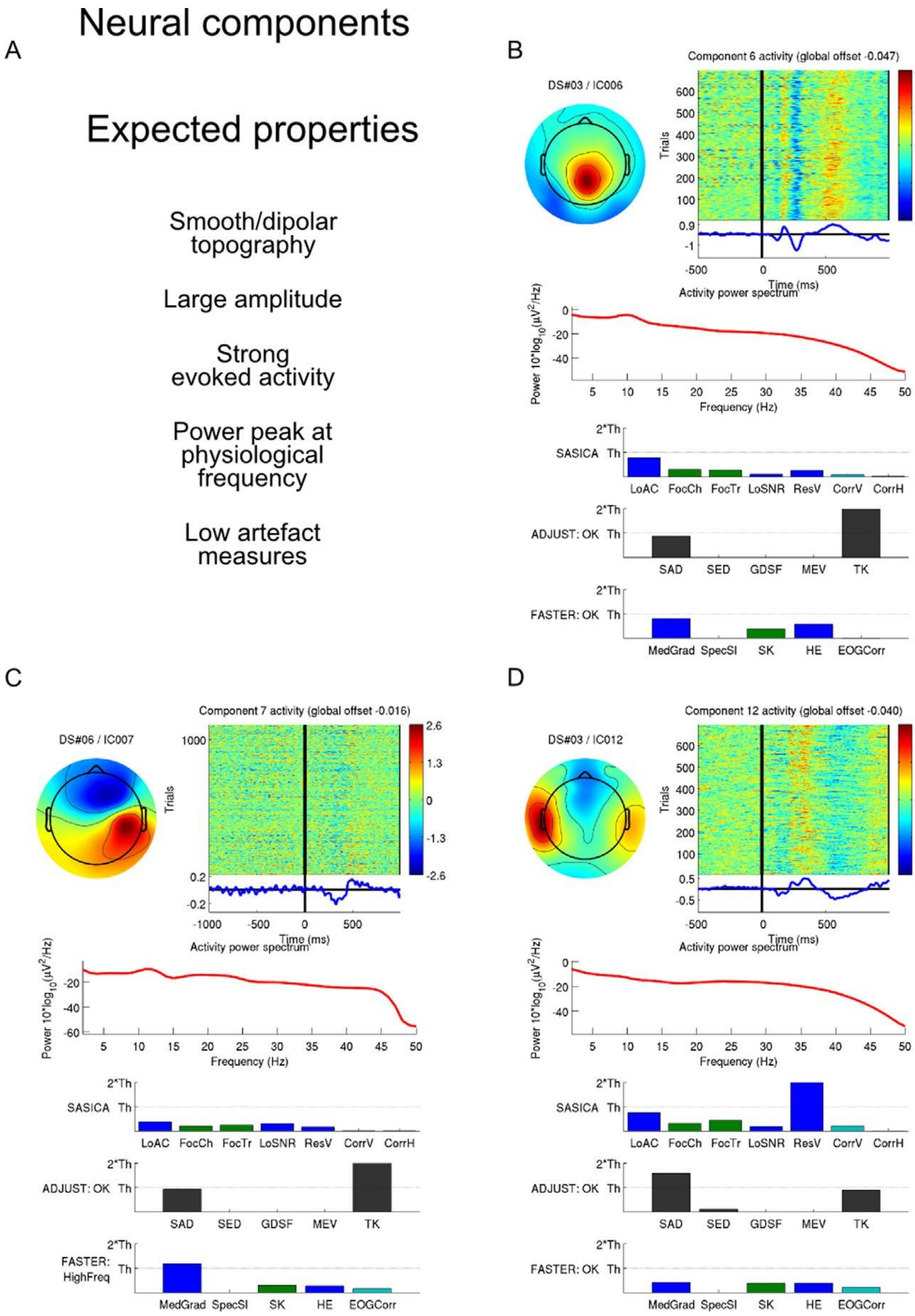
Chaumon, M., Bishop, D. V., & Busch, N. A. (2015). A practical guide to the selection of independent components of the electroencephalogram for artifact correction. *Journal of neuroscience methods*, *250*, 47-63.

