

*Downloads & Support*  
**Ocular Correction ICA**  
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EEG recordings are often compromised by noise resulting from muscular activity, environmental disturbances, blinks, saccades, smooth pursuit, and other eye movements. Electro-Ocular (EOG) artifacts are particularly severe, since eye movements can hardly be suppressed over a sustained period of time. In order to overcome the obvious problem of losing trials when rejecting data portions contaminated by EOG artifacts, several methods have been proposed to attenuate EOG processes and consequently correct the contaminated EEG data, one of which is Independent Component Analysis (ICA; Makeig, Bell, Jung, & Sejnowski, 1996). ICA separates the EEG signal mixtures recorded at the scalp into temporally maximally independent component time courses, allowing for the removal of artifactual processes. While the selection of artifactual components is subjective and up to the user, Jung and colleagues (1998) showed that “ocular” components (representing eye movements and blinks) have characteristic patterns in both their time courses as well as their topographies which can be used as selection criteria (Figure 1). Interestingly, ICA-based attenuation of ocular artifacts succeeds even in the absence of designated eye channels. This is a major advantage over regression-based algorithms, for example of Gratton, Coles and Donchin (1983).

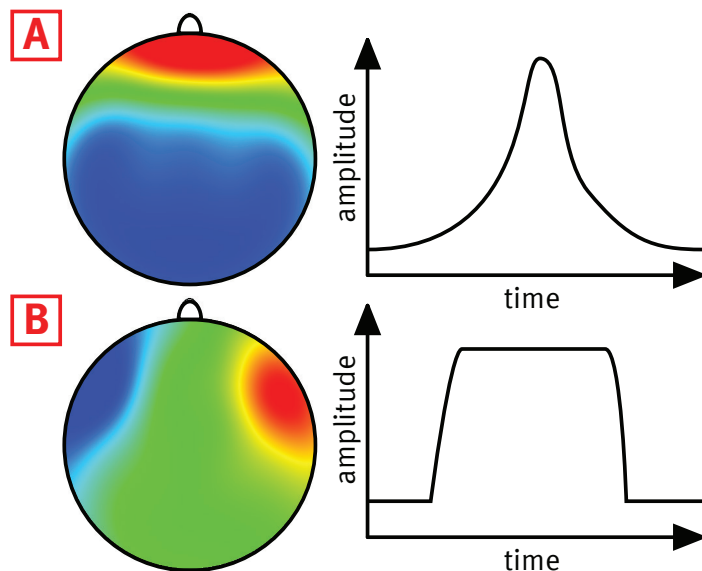


Figure 1: Prototypical channel projections (topographies; left) and activation profiles (time courses; right) of Independent Components representing vertical eye movements and blinks [A] and horizontal eye movements [B]. Please note that due to the nature of the ICA algorithm topographies and/or time courses could also be inverted in polarity.

Now here's where the transformation Ocular Correction ICA as implemented in BrainVision Analyzer 2 comes into play. It is a specialized version of the general ICA transformation, which identifies and pre-selects components with time-courses that are potentially associated with eye movements and blinks. Before delving into the intricacies of the transformation parameters and settings, I would like to raise your attention

towards the crucial necessity of proper data pre-processing for optimal, reliable and valid ICA results. In detail, data should have undergone at least the following steps:

- **Filtering.** High-pass filtering (low cutoff) is recommended for removal of slow drifts resulting, for example, from slow body movements or sweating, which ICA cannot handle well. In case of higher sampling rates it might also make sense to apply a low-pass filter (high cutoff). This prevents higher frequency content from using up additional components.
- **Raw Data Inspection/Artifact Rejection.** This step is suggested for marking non-stereotypical artifacts such as punctual bursts of electromyographic (EMG) activity, whole-body startle reactions, rare non-EEG glitches across all channels and other artifacts. ICA might separate each of these into separate components, massively reducing the number of components left for capturing remaining processes. Since data portions that have been marked as “Bad Intervals” are disregarded by Ocular Correction ICA, please select rejection criteria such that blink periods are not marked. I am emphasizing this here since blinks and other eye movements are supposed to be used by the transformation Ocular Correction ICA.

