Content	Size	Date/Time	2 ↓ 5	
lightgraph1.raw.Block1	Numeric	Light	1063 x 48	6/6/2015 2:55:54 PM		
lightgraph1.raw.Time1	Numeric	Time	1063 x 1	6/6/2015 2:55:54 PM		
lightgraph1.raw.Marker1	Numeric	Marker	29 x 2	6/ /2015 2 5		
+ lightgraph1.raw.lnfo1	List	Composite	25 variables			
mbll1.result1.hbo.Block	Numeric	Hemoglobin	1063 x 16	-J PM		
mbll1.result1.hbr.Block	Numeric	Hemoglobin	1063 x 16	10 8:56:25 PM		
mbll1.result1.hbt.Block	Numeric	Hemoglobin	1063 x 16	6/7/20 5 8:56:25 PM	1	
mbll1.result1.oxy.Block	Numeric	Hemoglobin	1063 x 16	6/7/2015 8:56:25 PM	1	
mbll1.result1.hbo.Time	Numeric	Time	1063 x 1	6/7/2015 8:56:25 PM		
mbll1.result1.hbr.Time	Numeric	Time	1063 x 1	6/7/2015 8:56:25 PM		
mbll1.result1.hbt.Time	Numeric	Time	1063 x 1	6/7/2015 8:56:25 PM		
mbll1.result1.oxy.Time	Numeric	Time	1063 x 1	6/7/2015 8:56:25 PM		
<				>		
Load Save - Delete - Impo	ort Export			Total: 4, 4	4 vars, 0 lightgraphs, 0 oxygraphs, 0 top	ographs Refresh

6. Export Data Tool

1. The Export Data Tool can save variables in Dataspace to output file formats in various format for other applications to use. The Export Data tool is accessible from Main window, toolbar button, "Tools" dropdown menu item, or fnirSoft Processing Tool, variable tab, export button.



2. The wizard style dialog, provides 4 steps where all variables or selected ones can be saved in various formats and styles. The first step includes selection of all variables or selection of a subset of variables for export.

ď	Export Data Tool
Step 1 of 4: Data	Please select data you would like to export!
All Variables Use all available variab	les currently in memory.
O Selected Variab	les bles as shown below.
none!	
To see list of variables in m button at the main window.	emory, use 'Dataspace' toobar Next

3. Next, one of the available file formats is selected: tab-separated text file, comma separated Excel file and Matlab file format, Biopac Acknowledge or fnirSoft data file format. Also, exported variables can be saved into separate files (one file for each variable) or all of them into a single output file (one file for all variables). Also, a report file can be generated. The report option generates a summary file for each input variable by saving mean and standard deviation of all optodes (columns) of each variables.



4. The next step is to name the output files. Name template is applied to each output file generated and if it includes placeholders (special keywords in between curly parenthesis) as listed below on screen, appropriate values are replaced. For example, "{name}" placeholder is replaced by the variable name. A preview of output filenames based on current input variables and name template is listed at the bottom of the screen.

ď	🖻 Export Data Tool 🗙											
Step 3 of	Step 3 of 4: Output Filename(s) Add placeholders to use values											
Filename Ter fS_Exported_	mplate: {name}											
{name}	{index}	{count}	{file count}	{type}								
{size}	{label}	{width}	{height}	{date}								
{time}	{year}	{month}	{day}	{hour}								
{minute}	{second}											
Preview: fS_Exported_ fS_Exported_ fS_Exported_ fS_Exported_ fS_Exported_ fS_Exported_ fS_Exported_	<pre>{minute} {second} Preview: fS_Exported_oxygraph1ref.hbo.Block1tbt fS_Exported_oxygraph1ref.hbo.Block2tbt fS_Exported_oxygraph1ref.hbo.Time1tbt fS_Exported_oxygraph1ref.hbo.Block2tbt fS_Exported_oxygraph1ref.hbr.Block1tbt fS_Exported_oxygraph1ref.hbr.Block2tbt fS_Exported_oxygraph1ref.hbr.Time1tbt </pre>											
Previous				Next								

5. At the last step, the output folder is selected by using the "Select Output Folder" button. Also, summary of overall action (number of input, type of output files, etc.) are presented for final confirmation. Hit Export button to perform the action.

🗳 Export Data Tool	x
Step 4 of 4: Location Please select location of output files!	
Select Output Folder	-
C:\Users\Hasan\Desktop	
After Export	
Show output files in folder Open Windows File Explorer	
Additional Info	es
16 variables will be exported to separate files. Type of the file is Text File(*.txt);Tab-separated text	
Previous	

Below is a representative output file (plain text with tab separated columns) that contains header rows that includes description of the data and individual column content type and descriptive captions.

fnirSoft:	Exported 1	ext File													
Version:	4														
ExportDat	6/7/2015	23:46													
VariableIn	fo						Head	er row	S						
Name:	oxygraph1	.ref.hbo.Bl	ock1												
Size:	49 x 16														
Type:	Numeric														
Content:	Hemoglob	in													
Date:	6/7/2015	10:50													
Notes:	Oxygenate	d-hemoglo	bin concen	tration cha	nges refine	d data save	ed by Oxygr	aph from fi	le C·	C	olumn	descri	ptors	5_1_07	301658.oxy
Labels:	HBO	DATA													
VariableDa	ata														
Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemog		Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglob	Hemoglobin
Optode1	Optode2	Optode3	Optode4	Optode5	Optode6	Optode7	Optode8	Οριο 9	Optode10	Optode11	Optode12	Optode13	Optode14	Optode15	Optode16
0.654976	0.619831	0.	188677	0.891127	1.13215	1.128692	3.013687	0.566331	3.106394	0.719753	1.078529	0.632966	0.750965	1.960423	1.003706
0.703441	0.640601	0.:	219211	0.945265	1.151786	1.189305	3.04343	0.593639	3.102431	0.725675	1.094304	0.649117	0.769801	1.990398	0.992387
0.750071	0.652797	0.1	1308	0.987399	1.154202	1.238813	3.046335	0.605892	3.072513	0.712898	1.092623	0.653251	0.779216	2.015963	0.969483
0.792075	0.655658	0.1 J84	9	1.012618	1.137738	1.272618	3.019714	0.603653	3.019797	0.683378	1.075912	0.645749	0.780447	2.03816	0.937862
0.826712	0.64926	0.153527						89591	2.951034	0.641488	1.049072	0.628503	0.776027	2.058231	0.901256
0.85163	0.634418	0.143287	1.24		Data s	start ro	ws	67653	2.87505	0.592901	1.018017	0.604387	0.768913	2.076647	0.863093
0.86496	0.612343	0.120412	1.23277		Datas			42249	2.801077	0.543467	0.988503	0.576585	0.761935	2.093008	0.826035
0.865495	0.58442	0.086164	1.212942	0.920900	0.933364	1.231300	2.705951	0.517069	2.736703	0.497783	0.964532	0.547903	0.75733	2.10594	0.791599
0.853048	0.552047	0.042823	1.191344	0.864446	0.874744	1.190195	2.619394	0.494632	2.686659	0.458382	0.947941	0.520216	0.756234	2.113307	0.759997
0.828303	0.516432	-0.0068	1.170869	0.805792	0.822807	1.146944	2.547171	0.47589	2.652264	0.425568	0.938454	0.494437	0.758945	2.113169	0.730739
0.792957	0.478663	-0.05957	1.154095	0.750967	0.780997	1.107064	2.494155	0.460249	2.631547	0.39754	0.933845	0.470501	0.764849	2.10439	0.703043
0.749584	0.439752	-0.11238	1.142935	0.704594	0.750083	1.075121	2.461723	0.446086	2.620312	0.371364	0.931097	0.447748	0.772835	2.087031	0.676305
0.701059	0.400579	-0.16293	1.138145	0.669308	0.728819	1.053834	2.44785	0.431477	2.61338	0.343836	0.927366	0.425241	0.781578	2.062512	0.650509
0.650372	0.362085	-0.20972	1.139441	0.645326	0.714234	1.043847	2.447753	0.414496	2.605861	0.312474	0.920334	0.402058	0.78951	2.033155	0.625986
0.600452	0.325303	-0.25231	1.145616	0.630643	0.702542	1.04362	2.454797	0.39398	2.59429	0.276285	0.909089	0.377653	0.795313	2.001805	0.603438
0.553521	0.291133	-0.2912	1.154723	0.621366	0.689608	1.049734	2.461783	0.369745	2.577194	0.236015	0.894175	0.352032	0.798129	1.971621	0.583803