ICA component of Neural Origin

- The components are often dipolar, and their topography is regular and smooth.
    - Delorme A, Palmer J, Onton J, Oostenveld R, Makeig S. Independent EEG sources are dipolar. PLoS ONE 2012;7(2):e30135, http://dx.doi.org/10.1371/journal.pone.0030135.
    - The dipolar nature of the components can be measured by first fitting a dipolar source to the component (as implemented in the DIPFIT toolbox distributed with EEGLAB), and then measuring the residual variance after removing the fitted data. Residual variance is often very low for accurately modeled components .
- Often rank amongst the strongest components in the dataset
- often contain a peak at physiological frequencies (e.g. alpha, beta, delta or theta)
    - Alpha (8–12 Hz), Beta (15–30 Hz), delta (1–4 Hz), or Theta (~5 Hz)
    - particularly true of components whose topography loads mostly on posterior, middle, or frontal sensors for Alpha, Beta, and Theta frequencies, respectively.
- May show a strong evoked response to sensory stimuli.



A
Neural components
Expected properties
Smooth/dipolar topography
Large amplitude
Strong evoked activity
Power peak at physiological frequency
Low artefact measures
B
DS#03 / IC006
Component 6 activity (global offset -0.047)
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)
SASICA
LoAC FocCh FocTr LoSNR ResV CorrV CorrH
ADJUST: OK
SAD SED GDSF MEV TK
FASTER: OK
MedGrad SpecSl SK HE EOGCorr
C
DS#06 / IC007
Component 7 activity (global offset -0.016)
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)
SASICA
LoAC FocCh FocTr LoSNR ResV CorrV CorrH
ADJUST: OK
SAD SED GDSF MEV TK
FASTER: HighFreq
MedGrad SpecSl SK HE EOGCorr
D
DS#03 / IC012
Component 12 activity (global offset -0.040)
Trials
Time (ms)
Activity power spectrum
Power 10*log10(μV²/Hz)
Frequency (Hz)
SASICA
LoAC FocCh FocTr LoSNR ResV CorrV CorrH
ADJUST: OK
SAD SED GDSF MEV TK
FASTER: OK
MedGrad SpecSl SK HE EOGCorr

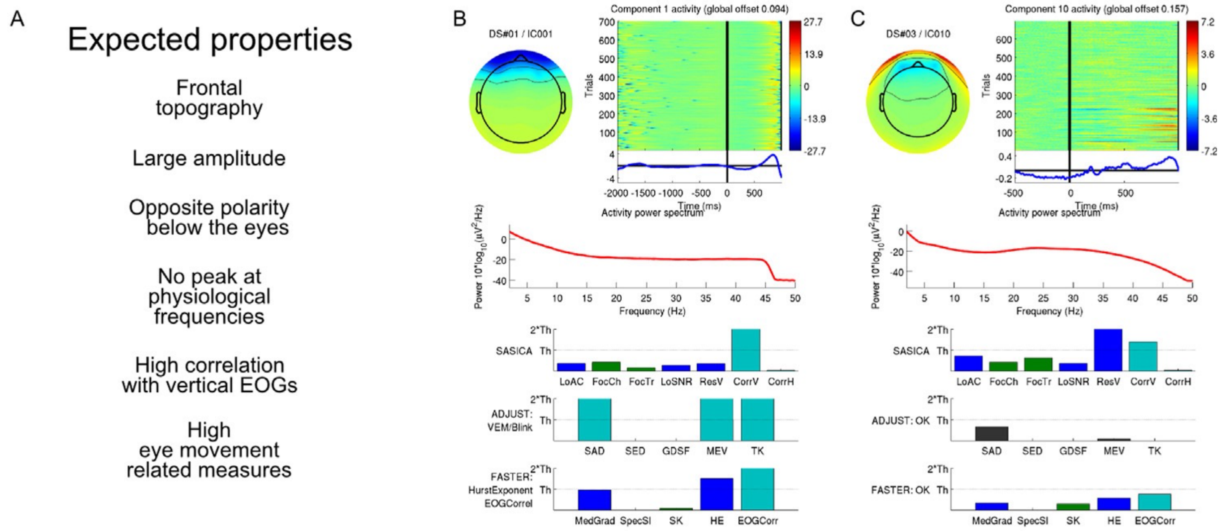
Fig. 2. Neural components. Three example neural components and their properties, as shown by SASICA.
(A) Properties to pay particular attention to in order to determine if a component captures Neural activity. None of these properties should be met for a component to be considered as isolating Neural activity.
(B and C) Two exemplar neural components, showing all of the properties listed in (A).
(D) Neural component with non-dipolar topography, where the Residual Variance (ResV) measure passed threshold. Abbreviations for all measures are listed in Table 1.

