

# CAP ANALYSIS

version 4.0

User Guide

**SW**are  
**softS**leep Analysis  
for

Developed by Raffaele Ferri ([raffaele.ferri@tiscali.it](mailto:raffaele.ferri@tiscali.it))

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**Important notice:** All attempts have been made to make the information in this document complete and accurate. The software developer is not responsible for any direct or indirect damages or loss of business resulting from inaccuracies or omissions. The specifications contained in this document are subject to change without notice.

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# Chapter 1 – Introduction to CAP Analysis Version 4.0

*CAP Analysis ver. 4.0* is a software which performs a series of calculations on data from files containing all the necessary information on sleep macrostructure and microstructure (Cyclic Alternating Pattern or CAP).

This software was developed in order to be compatible with a series of different data files obtained by exporting the pertinent data from different commercial sleep recording and analysis systems. At present, files exported by the Somnologica© (Flaga hf. Medical Devices) and by the Rembrandt© systems can be read and analyzed.

Depending on the type of license obtained, the program will automatically activate the appropriate features and will allow users to process files from one system or the other, or both.

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## System Components

The system consists of three components:

- The **hardware key**, a programmable memory device providing the responses required to unlock the software. Without this key *CAP Analysis ver. 4.0* does not run; please take care of the key as you will need to buy the whole system package again in case of loss or damage. Keys can be upgraded in order to transform the license type (see above).
- The program **installation CD** with all the files you need to install and run *CAP Analysis ver. 4.0*; also this guide, in electronic format is included in the CD (you will need Adobe Acrobat Reader© v. 4.0 or above to read it; Adobe Acrobat Reader© is available, free of charge, on the internet <http://www.adobe.com/acrobat>).
- This **guide**.

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## System Requirements

*CAP Analysis ver. 4.0* runs under Windows 95, 98, 2000, NT, Me and XP. No particular RAM size is required; it occupies approximately 8 Mb of disk space (software and documentation) and a screen resolution of at least 800x600 pixel is recommended; however, also lower screen resolutions can be used.

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## Installing the Software

A Windows-based installation program is provided to facilitate installation of the *CAP Analysis ver. 4.0* software on your hard disk. The installer creates all required directories and copies the files required.

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**Note:** Contents and installation procedures may change. Refer to the README.TXT file for up-to-date information.

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### Running the Installer

- Insert the CD into the CD-ROM drive. If autorun is enabled, the system will automatically position you at the Welcome screen; otherwise, execute INSTALL.EXE.
- At the Welcome screen you can read a brief [Introduction to CAP](#) analysis. Also an electronic copy of the [User Guide](#) is available (PDF format).
- To install the software, click on [Install Software](#) and follow the directions on the screen. You will be prompted for a destination path for the files.
- Please make sure to install the hardware key driver for your system before running *CAP Analysis ver. 4.0*. Click on [Install Key Driver](#) to launch the appropriate driver, depending on your operating system and hardware platform.

## Chapter 2 – Recording CAP Data

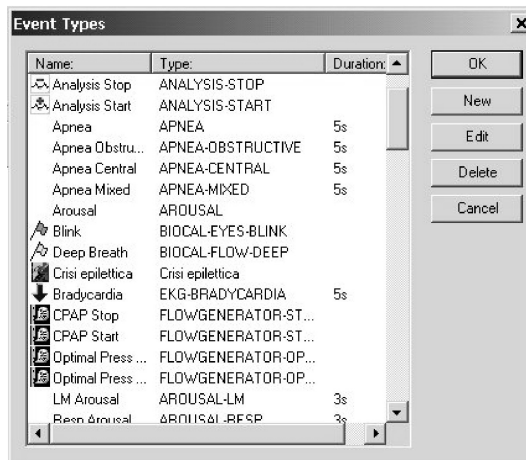
Before you can run *CAP Analysis ver. 4.0* you need to export CAP data from your sleep recording and analysis system. Most commercially available systems allow their users to define events and to export them in form of type, time, and duration. For CAP analysis, we need to define 3 types of events, i.e. the CAP-A phase subtypes A1, A2, and A3 and to mark them with our sleep analysis software. We do not need to mark CAP-B phases because they are automatically calculated as the interval between two consecutive CAP-A phases in a CAP sequence. We then need to store the values of all consecutive CAP-A phases, along with those of the sleep macrostructure (hypnogram), in a .TXT file which can be read by *CAP Analysis ver. 4.0*. This chapter explains how to perform this process with two systems: Somnologica© (Flaga hf. Medical Devices) and Rembrandt©.