### 1.1 The Transformation

Once your data fulfills these requirements, you can access the transformation via Transformations > Artifact Rejection/Reduction > Ocular Correction ICA. The core steps of this transformation are visualized in Figure 2 (you can find more details on these steps in the dedicated chapter of the Analyzer User Manual). I strongly recommend applying the transformation in semiautomatic mode for every history file, since only then you will be able to visually inspect and adjust the component selection accomplished automatically by Analyzer.



Figure 2: Steps of the transformation Ocular Correction ICA.

In detail, the steps are as following:

- (1) **Blink marker placement.** At this stage, a specified (eye or scalp) channel is scanned for blinks, and blink markers are placed. When not using existing markers, two detection algorithms are available: The Mean Slope algorithm of Gratton et al. (1983) will detect any high-amplitude activity in the scanned channels (potentially including non-blink artifacts). By contrast, the Value Trigger algorithm has been optimized for the detection of prototypical blink patterns. Please note that horizontal eye movements will not be detected and marked.

**(2) ICA decomposition.** In this step you define the amount of data to be fed into ICA, both in terms of the number of channels and time points. Channels that are not selected for ICA will be displayed below the component activations, which might be quite helpful for the comparison of component activations and actual VEOG and HEOG channel activity. Regarding the minimum number of data points (samples) there is a simple rule of thumb: You should use at least as many data points as the number of channels squared times 20 (less than 64 channels) or times 30 (more than 64 channels). Of course this is only a minimum recommendation, which in practice often is not sufficient, as the data should include the relevant information content to be decomposed (for example, enough eye movements and blinks). Therefore, I suggest to use longer, representative data intervals or even the whole data (provided that it can be afforded with respect to memory constraints). Please keep in mind that “Bad Intervals” are neglected by ICA. The ICA procedures available to you (e.g., Infomax, Fast ICA) have already been addressed in a previous Support Tip [<http://www.brainproducts.com/productdetails.php?id=17&tab=3>]. The resulting ICA and Inverse ICA weight matrices can also be saved to text files.

**(3) Criterion-based identification of “ocular” components.** Once ICA has been accomplished, the extracted components are evaluated in terms of their consistency and similarity to the EEG data. For identification of components related to VEOG activity only the time intervals limited by blink markers are used. By contrast, for identification of components related to HEOG activity all data is used. There are three methods available, each using different measures:

- a. Sum of Squared Correlations with VEOG/HEOG is a correlative score between the component activations and the activity of the VEOG/HEOG channels selected in step 1. This option does not require the VEOG/HEOG channels to be fed into ICA.
- b. Relative VEOG/HEOG Variance calculates the share of each

ICA component in the variance of the selected ocular channel activation. This method requires the specified VEOG/HEOG channel(s) to be also fed into ICA.

- c. Global Field Power (only available for VEOG) calculates the contribution of each component to the Global Field Power of all channels used for ICA during blink intervals. Here, both the activation profiles as well as the channel projections of the components are evaluated. This option does not require the VEOG channel to be fed into ICA.

For all methods the components will be ranked according to their score with respect to the selected “ocular” measure. Afterwards, component scores are compared to the threshold specified in the field Total Value to Delete [%]. Depending on this threshold one or more components will be pre-selected as “ocular” and subsequently marked for removal (in red) in the semi-automatic interactive view of the transformation.

**(4) Removal of “ocular” components.** Analyzer will then open the component activations from step 2 in an interactive view, where “ocular” components selected for rejection are marked in red. The interactive view allows for an evaluation and further fine-tuning of the automatic component selection accomplished in step 3. After clicking Finish, the marked components will be removed from the data. You can utilize various visualization tools in the interactive view in order to make informed decisions. In the following, I will explain a couple of these in more detail.