7. Import Data Tool

 fnirSoft can import data from text files. This section describes Import Data Tool that parses text files with customizable formatting guideline and extract data to be stored as variables in Dataspace (See Dataspace chapter for more information on variables). To start the procedure, select "Import Data Tool" under Tools dropdown menu item, or from toolbar button.



2) The Import Data Tool will appear empty as below. From the "Add File" button, select as many text files to import as required.



3) From the "Add File(s)" dialog, select the text file to be imported. Alternatively, one or more text files can also be drag-dropped (with mouse cursor) to this list to be added automatically.

2		Oper	n				×
🔄 🕘 × 🕇 🎴	« Docum	ents + fnirSoft + Sample Data	Ý	Ċ	Search Sample Data		,ο
Organize 👻 Ne	ew folder					- 🔟	0
🜏 Homegroup	^	sample import file.bt Text Document 2.96 KB					
🛤 This PC							
膧 Desktop							
Documents							
🚺 Downloads							
Music							
Pictures	~						
	File name:	sample import file.txt		¥	All Files (*.*)		~
					<u>O</u> pen	Cancel	

4) A sample text file (provided in sample data folder) contents are shown in the Notepad as follows

		S	ample import file.txt - N	Votepad		_ 🗆	×
<u>F</u> ile <u>E</u> dit F <u>o</u> rmat <u>V</u> iew	<u>H</u> elp						
trials							~
0.0670604419563314	0.0948204513208016	0.0851783836332285	0.0837458262554616	0.0920681046179406	0.0600677773260197	0.0936778477003399	
0.124634552494766	0.108337818652866	0.168887743966754	0.196195893066998	0.206131413984881	0.285213961276986	0.128271817283664	
0.190384690654494	0.0743480533942673	0.276829873478147	0.136202532760803	0.249745080921805	0.225347230547368	0.223430651863995	
0.145754977413809	0.160000405282469	0.128930887425282	0.105095277064029	0.157539579179007	0.10047085657482	0.0737414533441764	
-0.0864229011852441	-0.0950242416531418	-0.0964991111768392	-0.0807649802355653	-0.00472924926580486	-0.000665908907530567	0.00740992003607504	
0.147355713425831	0.0717937304706595	0.0957256774064015	0.0882832991854619	0.144024863769742	0.15387382685147	0.0770802005886763	
-0.0477937855597527	-0.0360724403934753	0.00420834159394149	-0.0622484495890517	0.0574328414937931	0.0210859586720191	0.00970476283169806	
0.094019964864435	0.0333688468726268	0.122751092835297	0.0787357288643724	0.0976200178939888	0.0856612252106967	-0.0241331003543321	
0.0785283893613312	0.0642782623323895	0.165972137665925	0.103806946404057	0.170593042463872	0.0863870143199924	0.0452594740428887	
-0.0544179347546846	0.012728594779413	-0.0823589177216487	0.0701134395924949	-0.090018565116915	0.012003350029571	-0.0990049570786757	
							\sim
<							> .::

5) Once the file is added to Import data dialog, it will appear in the file list. And, if the file is selected, the import function with current parser settings can be previewed at the Data section (bottom pane of the dialog).

Ъ			Ir	nport Data	a Tool			_ □	×
Input Files	Parser Settin	ngs Value	Mapping 0	utput Settings	5				
C:\Users\H	Hasan\Docum	nents\fnirSol	ft\Sample Da	ata\sample im	port file.txt				
Add Fil	e(s) 1 file	is added fo	r processin <u>o</u>] .			[Remove Fi	ile
Previe	v Previe	wing item 1	: Found vari	able of size i	10 x 16			View F	ile
File row #	Кеу	Va	lue						
1	trials								
									-
File row #	1	2	3	4	5	6	7	8	9
✔ 2	0.06706	0.09482	0.08517	0.08374	0.09206	0.06006	0.09367	0.10797	0.1
✓ 3	0.12463	0.10833	0.16888	0.19619	0.20613	0.28521	0.12827	0.19374	0.0
✓ 4	0.19038	0.07434	0.27682	0.13620	0.24974	0.22534	0.22343	0.21538	0.2
✓ 5	0.14575	0.16000	0.12893	0.10509	0.15753	0.10047	0.07374	0.13242	0.0
< 6	-0.0864	-0.0950	-0.0964	-0.0807	-0.0047	-0.0006	0.00/40	-0.0583	0.0
▼ / 	0.0477	0.07179	0.09572	0.06828	0.05742	0.00100	0.07/08	0.03/34	-0.0
▼ 0 √ 9	-0.04/7	-0.0360	0.00420	-U.U622	0.00743	0.02100	0.003/0	0.02031	-0.0
▼ 5 √ 10	0.03401	0.05336	0.122/0	0.07673	0.03/62	0.00000	-0.0241 0.0452E	0.02236	-0.0
V 10	-0.0544	0.00427	-0.0823	0.07011	-0.0900	0.00030	-0.04020	-0.00345	-0.0
• •	0.0044	0.01272	0.0023	0.07011	0.0000	0.01200	0.0000	0.0270	-0.1
<									>
									-
Cancel								Impor	1

6) The first section contains the first row of the file (see above file contents above) as it is automatically detected header text and not data. To remove it from importing, simply remove the check at the beginning of the row. Any row can be removed from import by clearing the respective checkbox.

When the any row checkbox is cleared (customization), this is noted by adding selected row count in parenthesis at in the input files tab, next to the filename.

7) Another input file can be added at any time. For example, the following is the output of exporter described at the end of previous chapter. All the headers rows are listed in header section and data section column captions are named after the information found in the file.