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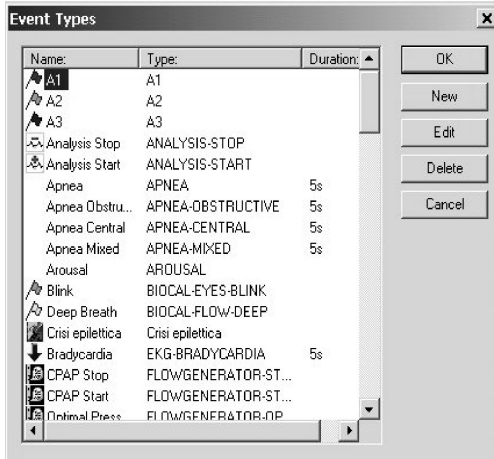
### Creating a Text File with the CAP Data from Somnologica©

#### Defining CAP Events

When you have your Somnologica© program running, click on **Events**, then **Types**; the following window will appear:



Click on **New** and define the **Default label** (A1, A2, and A3), the **Type** name should be the same as the **Default label** and assign a Hot-key (suggested: F1, F2, and F3). Repeat the same steps for the three A phase types. At the end of this operation, the **Event Types** window will appear like this:

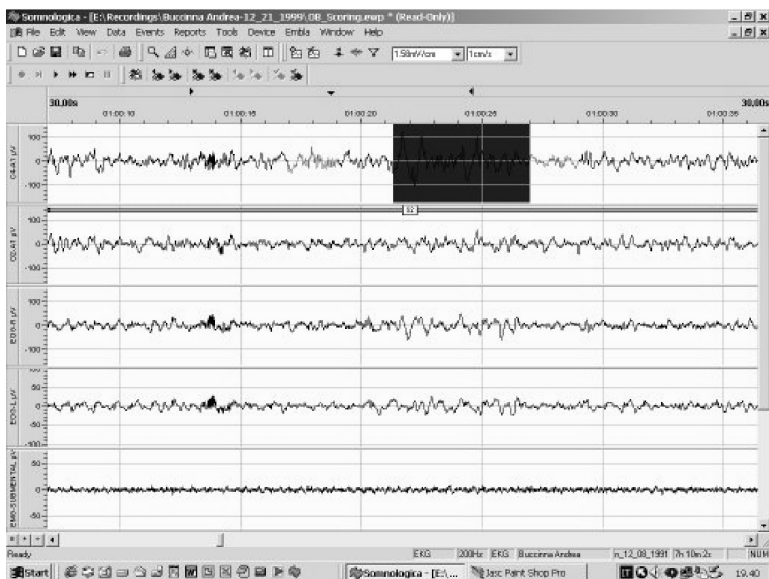


## Marking CAP Events

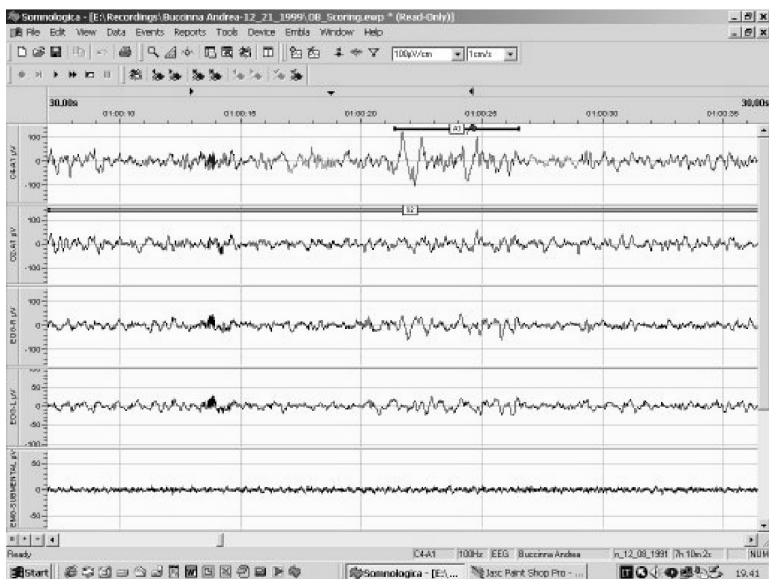
After loading a sleep file, you are ready to mark A1, A2 and A3 events. Note that you do not need to mark B phases because they are automatically detected by the CAP-Analysis software.

Click on the preferred channel with the left mouse button and drag the pointer to the end of the event; then release the left button of the mouse. The marked event will appear as in the following figure:



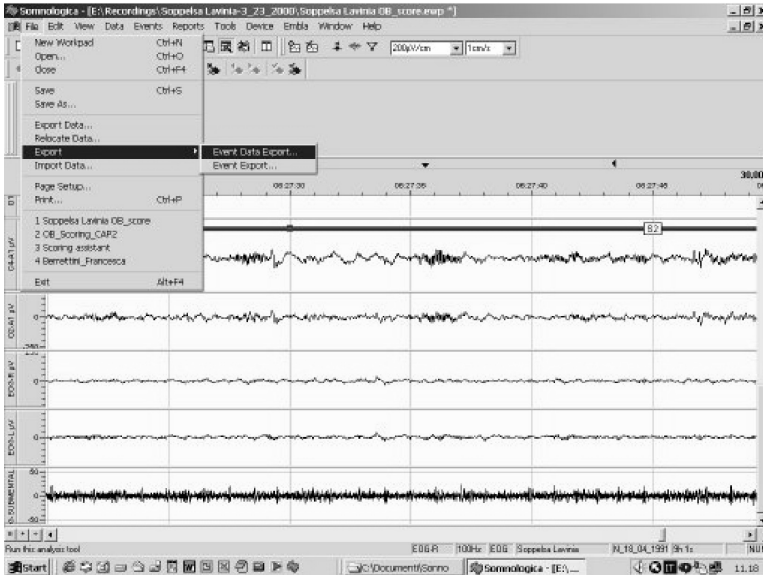


When the event is selected, press the desired Hot-key (F1, F2, or F3) to assign the A phase subtype; the event will then appear like this:

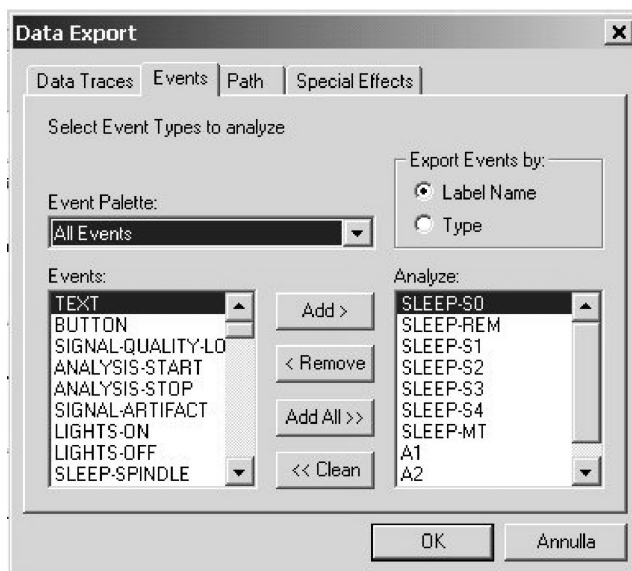


## Exporting CAP Events

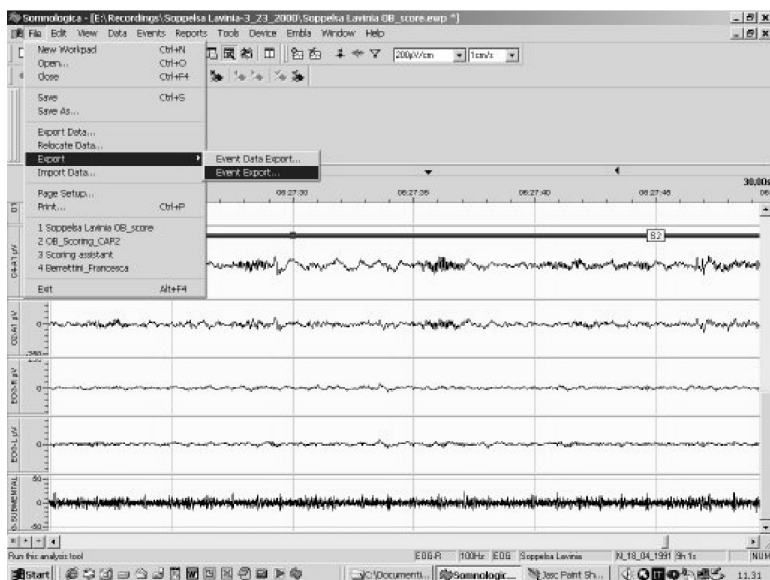
When you have selected all the events and the macrostructural sleep scoring has been performed, you can export all these events. Click the **File** menu, **Export** and **Event Data Export**.



When the following window appears on the screen, select **All Events** in **Event Palette** window and add A1, A2, and A3 to the window **Analyze**. Then click OK.



Click the File menu again, followed by **Export** and **Event Export**.



Save the file with the extension **.txt**.

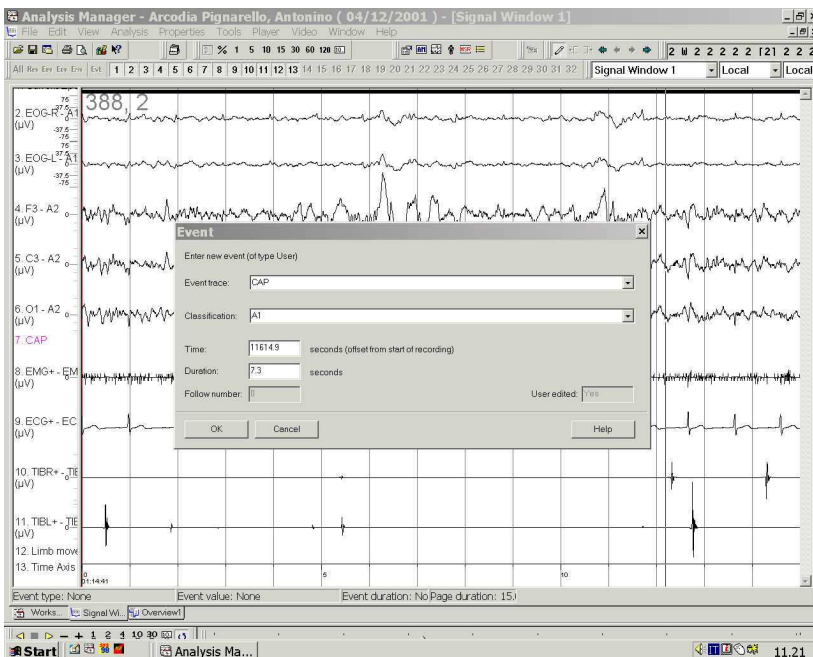
At this point you can leave Somnologica© and run *CAP Analysis ver. 4.0* for the computation of all CAP parameters.