Blink Component

- topography is essentially flat (i.e. inverse weights close to zero) at all but a few **frontal** and all **EOG** electrodes.
- Activity is usually very large during blinks and the components rank amongst the first dozen components
- Time courses show abrupt high amplitude variations in otherwise comparatively close to zero amplitudes
- power spectra show no power peak at physiological frequencies.
- Correlation with EOG electrodes is high.

CORRMAP	Blink components can be identified automatically by template matching with a stereotypical activity pattern
ADJUST	● Spatial Average Difference (SAD) and Spatial Variance Difference (SVD) ○ capture components with strong differences in signal between anterior and posterior channels ● Temporal Kurtosis (TK) ○ indicates the occurrence of rare high amplitude events (i.e. heavy tailed distribution).
FASTER and SASICA	correlate the time course of the ICs with EOG electrodes

Blink components



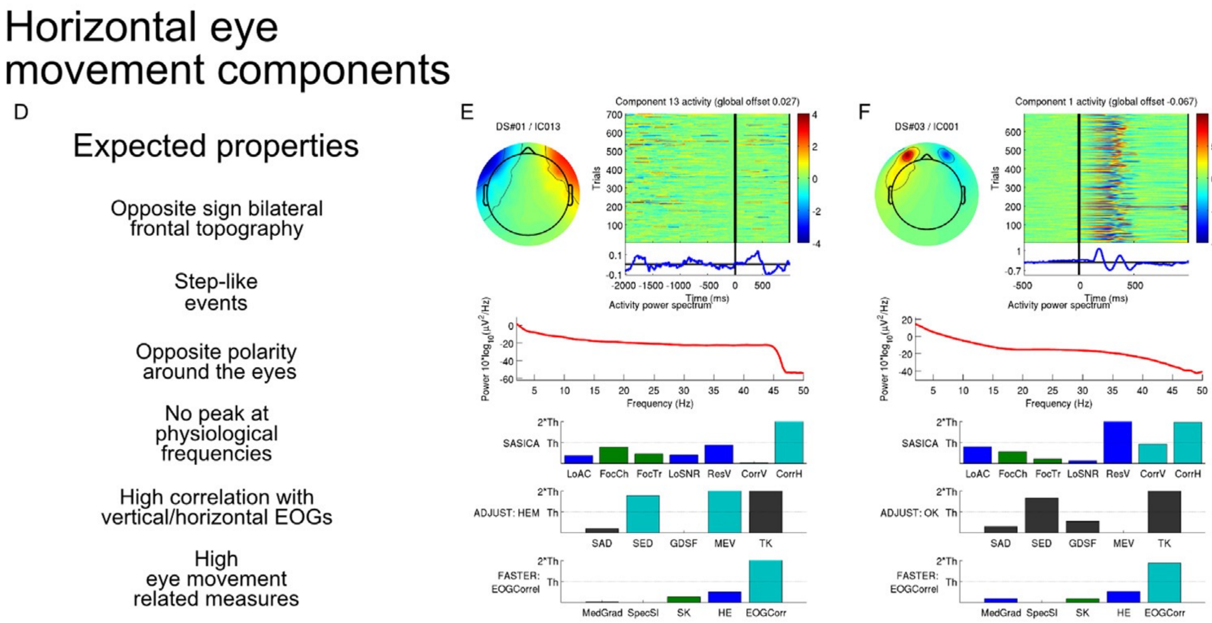
(A) Properties to pay particular attention to in order to determine if a component captures blink activity.
(B and C) Two exemplar blink components, where measures designed to identify ocular components (cyan bars) passed threshold, and showing all properties listed in (A).
(B) without EOG electrodes, (C) with EGO electrodes registered