Ъ			Ir	nport Data	a Tool			_ 🗆	×
Input Files	Parser Settin	ngs Value	Mapping 0	utput Setting:	s				
C:\Users\Hasan\Documents\fnirSoft\Sample Data\sample import file.txt									
C:\Users\H	Hasan\Deskto	op\fS_Expo	orted_oxygrap	h1.ref.hbo.Blo	ock1.txt				
Add File	e(s) 2 file	s are adde	d for process	ing.			[Remove I	File
Preview	v Previe	wing item	2: Found vari	able of size 4	49 x 16			View	File
File row #	Key	V	/alue						^
✓ 1	fnirSoft	E	exported Text	File					
✓ 2	Version	4	.0						
✔ 3	ExportDate	6	/7/2015 11:4	6:16 PM					
4	VariableInfo)							
✓ 5	Name	0	xygraph1.ref.h	nbo.Block1					
✓ 6	Size	4	9 x 16						~
J 7	Time	N	lumaric						
File row #	1 - Opto	2 - Opto	. 3 - Opto	4 - Opto	5 - Opto	6 - Opto	7 - Opto	8 - Opto	· ^
✓ 15	0.65497	0.61983	. 0.07684	1.18867	0.89112	1.13214	1.12869	3.01368	
✓ 16	0.70344	0.64060	. 0.11040	1.21921	0.94526	1.15178	1.18930	3.04343	
✔ 17	0.75007	0.65279	. 0.13590	1.24130	0.98739	1.15420	1.23881	3.04633	
✓ 18	0.79207	0.65565	. 0.15084	1.25343	1.01261	1.13773	1.27261	3.01971	
✓ 19	0.82671	0.64926	. 0.15352	1.25527	1.01789	1.10325	1.28808	2.96528	
✓ 20	0.85163	0.63441	. 0.14328	1.24775	1.00265	1.05415	1.28477	2.88879	
✓ 21	0.86496	0.61234	. 0.12041	1.23277	0.96896	0.99574	1.26462	2.79901	
✓ 22	0.86549	0.58441	. 0.08616	1.21294	0.92096	0.93398	1.23136	2.70595	
✓ 23	0.85304	0.55204	. 0.04282	1.19134	0.86444	0.87474	1.19019	2.61939	
✓ 24	0.82830	0.51643	0.0067	1.17086	0.80579	0.82280	1.14694	2.54717	•
 ✓ 25 	0./9295	0.47866	0.0595	1.15409	0.75096	0.78099	1.10/06	2.49415	· *
									-
Cancel								Impo	rt

8) The 'Parser Settings' tab can be used reconfigure the parsing of the input files

🔁 Imp	port Data Tool 🦳 🗖 🗙
Input Files Parser Settings Value Mapping Outp	put Settings
Row Separator EndOfLine ('\n') Tab ('\t')	Other
Column Separator Tab ('\t') Comma ('.')	Space (' ') Other
Header Ignore the first rows Detect header Detect column captions at row: Auto	Data Data block starts at: Auto Convert date/time or time values to unix timestamp (total number of seconds)

9) The 'Value mapping' tab can be used to convert various strings within the data (like keys, condition descriptions, etc.) to numeric values. By default empty cell values and "NaN" string

values are converted to NaN value. Any other string found in the files will be automatically added to the list.



10) The "Output settings" tab, contains the controls for naming the output variable (that will be saved in Dataspace). Also, labels can be added to the output variable. Any value mapping used can be saved as a separate list file. By default output data variable name template is "imported#". The '#' sign is a placeholder for the count number.

Input Files Parser Settings Value Mapping Output Settings
Output Variable Output variables name template: imported# Output variables label(s): Image: Save header information as an extra list variable Image: Save value mapping as an extra list variable Image: Verbose parsing and processing information to console

11) Click "Import" button to add this 10x16 and 49x16 variables to the Dataspace. Their names start with 'import' since they are generated by import tool and includes 'var1' for the first variable and 'var2' for the second variable that is count number (1, 2, etc.) of the input file list. The third variable is the header values for the second variable in a list.

Dataspace Directory Process Compare MBLL										
Enter text to filter										
Name	Туре	Content	Size	Date/Time	21 🖾					
imported1.var1.Block	Numeric	Generic	10 x 16	6/8/2015 12:50	⊿ Identity					
imported1.var2.Block	Numeric	Hemoglobin	49 x 16	6/8/2015 12:50	Name	imported1.var1.Block				
imported1 var2 lpfo	List	Composite	11 variables	6/8/2015 12:50	Date/Time	6/8/2015 12:50:10 AM				
imported1 ver2 lpfo/"fpirSoff")	String	Toxt	19 chara	6/8/2015 12:50	⊿ Data					
imported i.var2.inio(inirSoit)	Sung	Text	To criars	6/6/2015 12.50	Туре	Numeric				
imported1.var2.info("Version")	String	lext	3 chars	6/8/2015 12:50	Content	Generic				
imported1.var2.lnfo("ExportD	String	Text	20 chars	6/8/2015 12:50	Size	10 X 16				
imported1.var2.lnfo("Name")	String	Text	24 chars	6/8/2015 12:50	Notes	Imported from file (C:\Lleare\Has				
imported1.var2.lnfo("Size")	String	Text	7 chars	6/8/2015 12:50	Labels	imported from the C. (Users (Has				
imported1.var2.lnfo("Type")	String	Text	7 chars	6/8/2015 12:50	Log					
imported1 var2 lnfo("Content")	String	Text	10 chars	6/8/2015 12:50	⊿ Value					
imported 1.var2.info(Content)	Chring	Text	20 share	0/0/2010 12:00	Preview	0.0671 0.0948 0.0852 0.083				
imported i.var2.inio(Date)	String	Text	20 chars	6/6/2015 12.50						
imported1.var2.Info("Notes")	String	lext	151 chars	6/8/2015 12:50						
imported1.var2.lnfo("Labels")	String	Text	8 chars	6/8/2015 12:50						
imported1.var2.lnfo("Variable	String	Text	0 chars	6/8/2015 12:50	Name					
< >										
Last Com Datas Davast Com			4.5	The second se	Official and a first state of the second state	and the Other state of the Court				

8. Organizer Tool

A typical experimental study contains many recording sessions from multiple participants. Each experiment might contain multiple files (such as nir, mrk, log) and multiple iterations.

The Organizer tool helps coordinating data files each might reside in many different folders or subfolders. And, Organizer tool catalogs them, lists & visualizes data contents and enables users to sort according to various criteria and finally access file content with one click.

The following window displays a typical Organizer window that lists a folder and all of its sub-folders by searching *.nir files. Also the number of associated files (such as mrk, oxy, log) are counted and visualized in the icon as number of compiled sheets that are slightly rotated. The data acquisition length in each file is also visualized in a horizontal bar by looking at the maximum recording length. In the example below it is 3 hours and half full bar indicates 1 and half hours of data collection on COBI Studio.



The total number of files and total duration is listed at the lower left corner of the window. The right hand side pane lists properties of selected item.

The view type can be changed from top right down button: available options are small, medium or large icon display, or details list as shown below.

torie	es	Vie	w Type • Sort By • G	roup By -	0]2↓ 🖾	
tion Duration 1 hours, 51 minu	~	Details Small Icons			Experiment 1 Experimente		
					2. Subject ID		
1 hours, 51 min			Medium Icons	-		3. Experiment	
	1 hours, 49 mini	-	Large Icons	=	1	File	
	1 hours, 49 min		Large Icons			Collection	
	1 hours, 53 minu	ites.	3 \9\8\COBI			Name	
	1 hours 53 min	ites	3 19\8\COBI			Path	
	1 hours 53 min					Miscellaneous	
	1 Hours, 55 minu	lutes, 2 19//CODI				Duration	

The Details view type is list and each experiment data file group is shown is a separate row. Sorting of rows can be changed by clicking on the headers (such as Start Time, Experimenter, Subject ID, Experiment ID, Duration, Path) or from the "Sort By" dropdown button menu.