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## Creating a Text File with the CAP Data from Rembrandt©

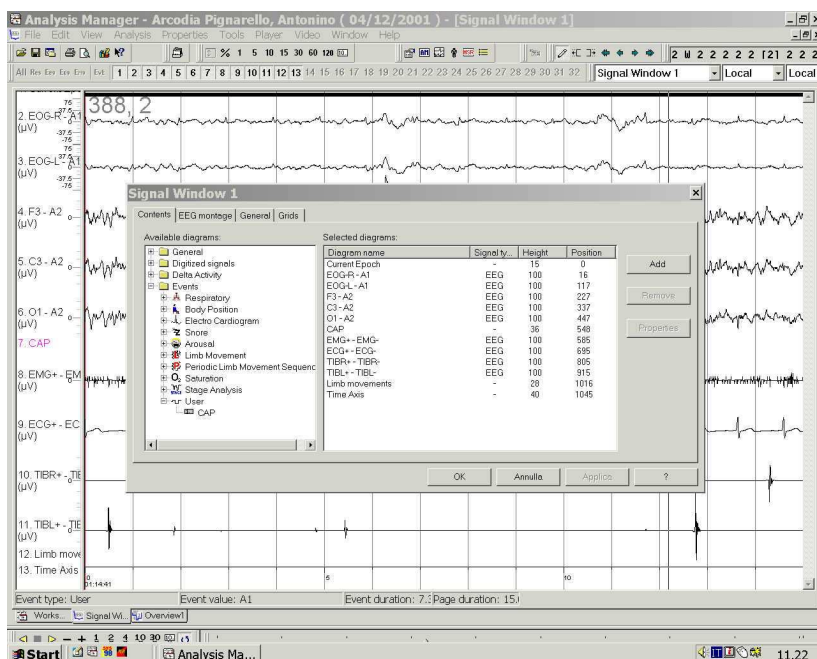
### Marking CAP Events

When you have your Rembrandt© program displaying the **Signal Window**, select the **Draw Event Mode** on, then place it at the beginning of the epoch to mark, push the left mouse button down and move the cursor up to the end of the epoch to mark, then release the left mouse button; choose the **User Events** option from the popup menu and the following window will appear:

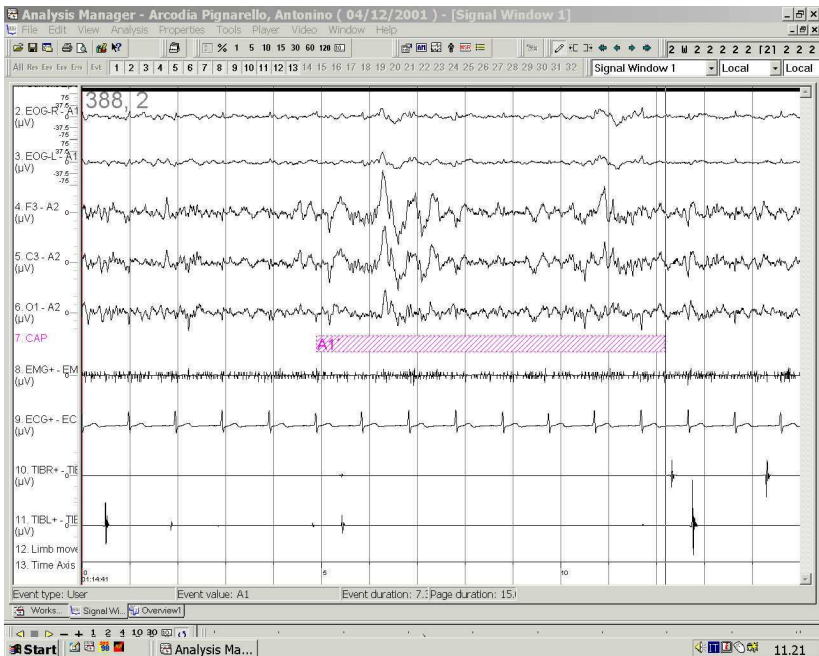


Type **CAP** in the **Event Trace** window and **A1**, **A2**, or **A3** in the **Classification** window. You will need to type **CAP** in the **Event Trace** window only the first time, then you will select this type of user events for all your **CAP** events. You also need to type **A1**, **A2**, and **A3** only once in the **Classification** window; you will only need to select the appropriate classification for the rest of your **CAP** events.