Saccade Eyemovement

- horizontal saccade activity load maximally onto anterior electrodes, but with opposite polarity on both sides.
- Vertical saccades load maximally onto anterior sites, with a topography similar to that of blink components.
- Time courses show abrupt step-like variations
- power spectra show no power peak at physiological frequencies.
- Correlation with EOG electrodes is high.

CORRMAP	These components are identified automatically by template matching with a stereotypical activity pattern
ADJUST	• For vertical eye movements, it combines a Maximum Epoch Variance (MEV) measure that captures components with strong within epoch variability with the same SAD measure as for blink components. • For horizontal eye movements, it uses MEV along with a Spatial Eye Difference (SED) measure to capture strong differences between two lateral regions of the EEG cap.

FASTER and SASICA	FASTER and SASICA use correlation of component time courses with EOG electrodes (EOGCorr, CorrV and CorrH) to detect eye movements and blink components.



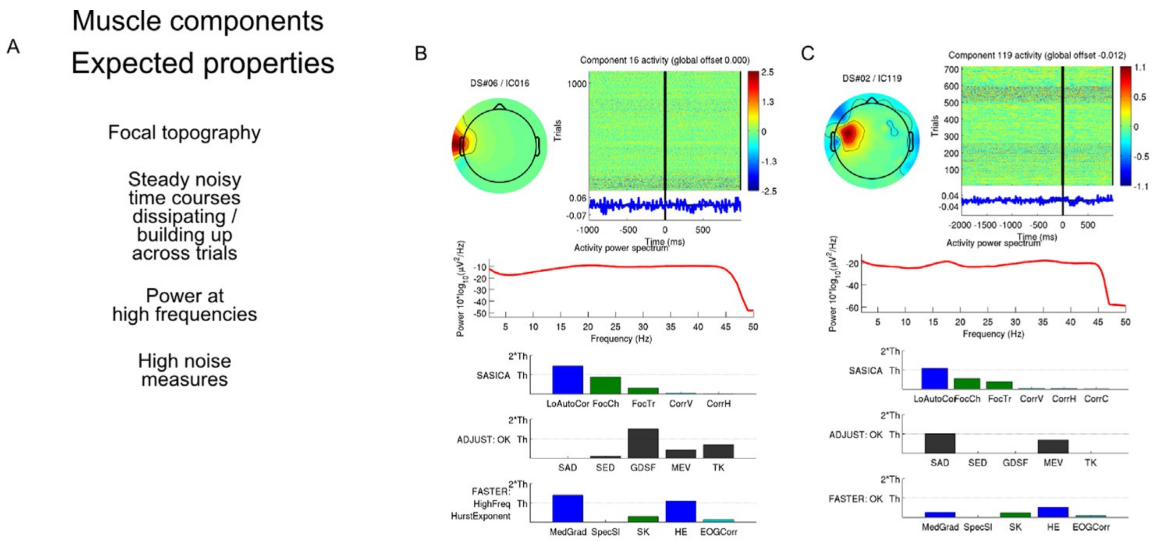
(D) Properties to pay particular attention to in order to determine if a component captures horizontal eye movements.
(E and F) Two exemplar horizontal eye movement components, where measures designed to identify ocular components (cyan bars) passed threshold, and showing all of the properties listed in (D).
In panels (B), (C), (E) and (F), two situations are depicted, in which EOG electrodes are rendered on the topographical maps (C and F), or not (B and E).