🛃 Experiment Data Organizer	Tool									
Data Folder : C:\Users\Hasan	\Dropbox\UAV			🔽 Include Su	bdirectori	es View Tj	ype • Sort By • Group By •	-]2↓ □	
Name	Start Time	Experimenter	Subject ID	Experiment ID	Collection	Duration	Path 🔺	1	Experiment 1 Experimenter	ABC
BABC_9_9_04171557_corr.nir	4/17/2011 3:57:57 PM	ABC	9	9	1	1 hours, 51 minutes, 8	(10)9/COBI		2 Subject ID	9
BABC_9_9_04171557.nir	4/17/2011 3:57:57 PM	ABC	9	9	6	1 hours, 51 minutes, 8	(10)9/COBI		3. Experiment ID	6
BABC_9_9_04070911_corr.nir	4/7/2011 9:11:29 AM	ABC	9	9	1	1 hours, 49 minutes, 1	(9\9\COBI Ξ		File	
BABC_9_9_04070911.nir	4/7/2011 9:11:29 AM	ABC	9	9	5	1 hours, 49 minutes, 1	(9)9/COBI		Collection	5
BABC_9_8_04061826_corr.nir	4/6/2011 6:26:41 PM	ABC	9	8	1	1 hours, 53 minutes, 3	(9\8\COBI		Name	ABC_9_6_03310937.nir
BABC_9_8_04061826.nir	4/6/2011 6:26:41 PM	ABC	9	8	6	1 hours, 53 minutes, 3	(9\8\COBI		Path	\9\6\COBI
BABC_9_7_04041527_corr.nir	4/4/2011 3:27:56 PM	ABC	9	7	1	1 hours, 53 minutes, 2	(9)7(COBI	1	Miscellaneous	11. 51. 1. 10.
BABC_9_7_04041527.nir	4/4/2011 3:27:56 PM	ABC	9	7	6	1 hours, 53 minutes, 2	(9)7(COBI		Duration	1 hours, 51 minutes, 43 second
BABC_9_6_03310937_corr.nir	3/31/2011 9:37:13 AM	ABC	9	6	1	1 hours, 51 minutes, 4	(9)6\COBI		Start Time	5/51/2011 9:57:15 AM
BABC_9_6_03310937.nir	3/31/2011 9:37:13 AM	ABC	9	6	5	1 hours, 51 minutes, 4	\9\6\COBI			
ABC_9_5_03301818_corr.nir	3/30/2011 6:18:57 PM	ABC	9	5	1	2 hours, 52 seconds	\9\5\COBI			
BABC_9_5_03301818.nir	3/30/2011 6:18:57 PM	ABC	9	5	6	2 hours, 52 seconds	\9\5\COBI			
BABC_9_3_03241701_corr.nir	3/24/2011 5:01:07 PM	ABC	9	3	1	2 hours, 2 minutes, 9 s	\9\3\COBI			
BABC_9_3_03241701.nir	3/24/2011 5:01:07 PM	ABC	9	3	6	2 hours, 2 minutes, 9 s	(9)3)COBI			
ABC_9_2_03221650_corr.nir	3/22/2011 4:50:37 PM	ABC	9	2	1	1 hours, 55 minutes, 3	\9\2\COBI			
ABC_9_2_03221650.nir	3/22/2011 4:50:37 PM	ABC	9	2	6	1 hours, 55 minutes, 3	\9\2\COBI			
ABC_9_1_03211705_corr.nir	3/21/2011 5:05:02 PM	ABC	9	1	1	52 minutes, 18 seconds	\9\1\COBI			
BABC_9_1_03211705.nir	3/21/2011 5:05:02 PM	ABC	9	1	6	52 minutes, 18 seconds	\9\1\COBI			
B ABC_15_8_10231515.nir	10/23/2011 3:15:09 PM	ABC	15	8	5	2 hours, 9 minutes, 46	\15\8\COBI			
ABC_15_7_10221701.nir	10/22/2011 5:01:08 PM	ABC	15	7	5	1 hours, 49 minutes, 3	(15)7(COBI			
BABC_15_6_10221027.nir	10/22/2011 10:27:22 AM	ABC	15	6	4	2 hours, 27 seconds	(15)6(COBI			
ABC_15_5_10211715.nir	10/21/2011 5:15:13 PM	ABC	15	5	5	2 hours, 13 seconds	(15)5)COBI			
BABC_15_4_10190917.nir	10/19/2011 9:17:55 AM	ABC	15	4	4	1 hours, 54 minutes, 1	\15\4\COBI			
BABC_15_3_09301026.nir	9/30/2011 10:26:06 AM	ABC	15	3	4	1 hours, 53 minutes, 1	(15)3)COBI			
RARC 15 2 00231144 pir	0/03/0011 11-///-10 AM	ARC	15	2	F	1 hours 55 minutos 3	115/2/CORI	1.	Experimenter	
•		111					•	_ N	me of the experimente	r for the data collection
108 files, total duration: 7 day	s, 17 hours, 46 minutes,	58 seconds						Se	ssion	

To load any of them to a Lightgraph, simply double click on the row or icon.

Right-click on a row or an icon to display loading options.



If "Load as Variable" is selected, the data file is loaded to Dataspace with variable names that start with "OrgVar".

fnirSoft Processing Tool					
Dataspace Process Compare MBLL					
Name	Туре	Size	Date/Time	Notes	Labels
OrgVar.ABC_9_9_04070911_1.DataBlock	Numeric	13037 x 48	4/23/2014 6:23:31	Loaded raw data from C:\	
OrgVar.ABC_9_9_04070911_1.DataTime	Numeric	13037 x 1	4/23/2014 6:23:31	Time data from C:\Users\	
OrgVar.ABC_9_9_04070911_1.StartTimeStamp	Numeric	1 x 1	4/23/2014 6:23:31	Start time (origin) in unix ti	
OrgVar.ABC_9_9_04070911_1.BaseBlock	Numeric	20 x 48	4/23/2014 6:23:31	Loaded raw baseline data f	
OrgVar.ABC_9_9_04070911_1.BaseTime	Numeric	20 x 1	4/23/2014 6:23:31	Baseline time data from C:	
OrgVar.ABC_9_9_04070911_1.DataMarker	Numeric	155 x 2	4/23/2014 6:23:31	Marker data from C:\Users	

9. Topograph Tool

 Click on Topograph button at the main window toolbar or from Tools drop-down menu. This will create a new window which is a Topograph object named 'topograph1'. The new object is created in the Dataspace and can be accessed or deleted from the Dataspace window.



topograph1	-		×
Topograph ♥ fitisSoft Regular - (1x1) BlueResTellow			
*			
			~
Variable Type • Color Palette • Display Settings Brain View Video		U	Jpdate

E fnirSoft Processing Tool -									
Dataspace Directory Process Compare MBLL									
Q - Enter text to search in name									
Name	Туре	Value Preview	Content	Size	Date/Time	Labels			
topograph1	Topograph		{Topograph}	{Empty}	11/2/2018 5:54:34 PM				

2) First load sample fsd file "data_3.2.2_refined.fsd" to use as variable.