## 1.2 The Interactive View

Prior to examining the contents of the interactive view, I recommend checking the Operation Infos of the newly created “Ocular Correction ICA” node, in particular whether the algorithm has converged. Only in this case the ICA decomposition and the displayed data are valid and can be interpreted. As can be seen in Figure 3, the interactive view displays the component

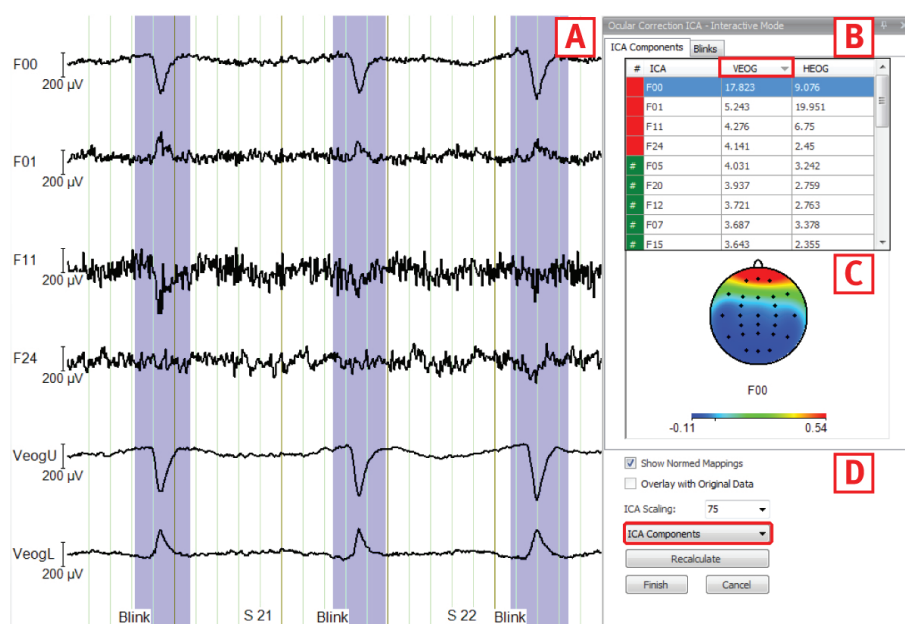


Figure 3: [A] Component activations (scaled by a factor of 75) of components F00, F01, F11 and F24 as well as upper and lower VEOG channel activity. Blinks are represented by interval markers, highlighted in blue. [B] Table containing the criterion score (%) of all components for VEOG and HEOG activity as well as a color code on whether the component will be removed (red) or retained (green). In the current example, components have been sorted based on their VEOG criterion score. [C] Topography of the component highlighted in the criterion table. The map represents the “normed” component projections towards the channels (unit-less weights, units can be neglected). [D] Display settings. In this part of the interactive view, you can adjust the information displayed in the main window, for example the component scaling with respect to the channel amplitudes.

activations (labeled by “F” followed by a number) in the main view. In the current example, interval markers were selected for marking blink periods. The table in the upper right corner lists the criterion score (%) of all components for VEOG and HEOG activity. The red and green cells in the first column of the table represent the components that will be removed or retained, respectively: components that are marked in red have been categorized as “ocular” components and will be removed; components marked in green will be kept. By double-clicking the colored cell you can change its assignment. You can sort the table based on the VEOG and HEOG criterion scores by clicking the respective field in the table header (also see Figure 3). I generally suggest dedicating some time to the careful examination of all components (red and green) one by one following the sorting order with respect to VEOG and HEOG criterion scores separately.

Below the table you can find a topographic mapping view of the component currently selected in the criterion table. The map represents an interpolated representation of the component projections (unit-less weights) towards the channels. By using the options available below the mapping view, you can scale the component activations with respect to the channel amplitudes (ICA Scaling), or use the drop-down list to switch between the component activations (ICA Components), the cleaned/corrected channel data after removing the components currently selected as “ocular” (Correction), or the simultaneous display of the projections of all components towards the channels (Topographies).

If you select Correction from the drop-down list you can display the corrected channel data after removing the “ocular” components (Figure 4). When combining this selection with

the option Overlay with Original Data, you can compare the data before (red graphs) and after (black graphs) removing the currently selected “ocular” components in the main window. This option can come in quite handy when clarifying whether specific components should be removed or retained since you can observe the immediate effects of your selection.

As you can see, the key to properly attenuating ocular artifacts in your data in fact is to make careful, conscious, and informed decisions about the “ocular nature” of a component based on its criterion score, time course and topography. “Ocular” components ideally reflect processes purely based on eye movements while at the same time containing absolutely no brain-based EEG signals. As soon as you are satisfied with your component selection, you can click Finish in order for the changes to take effect.