Muscle Component

- Components capturing muscle activity are usually very focal, encompassing a local group of electrodes (sometimes with opposite polarity) on the edge of the electrode cap.
- Time courses show a steady noise activity, often remarkable because they do not vary with task events (i.e. no ERP is visible), but rather across trials.
- The power spectrum of these compo- nents often shows strong power at high frequencies (>20 Hz).

FASTER	or by high Median Gradient (MedGrad) value, or low Hurst Expo- nent (HE) computed by FASTER
SASICA	detected by measuring the high time-point by time-point variabil- ity, captured by the low autocorrelation (LoAC) measure of SASICA

* ADJUST and CORRMAP do not attempt to detect muscle components specifically.

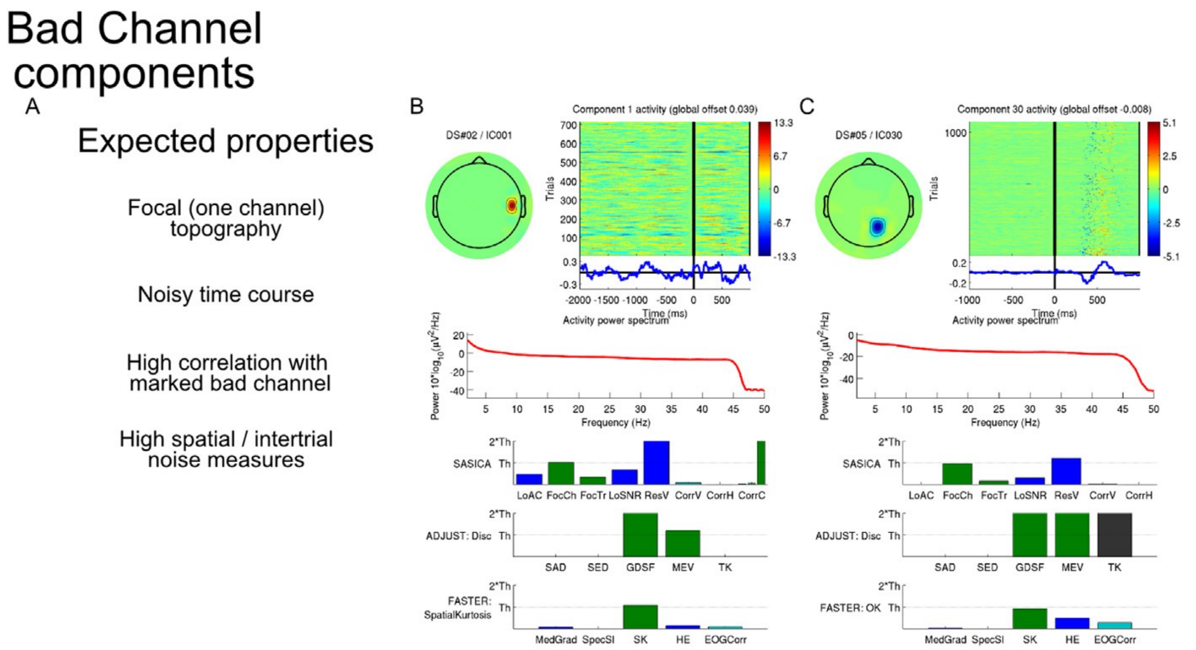


(A) Properties to pay particular attention to in order to determine if a component captures muscle activity.
(B and C) Two exemplar muscle components, where some measures designed to identify noisy components (blue) passed threshold, and showing all of the properties listed in (A).