Enter text to search in name							
lame	Туре	Value Preview	Content	Size	Date/Time	Labels	
oxygraph1.ref.hbo.Block1	Numeric	0.654976 0.619	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA, HBO	
oxygraph1.ref.hbo.Block2	Numeric	0.086337 0.93	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA, HBO	
oxygraph1.ref.hbo.Time1	Numeric	248.146 248.65	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	
oxygraph1.ref.hbo.Time2	Numeric	303.225 303.73	Time	49 x 1	6/7/2015 10:50:12 AM	HBO, TIME	
oxygraph1.ref.hbr.Block1	Numeric	0.387138 -0.40	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,HBR	
oxygraph1.ref.hbr.Block2	Numeric	0.427619 -0.58	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,HBR	
oxygraph1.ref.hbr.Time1	Numeric	248.146 248.65	Time	49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	
oxygraph1.ref.hbr.Time2	Numeric	303.225 303.73	Time	49 x 1	6/7/2015 10:50:12 AM	HBR, TIME	
oxygraph1.ref.hbt.Block1	Numeric	1.042114 0.217	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,HBT	
oxygraph1.ref.hbt.Block2	Numeric	0.513956 0.352	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,HBT	
oxygraph1.ref.hbt.Time1	Numeric	248.146 248.65	Time	49 x 1	6/7/2015 10:50:12 AM	HBT, TIME	
oxygraph1.ref.hbt.Time2	Numeric	303.225 303.73	Time	49 x 1	6/7/2015 10:50:12 AM	HBT, TIME	
oxygraph1.ref.oxy.Block1	Numeric	0.267838 1.02	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,OXY	
oxygraph1.ref.oxy.Block2	Numeric	-0.341282 1.52	Hemoglobin	49 x 16	6/7/2015 10:50:12 AM	DATA,OXY	
oxygraph1.ref.oxy.Time1	Numeric	248.146 248.65	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	
oxygraph1.ref.oxy.Time2	Numeric	303.225 303.73	Time	49 x 1	6/7/2015 10:50:12 AM	OXY, TIME	
topograph1	Topograph		{Topograph}	{Empty}	11/2/2018 5:54:34 PM		

3) The new Topograph object (topograph1) is empty. To load a variable, click on variables button at the toolbar. Select variables window will appears as below. On the left-hand side, all available variables are listed and on right-hand side, those already selected (loaded) to the current detailview window are listed. You can move a variable from one to the other and select "Save" to commit the changes to update the graph.

Available variables	Selected variables
• Enter text to search	
	→
Show size Show labels	
oxygraph1.ref.hbo.Block1 (DATA,HBO)	L
oxygraph1.ref.hbo.Block2 (DATA,HBO)	
oxygraph1.ref.hbo.Time1 (HBO,TIME)	
oxygraph1.ref.hbo.Time2 (HBO,TIME)	*
oxygraph1.ref.hbr.Block1 (DATA,HBR)	•
oxygraph1.ref.hbr.Block2 (DATA,HBR)	10
oxygraph1.ref.hbr.Time1 (HBR,TIME)	W
oxygraph1.ref.hbr.Time2 (HBR,TIME)	
oxygraph1.ref.hbt.Block1 (DATA,HBT)	
oxygraph1.ref.hbt.Block2 (DATA,HBT)	
oxygraph1.ref.hbt.Time1 (HBT,TIME)	
oxygraph1.ref.hbt.Time2 (HBT,TIME)	
oxygraph1.ref.oxy.Block1 (DATA,OXY)	
oxygraph1.ref.oxy.Block2 (DATA,OXY)	
oxygraph1.ref.oxy.Time1 (OXY,TIME)	
oxygraph1.ref.oxy.Time2 (OXY,TIME)	
^	^
~	

4) Select oxygraph1.ref.oxy.Block1 from the list on the left and transfer it to the selected variables list on the right by clicking on the right arrow button.



5) Click 'Select' button to use the selected variable and close this window. The Topograph window will be updated immediately to show the current variable's all optodes together in color code by value.



6) Since the variable contains more than one row, temporal progression of spatial changes can be visualized. (Similar to a video with each row being a different frame). Click play button to start. You can drag the slider to the desired location.



7) Change the view type from regular to "Interpolated-Bordered" for visualization.

			-1.632
248.146	; 	266.505 (248.146 - 272.625)	272.625
1	Regular	37/49	49
	Interpolated Interpolated-Bordered	\mathbf{K} $\mathbf{\langle}$ $\mathbf{\rangle}$ $\mathbf{\square}$ $\mathbf{\rangle}$ $\mathbf{\rangle}$	x1.00 (2.00 fps) $ \lor $
Variable	Type • Color Palette • Display Sett	ings Brain View Video	Update

8) The graph will change immediately to reflect the changes.



9) Interpolation type, range and other properties can be changes by right-clicking on the graph and selecting "Display Settings". A new dialog box will appear as shown below.

opograph1 Disp	×	topo	graph1 Display Settings							
Type Range E	Irain Graph	Description	About	Туре	Range	Brain	Graph	Description	About	
Select spatial vis	ualization typ	e:		Sele	ect graph se	ettings:				
Type Interpolated-Bordered ~			~	Cu	Current Color Palette BlueRedYellow ~					
Interpolation Sett	ings				Display ru	uler on n	nain pane	l view		
Interpolation Type BSpline ~					Update graph only when 'Update Button' is pressed					
Number of Intermediate Points 18				Nu	Number of decimal digits for range display 3					
Update			Hide	Up	date				Hide	

10) At the 'Graph' tab, select "BlueCyanYellowRed" from as the color pallet and click 'Update'. The graph will be updated as follows.




11) Change the color pallet back to "BlueRedYellow from the display settings.

TIP

Note that, in topograph main window, left side contains subjects left side optodes (1,2, etc.) and right hand-side contains subjects right-hand side optodes (16, 15, etc.)



9.1.Visualize activations on brain surface image

12) Click "Brain View" from the bottom toolbar. A new visualization window will appear that registers the data to a brain surface image. See Ayaz et. al. (2006) for details.



13) On the color legend, you can adjust the threshold value based on your context (e.g. statistical significance, etc.). To change the threshold level, move your mouse pointer to the threshold point at the center of the color legend (the last visible color part, the middle value is the threshold) click and hold, while moving it up or down. As you move it up, the color bar will shrink, and the threshold value will change.



14) It is also possible to enter specific values from 'Display Settings' and at Brain tab. You can specify threshold value as a scale (between 0 to 255), or as value based on your current data range. Note that is also possible to specify dual threshold, one for upper and one for lower part of data range.

ype Range	Brain Graph	Description	About	Туре	Range	Brain	Graph	Description	About
Select brain visu	alization options	s:		Selec	t brain vis	sualiza	tion option	S:	
View	Frontal		\sim	View		[Frontal		\sim
Style	Transparen	t	\sim	Style		[Transparer	t	\sim
Background	White		~	Back	ground	1	White		\sim
Threshold			_	Three	shold				
Dual Thres	nold Scale (0-255) Value			Dual Three	shold	cale (0-255	5) Value	
Threshold	212	0.955		Thre	eshold (H	igh)	212	0.955	
				Thre	eshold (Lo	ow)	1	-1.632	
For 'Scale', use -1 t note that, 'Value' fie	o eliminate all, use i id depends on the o	256 to include al urrent data.	II, Also,	For 'So note th	ale', use -1 at, 'Value' f	to elim ield dep	nate all, use ends on the o	256 to include a surrent data.	II. Also,

15) To increase the visibility, activation rendering can be changed from *Transparent* to *Opaque* for clear image. To do this, at the top menu, select *Style > Opaque*

fS **2018**



9.2.Save activations as image

16) The current view can be saved as image. Right click on the brain surface and select "Save as Image" from the context menu. Current image can be saved or series (by time or threshold) can be used to scan from beginning to end to generate multiple image files all at once. Or a video file can be generated.



9.3.Save activations as video

17) Next, select save as video option. A wizard will appear with 4 steps. The first step identifies the type. Time-series is the default option and it will generate a video that spans across time (from beginning to end) including all frames. The other option, threshold series, spans across different threshold values on the same (current) frame.



18) In the second step, select the video encoder. Keep the default.