Taken together, the transformation Ocular Correction ICA of BrainVision Analyzer 2 is a fantastic, easy to use tool to diminish the effects of eye movements in your EEG recordings based on data-driven methods. When you go for the recommended semiautomatic mode you have access to all the comfortable visualizations of the interactive view which render the fine-tuning and manual adjustment of the automatically pre-selected “ocular” components for each dataset transparent, efficient and convenient.

I hope that this brief introduction into Ocular Correction ICA made you curious about what else there is to know about the transformation and how it can be used for your particular research endeavors. For any further questions regarding the transformation please contact us at [support@brainproducts.com](mailto:support@brainproducts.com).

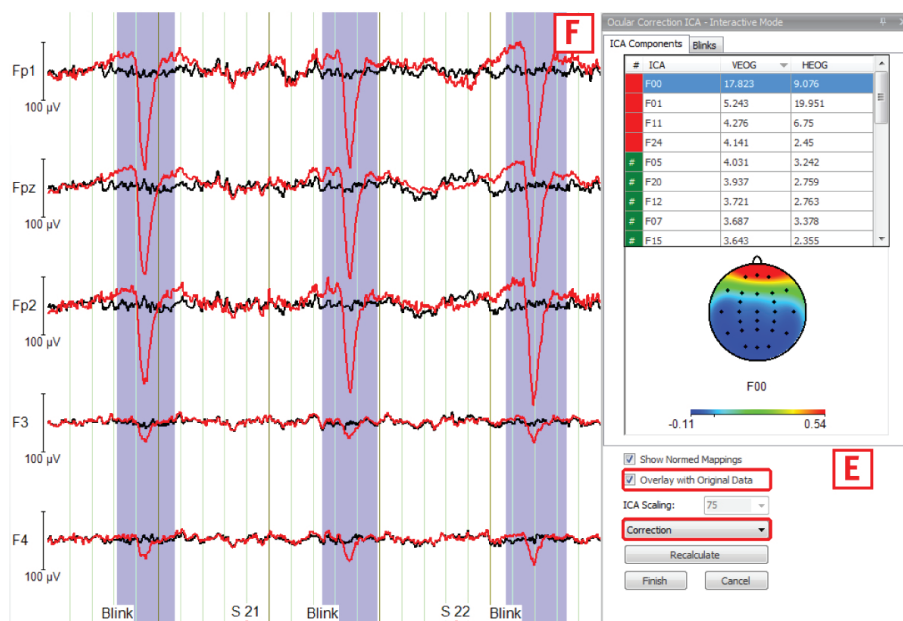


Figure 4: [E] Selecting Correction from the drop-down list displays the cleaned/corrected channel data after removing the four “ocular” components (marked red in the criterion table) in the main window. Additionally activating the check box Overlay with Original Data allows for a comparison of the data before (red) and after (black) removing the “ocular” components [F].

**Further reading: Physiological basics of ocular artifacts.**

Electro-oculographic (EOG) artifacts result from two processes: First, rotations of the eyeballs alter the orientation of the electric fields generated by the corneo-retinal dipole. Whereas the cornea is electrically positive, the retina is negative. As a result, rotations of the corneo-retinal dipole differentially interfere with cortically generated electric fields over the scalp. Interestingly, even sleep EEG recordings are contaminated with this type of horizontal EOG artifacts (Schlögl et al., 2007). A second source of EOG artifacts arises from contact of the eyelid with the (negative) cornea during blinks, eliciting a burst of negativity (Overton & Shagass, 1969). EOG amplitude has been found to be attenuated approximately with the square of the distance to the eyes with frontal channels being affected most severely (Croft & Barry, 2000). Due to principles of volume conduction artifacts spread throughout all layers of cortex, skull, and tissue, and are present at any scalp site, where they interfere with the detection and analysis of cortical responses of interest. Hillyard and Galambos (1970) were the first to report such modulations of the auditory CNV in all recorded scalp EEG channels: whereas upward eye movements caused the CNV to be positive, downward eye movements resulted in a negative CNV. ●

**References**

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