In order to see the epochs you mark in the **Signal Window**, you need to modify it and to insert a new signal. First, right click with your mouse the left area of the **Signal Window** where all the channel labels are displayed and choose **Signal Window Properties** from the popup menu. The following window will appear:



Select **CAP**, under **User** and click the **Add** button. A channel will be added at the bottom of your **Signal Window** and you can move this trace to the position you prefer. After this operation, your **CAP** events already marked will appear as follows:



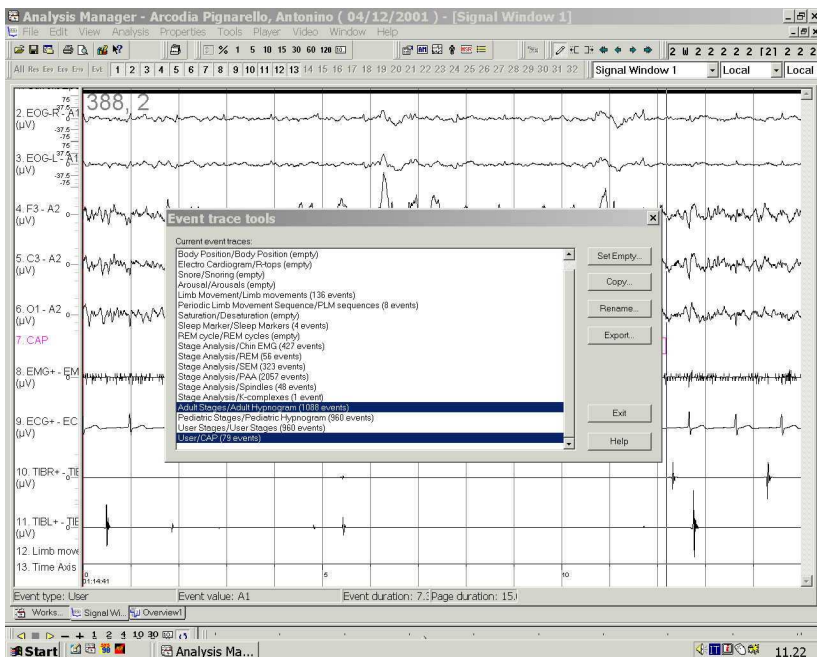
Mark all CAP events before going to the next step.

Note that you do not need to mark B phases because they are automatically detected by the CAP-Analysis software.

### Exporting CAP events

When you have selected all the events and the macrostructural sleep scoring has been performed, you can export all these events. Click the **Tools** menu, and then **Event Trace Tool**.

The **Event Trace Tool** window will appear:



In this window, select first **Adult Stages/Adult Hypnogram** (or **Pediatric Stages/Pediatric Hypnogram**) and then **User/CAP**, then click **Export**.

Save the file with the extension **.txt**.

At this point you can leave Rembrandt© and run **CAP Analysis ver. 4.0** for the computation of all CAP parameters.

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## Warning

Please note that it is mandatory to score the sleep macrostructure *before* the analysis of CAP; for this reason, it is necessary to have the sleep scored (automatically or visually) before exporting CAP data. On the contrary, the files exported will generate an error when loaded by *CAP Analysis ver. 4.0*.

Moreover, *CAP Analysis ver. 4.0* assumes a *fixed sleep epoch length of 30 seconds*; the use of different sleep epoch lengths will cause the computation of inconsistent results.



# Chapter 3 – Running CAP Analysis ver. 4.0

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## Installing the Hardware Key

*CAP Analysis ver. 4.0* requires the hardware key, provided together with the other components of the package, to run. The hardware key has a 25-pin connector to be attached to a parallel printer port of your IBM-compatible computer. Tighten the screws to connect the key securely to the port.

If a printer is connected to the computer, attach the printer cable to the outside connector of the key.

Multiple key can be connected to the same parallel port. This is called “cascading”. Make sure that the hardware key is the *last* key in the chain (farthest from the computer).

If the computer is close to a wall or another obstacle, you can attach an extension cable to the port, then attach the hardware key to the cable. Use a straight-through DB-25 male-to-DB-25 female cable.