Video Exporter	X
Step 2 of 4: Encoding	Please select video output type
Encoder	Microsoft Video 🔻
Please select one of the available	encoders on this computers
Previous	Next

19) In the third step, select frames per second (fps) of the output video. This indicates how fast the video will play. For a signal that was collected at 2Hz, selecting 2 fps will result in real-time speed. And, selecting 4 fps will result in twice as fast playing and selecting 10 fps will indicate 5 times as fast as real speed.



20) At the last step, confirm the settings and click "export" button to select the output filename. Once operation starts, "please wait" message will appear. Depending on the data and computer hardware, this might take couple seconds or couple of minutes or more. Please wait until output report arrives.

Video Exporter	Video Exporter
Step 4 of 4: Output Please confirm settings and export	Step 4 of 4: Output Please confirm settings and export
Type : Time series Encoder: Microsoft Video FPS: 2	Type : Time series Encoder: Microsoft Video FPS: 2
	Please wait!
Previous Export	Previous

10. Lightgraph Tool

This tool enables visualizing, refining, processing and analyzing light intensity measurements that are recorded by COBI Studio to '*.nir' files. The tool includes many settings to visualize specific group of channels or optodes. Also, display time synchronized markers, custom time range settings are included. And, block analysis and various signal refinement options are available. Below are representative screens.





11. Oxygraph Tool

This tool enables visualizing, refining, processing and analyzing oxygenation/hemoglobin measurements that are recorded by COBI Studio to '*.oxy' files. Note that, earlier versions of COBI Studio save the oxy files as "filename.nir.oxy" that is "oxy" extension append to the nir filename. And some computers are set hide file extensions so nir file (filename.nir) would be display as "filename" and oxy file (filename.nir.oxy) would be displayed "filename.nir". The tool includes many settings to visualize specific group of optodes. And, display time synchronized markers, custom time range settings options are included. Also, block analysis and various signal refinement options are available. Below are representative screens.



12. Define Block Automation

This tool can be used in Lightgraph and Oxygraph to define multiple types of blocks at once. This is especially very useful as once the block configuration of an experiment is defined, this can be applied to many subjects easily using the 'Define Block Automation' tool.

Define Block Automations actually a list of presets that each defines one type of block. A preset, actually contains the 'start pattern', 'end pattern' and other settings such as 'label' that is used at the Define Block dialog. When a preset is executed zero or many blocks can be created at once. When an automation is executed, many presets can be executed at once.

12.1 Define Preset

A new preset can be created at the 'Define Block Automation' dialog or 'Define Block' dialog. For information about 'Define Block' dialog see section 3.1.

12.1.1. Using 'Define Block' dialog

1. Expand the dialog by pressing the vertical button at the right-hand side of the dialog.

tart of a block: se Markers Use Time All available ev	Check End C				
se Markers Use Time All available evo		of a block:		Check	
All available ev	Use Ma	arkers Use Time	•		 Define Blocks
	ent markers		All available	event marke	Show/Hide Preset Se
Start pattern Sort: By Time E	By Value End	pattem	Sort: By Time	By Value	
 -2 (Baseline -3 (Baseline -4 (Baseline -5 (Recordin 	Starte ∧ value end) ng Sta		 -2 (Base -3 (Base -4 (Base -5 (Reco 	ine Starte ∧ line value ine end) rding Sta	> > > > >
Up 40 (Marker) 45 (Marker) 00 (Marker) 50 (Marker)	•		Up 40 (Mark 45 (Mark 90 (Mark 50 (Mark	ter) ter) ter) ter) ❤	~ ~ ~ ~
Ignore the first markers		nore the first	markers		>
Block start includes outer border	B	lock end include	s outer border		>
Only check within block:	✓ □ A	pply the following	g label:		Ś
Use all combinations of start and end tim	ies 🗌 B	iocks can overla	p or touch neighbor	S	>
ghtgraph2 Define Blocks	Check End	of a block ·		Chaok	× Dragota:
se Markers Line Time		arkers Lies Time		CHECK	Add New
All available ev	vent markers	Uncers Use Time	All available	e event markers	
Start pattern Sort: By Time	By Value End	pattem	Sort: By Time	By Value	B
-2 (Baseline	Starte 🔺		-2 (Base	line Starte 🔺	S FIRST10SECON
-3 (Baseline -4 (Baseline	end)		-3 (Base	line value line end)	LAST10SECON DASHBOARD
-5 (Recordir 40 (Marker)	ng Sta		-5 (Reco	ording Sta	
Up 45 (Marker)			Up 45 (Mar	(er)	GOALS
Down 50 (Marker) 50 (Marker)	~		Down 50 (Man 50 (Man	ker) ker) ✓	OLD
Ignore the first markers		gnore the first	markers		< > >
Block start includes outer border	E	Block end include	s outer border		Load
	~ 4	Apply the followin	g label:		Rename
Only check within block:		SIOCKS Can overla	ap or touch neighbo	15	IS I I I I I I I I I I I I I I I I I I
Only check within block: Use all combinations of start and end tin Pondy	nes 🗌 E				C Delete
Only check within block: Use all combinations of start and end tin Ready	nes 🗌 E				< Delete

- 2. The preset list is displayed. Clicking any preset will attempt load the preset to the 'Define Block' dialog. (i.e. update all the input sections of the dialog with respect to the preset settings.). Note that if preset is not compatible with the current data (in Lightgraph or Oxygraph) not all settings of the preset could be loaded. This is not the case for Define Block Automation Tool as it is independent of the data for display.
- 3. Enter settings on the 'Define Block' dialog, (start pattern, end pattern, label, etc.) that you wish to use for preset.
- 4. Click on the 'Add New' button at the right top.

lightgraph2 Define Blocks		Define Blocks
Start of a block: Check	End of a block: Check	Pre: Create a new preset by saving all current inputs for later use
Use Markers Use Time	Use Markers Use Time	Add N
All available event markers	All available event markers	A
Start pattern Sort: By Time, By Value By Value 90 (Marker) -2 Gaseline state > -3 Gaseline value > -4 Gaseline value -5 (Recording Sta 40 (Marker) -	End pattern Sort: By Time (By Value) 50 (Marker) < 2 (Baseline statt A 3 (Baseline value) > 4 (Baseline end) 5 (Pecording Sta Up 45 (Marker) 90 (Marker) 50 (Marker) ×	ENTIRE ENTIRE FIRST10SECON LAST10SECON UAST10SECON V V PERF GOALS ACTIVITIES OLD
Ignore the first markers	Ignore the first markers	
Block start includes outer border Only check within block: V Use all combinations of start and end times	Block end includes outer border Apply the following label: 90 Blocks can overlap or touch neighbors	Rename
>> Ready Run (Step 1) Save (Step 2)	Manage Clear All Close	Delete

5. A popup dialog will appear asking you to enter a new name for the preset.

Please enter a block p	oreset name	x
90		Save
Asdasd		
>> Ready >> New preset save	d.	
Run (Step 1)	Save (Step	2)

12.1.2. Using Automation dialog

A new preset can be created directly at the Automation Dialog.

- 1. Open the Automation dialog using the 'Automation' button at the bottom toolbar of Lightgraph or Oxygraph.
- 2. On the Automation dialog, select 'Default' automation item from the list and click View/Edit button on the right-hand side of the window.

6.

lightgraph1 Define Block Automations	×
Define Block Automations Run available automations or add/edit new automations by combining existing presets Available Automations:	s.
DEFAULT (contains 3 presets)	Add New
TEST (contains 6 presets)	
	View/Edit
	Rename
	Delete
	Delete
Run (Step 1) Save (Step 2) Blocks: Manage Clear All	Close
>> Ready	

3. At this screen, you can modify the automation list items (the right-hand side list) by moving available presets from the left. Also, using the 'Add New' button, you can create new presets. Click 'Add New'

lightgraph1	Define Bloc	k Automations					×
Automati Add/remove pr	on > D	EFAULT	tion Preset	ts' list be	elow to edit cu	rrent autom	ation.
	Presets:	Add New	View / E	dit	Delete]	
Available Pr	esets:			Curren	nt Automation	Presets:	
A (Start:Mat B (Start:Mat DASHBOA INV (Start:W PERF (Start GOALS (Start ACTIVITIES OLD (Start:I 90 (Start:Mat	rkers 46 Er rkers 46 Er RD (Start) Markers 25 tMarkers 2 artMarkers S (StartMa Markers 22 arkers 90 E	nd:Markers 45 nd:Markers 82 Markers 230 E D End:Markers 260 End:Mark s 270 End:Mark core 280 End 20 End:Markers 5 nd:Markers 5		ENTI FIRS LAST	RE (Start.Ma T10SECONI T10SECONE	arkers -5 E DS (Start) DS (Start:F	End:Markers Markers -5 E Relative Tim
'Define Blocks' seen here. 'De	' dialog side efine Blocks'	panel section al can be used to t	so allows a est and qu	adding a ickly bu	and removing p ild presets for	resets that the current	can be dataset.
However, it wil the 'Edit' on this	ll not be able s dialog to vi	to open incomp iew/edit any pres	atible pres set.	ets (that	t includes diffe	rent marker	s, etc) Use
Back			Define Blo	cks		[Save

4. Preset editor will open with all empty settings.

lightgraph1 Define Block Automations	×					
Automation > Preset > Add New Preset						
Start of a block:	End of a block:					
Use Markers Use Time	Use Markers Use Time					
Start pattern	End pattern					
Marker	Marker					
*	*					
Ignore the first markers	Ignore the first markers					
Block start includes outer border	Block end includes outer border					
Use all combinations of start and end times	Apply the following label:					
	Riceka esp everlap er teuch peighbors					
Back	Save					

5. To create a new preset, enter '-5' for start of a block, '-1' for end of a block and 'ALL' for label as follows.

lightgraph1 Define Block Automations	X
Automation > Preset > Add New	w Preset
Start of a block:	End of a block:
Use Markers Use Time	Use Markers Use Time
Start pattern	End pattem
Marker	Marker
▶ <mark>-</mark> 5	► -1
*	*
anore the first markers	Ignore the first markers
Block start includes outer border	Block end includes outer border
Use all combinations of start and end times	Apply the following label:
	ALL
	Blocks can overlap or touch neighbors
Back	Save

6. Click Save to record this new preset. A popup will appear. Enter 'ALL' as a name for this new preset.



7. Click save and you will be back to the preset list. The new preset is now should be available in the left-hand side list.

lightgraph1 Define Block Automations
Automation > DEFAULT Add/remove presets to the 'Current Automation Presets' list below to edit current automation.
Presets: Add New View / Edit Delete
Available Presets: Current Automation Presets:
B (Start:Markers 46 End:Markers 8 ∧ DASHBOARD (Start:Markers 230 INV (Start:Markers 250 End:Marker PERF (Start:Markers 260 End:Marker GOALS (Start:Markers 270 End:Markers ACTIVITIES (Start:Markers 280 Er OLD (Start:Markers 220 End:Markers 90 (Start:Markers 90 End:Markers ALL (Start:Markers -5 End:Markers
Define Blocks' dialog side panel section also allows adding and removing presets that can be seen here. 'Define Blocks' can be used to test and quickly build presets for the current dataset.
However, it will not be able to open incompatible presets (that includes different markers, etc) Use he 'Edit' on this dialog to view/edit any preset.
Back Define Blocks Save

8. Same preset is also available Define Block dialog preset list.

lightgraph1 Define Blocks				
Start of a block:	Check	End of a block:	Check	Presets:
Use Markers Use Time		Use Markers Use Time		< Add New
All available Start pattem Sort: By Time -5 (Recording Starte -5 (Recording Starte -3 (Baseli -3 (Baseli -3 (Baseli -5 (Record Up Up Up 00 (Markx 50 (Marx 50 (event markers By Value he Statte ∧ he value he end) ding Sta ar) ar) ar) y	All available End pattem Sort: By Time -1 (Device Stopped) < -2 (Basel -3 (Basel > -4 (Basel -5 (Reco Up 40 (Mark Down 50 (Mark	By Value ine Statte A ine value ine end) rding Sta ter) ter) ver)	<pre>< ENTIRE</pre>
Ignore the first markers		Ignore the first markers		$\langle \cdot \rangle$
Block start includes outer border		Block end includes outer border		Load
Only check within block: Use all combinations of start and end	∨ times	Apply the following label: ALL Blocks can overlap or touch neighbor	'S	Rename
>> Ready >> Preset ALL: Attempting to load. >> Preset ALL loaded.				< Delete
Run (Step 1) Save (Step 2)		Manage Clear All	Close	

12.2 Define Automation

An automation is essentially a list of presets. Different presets can be listed together to create different automation.

1. Open the Automation dialog using the 'Automation' button at the bottom toolbar of Lightgraph or Oxygraph.

lightgraph1 Define Block Automations	x
Define Block Automations Run available automations or add/edit new automations by combining existing presets. Available Automations:	
DEFAULT (contains 3 presets) TEST (contains 6 presets)	Add New
	View/Edit
	Rename
	Delete
Run (Step 1) Save (Step 2) Blocks: Manage Clear All >> Ready	Close

2. On the Automation dialog, click on the 'Add New' button at the right-top.

lightgraph1 Define Block Automations	x
Automation > Add New Automation Add/remove presets to the 'Current Automation Presets' list below to edit current automation.	
Presets: Add New View / Edit Delete	
Available Presets: Current Automation Presets:	
A (Start.Markers 46 End:Markers 4 B (Start.Markers 46 End:Markers 8 ENTIRE (Start.Markers -5 End:Ma FIRST10SECONDS (Start.Marker LAST10SECONDS (Start.Marker DASHBOARD (Start.Markers 230 INV (Start.Markers 250 End:Marker PERF (Start.Markers 260 End:Mar GOALS (Start.Markers 270 End:Marker ACTIVITIES (Start.Markers 280 Er <	
'Define Blocks' dialog side panel section also allows adding and removing presets that can be seen here. 'Define Blocks' can be used to test and quickly build presets for the current dataset.	
However, it will not be able to open incompatible presets (that includes different markers, etc) Use the 'Edit' on this dialog to view/edit any preset.	
Back Define Blocks Save	

3. A blank automation list will appear. From the available presets list (left-hand side) select 'ENTIRE' and 'FIRST10SECONDS' to the current automation list (right hand side)

Automation > Add New Add/remove presets to the 'Current Aut Presets: Add New	Automation tomation Presets' lie View / Edit	at below to edit curren	t automation.
Available Presets:	Cu	rent Automation Pre	sets:
A (Start:Markers 46 End:Markers B (Start:Markers 46 End:Markers LAST10SECONDS (Start:Relati DASHBOARD (Start:Markers 23 INV (Start:Markers 250 End:Mar PERF (Start:Markers 250 End:M GOALS (Start:Markers 270 End: ACTIVITIES (Start:Markers 280 OLD (Start:Markers 220 End:Ma 90 (Start:Markers 90 End:Markers	s 4 ∧ s 8 → Fil ve 30 ke lar Mi Er rkı rs v	NTIRE (StartMarke	ers -5 End:Markers (Start:Markers -5 E
<	>		>
'Define Blocks' dialog side panel section seen here. 'Define Blocks' can be used However, it will not be able to open inco the 'Edit' on this dialog to view/edit any	on also allows addir d to test and quickly ompatible presets (preset.	ng and removing prese v build presets for the that includes different	ets that can be current dataset. : markers, etc) Use
Back	Define Blocks		Save