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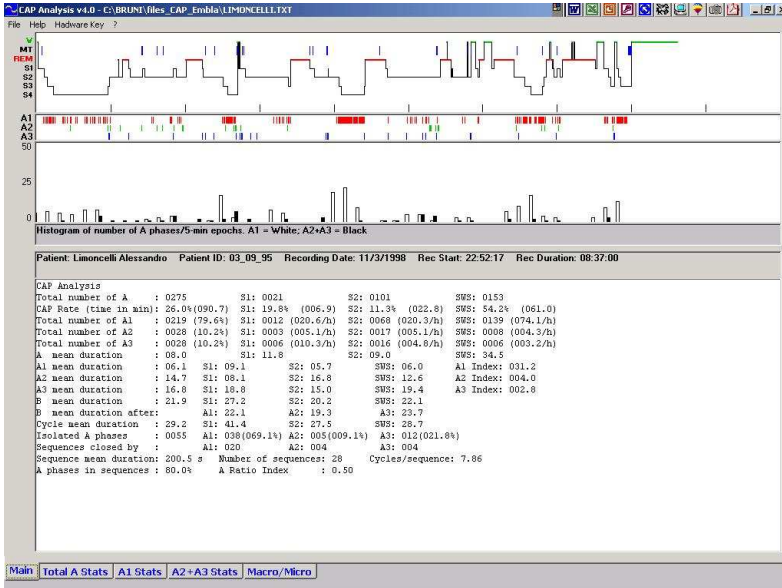
## Importing Text Files with CAP Data

After the installation, run *CAP Analysis ver. 4.0*. From the **File** menu, choose to import the appropriate file generated by one of the commercial sleep analysis systems supported (Somnologica© or Rembrandt©).

Please note that, if your hardware key allows you to import both data file types, you should pay attention to choose the **File** menu item appropriate for the system you used to generate the file (see Chapter 2); on the contrary, *CAP Analysis ver. 4.0* will generate an error message.

# Main Page

Soon after loading the file, *CAP Analysis ver. 4.0* displays the **Main Page** which appears as in the following example:



This Page shows 3 graphs and one table.

## Hypnogram

The top graph shows the hypnogram in a standard representation with the following sleep stages, in descending order: Wakefulness (green), REM sleep (red), and sleep stages 1, 2, 3 and 4 (black thin line). Movement epochs (MT) are shown as blue short segments at a level between Wakefulness and REM sleep. If you click on this graph you will be prompted for saving the corresponding bitmap (.BMP format).

## CAP-A Phase Subtype Occurrence Graph

The second graph from the top shows the occurrence of each CAP-A phase. A1 subtype phases are shown in the top row (red); A2 phases are shown in the middle row (green) and, finally, A3 phases are displayed in the bottom row (blue). If you click on this graph you will be prompted for saving the corresponding bitmap (.BMP format).

## Time Distribution Histogram of CAP

The last graph (the fourth from the top) shows the distribution histogram of the number of CAP-A1 phases per 5-minute epoch, throughout the entire recording (white columns); also the number of the CAP A2+A3 phases is shown in the same epochs (black columns). The scale of this graph is shown on the left. After clicking this graph you will be prompted for saving the corresponding bitmap (.BMP format).

## CAP Analysis Table

The bottom half of the main window is occupied by the Table reporting the results of the CAP analysis of the current file. A series of measures is listed which describes all important parameters of CAP:

*Total number of A (phases):*

during the whole recording and for each NREM sleep stage

*CAP Rate (time in min):*

CAP rate is defined as the percentage of time of NREM sleep (and of each stage) occupied by CAP sequences (see below for the definition of CAP sequences); also the CAP time is shown between brackets

*Total number of A1:*

during the whole recording (also the percentage of the total is shown between brackets) and for each NREM sleep stage (together with their rate/hour between brackets)

*Total number of A2:*

values shown as above

*Total number of A3:*

values shown as above

*A mean duration:*

total CAP-A phase mean duration, during the whole recording and for each NREM sleep stage, in seconds

*A1 mean duration:*

values shown as above for CAP-A1 phase subtype; the last value of this line represents the number of CAP-A1 phases/hour of NREM sleep (A1 index)

*A2 mean duration:*

values shown as above, for CAP-A2 phase subtype

*A3 mean duration:*

values shown as above, for CAP-A3 phase subtype

*B mean duration:*

values shown as above, for CAP-B phase

*B mean duration after:*

mean duration of CAP-B phases following each CAP-A phase subtype

*Cycle mean duration:*

values shown as above, for the entire CAP-A+B complex (cycle)

*Isolated A phases:*

number of total CAP-A phases not in sequences, followed by the number (and percentage) of each CAP-A phase subtype not in sequences

*Sequences closed by:*

a sequence is formed by a series of CAP-A phases 2-60 seconds apart from each other; the sequence starts with the onset of its first CAP-A phase and stops at the beginning of its last CAP-A phase; in this line the number of sequences stopped (closed) by each CAP-A phase subtype is shown

*Sequence mean duration:*

in seconds

*Number of sequences*

*Cycles/sequence:*

average number of CAP cycles per sequence

*A phases in sequence:*

percentage of total CAP-A phases in sequences

*A Ratio Index:*

A newly proposed index monitoring the ratio between A1 and A2+A3 CAP phase subtypes. A Ratio Index is calculated as follows:

**If  $A1 > (A2 + A3)$  then**

*A ratio =  $A1 / A \text{ total} * (A2 + A3)$  per minute*

**Else if  $A1 < (A2 + A3)$  then**

*A ratio =  $-(A2 + A3) / A \text{ total} * A1$  per minute*

**Else**

*$A1 = (A2 + A3)$  then A ratio = 0*

**End if**

## Pop-up Menu

Clicking the **CAP Analysis Table** with the right mouse button causes the appearance of a **Pop-up Menu** with the following aspect and options:

*Copy Data:*

to copy all the table values to the clipboard

*Copy Labels:*

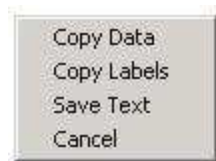
to copy all the data labels to the clipboard

*Save Text:*

to save the table text to a .TXT file

*Cancel:*

to exit this menu



This menu allows users to easily pass the results of the analysis from *CAP Analysis ver. 4.0* to the desired statistical application or spreadsheet program and then to perform, easily, the desired analysis of group statistics. The data labels are in the same order as the values.

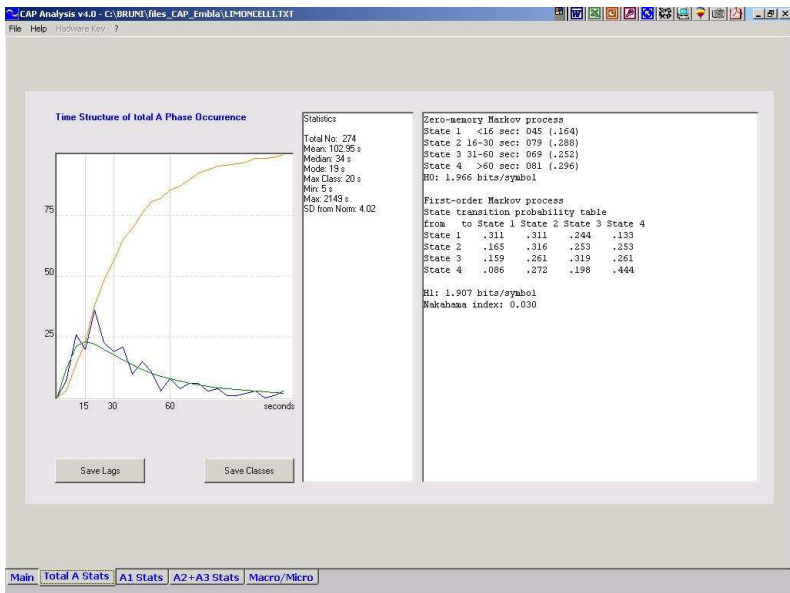
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## Stats Pages

When your file is loaded and the **Main Page** reports all the analysis detailed above, the **Stats Pages** become active and can be displayed by clicking their label at the bottom. These windows show some more detailed analysis of the time structure of the CAP-A phase occurrence by means of different statistical approaches.

### Total A Stats

The first Stats Page reports the detailed analysis of the time structure of the occurrence of all CAP-A phase subtypes. The following figure shows an example of this window.



The left graph shows the distribution histogram of the number of intervals between consecutive CAP-A phases, subdivided into 5-second classes (blue), plotted against the log-normal distribution with the same mean (green). The cumulative function is shown in red. The scale on the left reflects the raw number, for the distribution functions, and the percentage of the total, for the cumulative function.

The button labelled **Save Lags** allows the user to save a .TXT file with the sequence of all lags between the consecutive CAP-A phases; the button labelled **Save Classes** allows the user to save a .TXT file with the values of the distribution histogram.

The middle text window is labelled **Statistics** and shows the statistical analysis of some important features of the lags between all consecutive CAP-A phases:

*Total No.:*

total number of lags

*Mean:*

mean lag length (in seconds)

*Median:*

median lag length (in seconds)

*Mode:*

mode lag length (in seconds)

*Max Class:*

lag class with the highest value in the distribution histogram (in seconds)

*Min:*

shortest lag length (in seconds)

*Max:*

longest lag length (in seconds)

*SD from Norm:*

standard deviation of the observed distribution from the log-normal distribution

The last text window on the right shows the analysis of the time structure of the CAP-A phase occurrence by mean of the model of Markov chains. First the entropy of the zero-memory model (H0) is calculated and then that on the first-order Markov process model (H1). The Nakahama index is calculated as follows:

$$\text{Nakahama index} = (H0-H1)/H0$$

Please note that if the total number of lags being analyzed is less than 100, the results of the Markov process analysis can be inconsistent.

## **A1 Stats**

The **A1 Stats** Page reports the detailed analysis of the time structure of the occurrence of all CAP-A1 phase subtypes. This page has the same structure as that described above.