4. Click 'Save' at the lower right hand side of the dialog and enter 'All and First' for name

Please enter an automation name		x
ALL AND FIRST	Save	

5. Click 'Save' and the Automation is not listed on the Automations list.

lightgraph1 Define Block Automations	
Define Block Automations	
Run available automations or add/edit new automations by combining existing presets.	
Available Automations:	
DEFAULT (contains 3 presets)	Add New
TEST (contains 6 presets)	
ALL AND FIRST (contains 2 presets)	View/Edit
	-
	Rename
	Delete
Run (Step 1) Save (Step 2) Blocks: Manage Clear All	Close
>> Ready	

12.3 Using Automation

Automations can be executed on Lightgraph and Oxygraph tools, similar to running Define Block operation: Step 1: run (and see output) and Step 2: save (if you like the output).

1. Open the Automation dialog using the 'Automation' button at the bottom toolbar of Lightgraph or Oxygraph.

lightgraph1 Define Block Automations	x
Define Block Automations Run available automations or add/edit new automations by combining existing presets. Available Automations:	
DEFAULT (contains 3 presets)	Add New
TEST (contains 6 presets)	
ALL AND FIRST (contains 2 presets)	View/Edit
	Rename
	Delete
Run (Step 1) Save (Step 2) Blocks: Manage Clear All	Close
>> Ready	

2. Select 'ALL AND FIRST' that was created in the previous section. Click 'Run (Step 1). It says 2 blocks were found.

lightgraph1 Define Block Automations	x
Define Block Automations Run available automations or add/edit new automations by combining existing presets	
Available Automations:	
DEFAULT (contains 3 presets)	Add New
ALL AND FIRST (contains 2 prosots)	
ALL AND FIRST (contains 2 presets)	View/Edit
	Rename
	Delete
Run (Step 1) Save (Step 2) Blocks: Manage Clear All	Close
>> Ready >> ENTIRE Start Pattem Count: 1, End Pattem Count: 1 >> ENTIRE Run: (31.91,573.52)-ENTIRE Found 1 block >> FIRST10SECONDS Run: (31.91,41.91)-FIRST10SECONDS Found 1 block >> ALL AND FIRST A total of 2 blocks found	

3. Click 'Save (Step 2)' to accept these and save them to the Lightgraph (or Oxygraph). At the bottom output pane, 'Saved' message will appear.

lightgraph1 Define Block Automations		
Define Block Automations Run available automations or add/edit new automations by combining existing presets. Available Automations:		
DEFAULT (contains 3 presets) TEST (contains 6 presets) Add New		
ALL AND FIRST (contains 2 presets) View/Edit		
Rename		
Delete		
Run (Step 1) Save (Step 2) Blocks: Manage Clear All Close >> Ready >> ENTIRE Start Pattern Count: 1, End Pattern Count: 1 >> ENTIRE Run: (31.91,573.52)-ENTIRE Found 1 block >> FIRST10SECONDS Run: (31.91,41.91)-FIRST10SECONDS Found 1 block >> ALL AND FIRST A total of 2 blocks found >> Saved! (Total Blocks: 2)		
At the Lightgraph (or Oxygraph), blocks will appear immediately.	t. Total Chamica	τu
1057	2. Total Optodes 3. Current 4. Gains 5. Other	16 20 7 non
529	E. Statistics I. Mean Period 2. Period Std 2. Total Time	0.5
0 31.9 573.5	5. Log More information about t	the E

Load File | Display Settings | Optode Layout View | Define Blocks Automation | Refine | Save | Oxy

4.

References

- B. Chance, "Near-infrared images using continuous, phase-modulated, and pulsed light with quantitation of blood and blood oxygenation," *Annals of New York Academy of Sciences*, vol. 838, pp. 29-45, Feb 9 1998.
- [2] A. Villringer, J. Planck, C. Hock, L. Schleinkofer, and U. Dirnagl, "Near infrared spectroscopy (NIRS): a new tool to study hemodynamic changes during activation of brain function in human adults," *Neurosci Lett*, vol. 154, pp. 101-4, May 14 1993.
- [3] B. Chance, Z. Zhuang, C. UnAh, C. Alter, and L. Lipton, "Cognition-activated low-frequency modulation of light absorption in human brain," *Proc Natl Acad Sci U S A*, vol. 90, pp. 3770-4, Apr 15 1993.
- [4] H. Ayaz, P. A. Shewokis, S. Bunce, K. Izzetoglu, B. Willems, and B. Onaral, "Optical brain monitoring for operator training and mental workload assessment," *Neuroimage*, vol. 59, pp. 36-47, 2012.
- [5] H. Ayaz, B. Onaral, K. Izzetoglu, P. A. Shewokis, R. McKendrick, and R. Parasuraman, "Continuous monitoring of brain dynamics with functional near infrared spectroscopy as a tool for neuroergonomic research: Empirical examples and a technological development," *Frontiers in Human Neuroscience*, vol. 7, pp. 1-13, 2013.
- [6] H. Ayaz, P. A. Shewokis, A. Curtin, M. Izzetoglu, K. Izzetoglu, and B. Onaral, "Using MazeSuite and Functional Near Infrared Spectroscopy to Study Learning in Spatial Navigation," J Vis Exp, p. e3443, 2011.
- [7] H. Ayaz, "Functional Near Infrared Spectroscopy based Brain Computer Interface," PhD Thesis, School of Biomedical Engineering Science & Health Systems, Drexel University, Philadelphia, PA, 2010.
- [8] A. C. Ruocco, A. H. Rodrigo, J. Lam, S. Di Domenico, B. Graves, and H. Ayaz, "A Problem-Solving Task Specialized for Functional Neuroimaging: Validation of the Scarborough adaptation of the Tower of London (S-TOL) using Near-Infrared Spectroscopy," *Frontiers in Human Neuroscience*, vol. 8, 2014.
- [9] A. Rodrigo, S. I. Di Domenico, H. Ayaz, S. Gulrajani, J. Lam, and A. C. Ruocco, "Differentiating functions of the lateral and medial prefrontal cortex in motor response inhibition," *NeuroImage*, vol. 85, Part 1, pp. 423-431, 1/15/ 2014.
- [10] R. McKendrick, H. Ayaz, R. Olmstead, and R. Parasuraman, "Enhancing dual-task performance with verbal and spatial working memory training: Continuous monitoring of cerebral hemodynamics with NIRS," *NeuroImage*, vol. 85, Part 3, pp. 1014-1026, 1/15/ 2014.
- [11] H. Ayaz, P. Crawford, A. Curtin, M. Syed, B. Onaral, W. M. Beltman, et al., "Differential Prefrontal Response during Natural and Synthetic Speech Perception: An fNIR Based Neuroergonomics Study," in *Foundations of Augmented Cognition*. vol. 8027, D. Schmorrow and C. Fidopiastis, Eds., ed: Springer Berlin Heidelberg, 2013, pp. 241-249.
- [12] H. Ayaz, M. Izzetoglu, P. A. Shewokis, and B. Onaral, "Sliding-window Motion Artifact Rejection for Functional Near-Infrared Spectroscopy," *Conf Proc IEEE Eng Med Biol Soc*, pp. 6567-70, 2010.