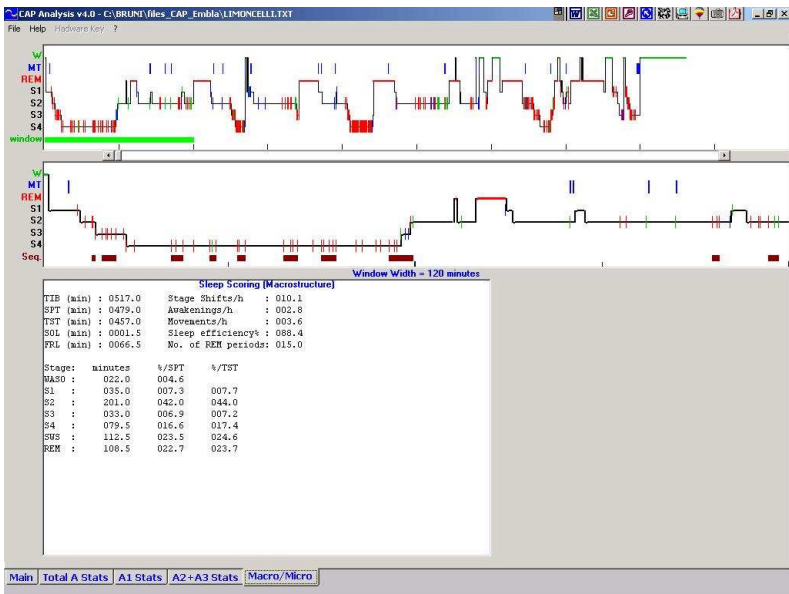
## A2+A3 Stats

The **A2+A3 Stats** Page reports the detailed analysis of the time structure of the occurrence of all CAP-A2 and CAP-A3 phase subtypes. Also this page has the same structure as that described above for all CAP-A phases.

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## Macro/Micro Page

The Macro/Micro page contains two graphs and one table and appears as shown below:



## Macro/Micro Hypnogram

The graph on the top shows the classical hypnogram with the sleep macrostructure and the addition of thin vertical bars indicating the occurrence of each CAP-A phase subtype (A1 in red, A2 in green, and A3 in blue). The green bar at the bottom of this graph indicates the section which is enlarged in the second graph of this page and can be shifted by means of the tool between the two graphs.

## Enlarged Macro/Micro Hypnogram

This graph shows a section of two hours of the graph described above, corresponding to the position of the green bar. In this graph, the details of the correlation between sleep macrostructure and microstructure can be seen. The thick brown bars at the bottom of this graph show the extension of the different CAP sequences identified by *CAP Analysis ver. 4.0*.

## Sleep Scoring Table

At the bottom of the Macro/Micro page a table reports all the main sleep macrostructure parameters:

**TIB:**

time in bed, in minutes

**SPT:**

sleep period time, from sleep onset to sleep end, in minutes

**TST:**

total sleep time, SPT-wakefulness after sleep onset, in minutes

**SOL:**

sleep onset latency, from recording start to sleep onset, in minutes

**FRL:**

first REM latency, from sleep onset to the occurrence of the first REM period, in minutes

**Stage shifts/h:**

number of sleep stage shifts after sleep onset per hour

**Awakenings/h:**

number of awakenings after sleep onset per hour

**Movements/h:**

number of sleep epochs classified as MT after sleep onset per hour

**Sleep efficiency%:**

$TST / TIB \times 100$

**No. of REM periods**

number of REM periods

**WASO:**

wakefulness after sleep onset, minutes and percentage of SPT

**S1, S2, S3, S4, SWS, REM:**

sleep stages 1, 2, 3, 4, 3+4 (SWS), and REM after sleep onset, minutes and percentage of SPT and of TST

## Pop-up Menu

Clicking the [Sleep Scoring Table](#) with the right mouse button causes the appearance of a [Pop-up Menu](#) with aspect and options similar to those already described for the [CAP Analysis Table](#) (see page 15).



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## Menus

*CAP Analysis ver. 4.0* has four main menus with the functions listed below.

### File Menu

This menu should be clicked for the following functions:

- **Import** CAP data files (.TXT format)
- **Printer Setup**
- **Print Form** and **Print Screen**  
both these functions allow to print a copy of the entire screen; try both functions and use the best for you needs
- **Save Form BMP**  
with this function it is possible to save a bitmap of the current screen and to use it in graphical applications
- **Exit**  
to end the *CAP Analysis ver. 4.0* session.

### Help Menu

This menu allows the user to access online help on the following topics:

- **Importing** CAP data files (.TXT format) from the supported sleep recording and analysis systems
- A brief **Introduction** to the basic information on CAP analysis
- **Using** the *CAP Analysis ver. 4.0* software.

## Hardware Key Menu

This menu allows the user to read the Hardware Key Serial Number (SN) and the type of Licence (Somnologica, Rembrandt, or Full).



Please note that this information is needed for all requests on your *CAP Analysis ver. 4.0* software.

## ? Menu

This menu allows the user to display information on the program version and copyright.