Bad channel

- Such bad channel components have a focal topography, restricted to the bad channel
- Their time course reflects the noisy nature of the recording.
- They may also show a very high level of correlation with marked bad channels.

FASTER	high Spatial Kurtosis (SK)
SASICA	• Focal Channel topography (FocCh) • Components capturing an isolated bad channel correlate by definition very highly with data recorded at that channel, so correlation of ICs with the bad channel in question allows identifying these ICs in SASICA(CorrC)
ADJUST	Generic Discontinuity Spatial Feature (GDSF) and MEV



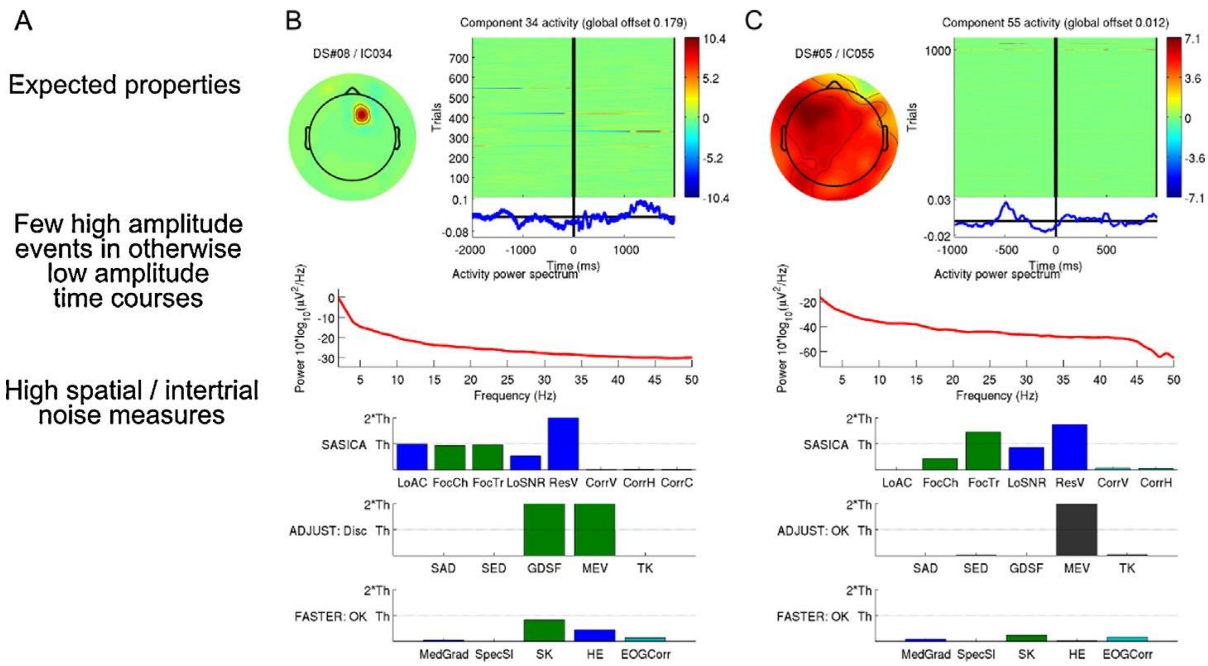
(A)Properties to pay particular attention to in order to determine if a component captures activity of a bad channel.
(B and C) Two exemplar bad channel components, where measures designed to identify isolated noise and discontinuities (green) passed threshold, and showing all of the properties listed in (A).

Rare events

A few high-amplitude events

- Occur at only one eletrodes: the associated IC topography is focal and the IC in question thus also qualifies for the bad channel category
- Occur at multiple eletrodes: eg. caused by movement
- If a component captures a unique event, a sensible strategy to remove the corresponding artifact from the data could be to reject the affected trial(s) and to compute the ICA anew.

SASICA	Focal Trials (FocTr)
ADJUST	GDSF and MEV
FASTER	SK

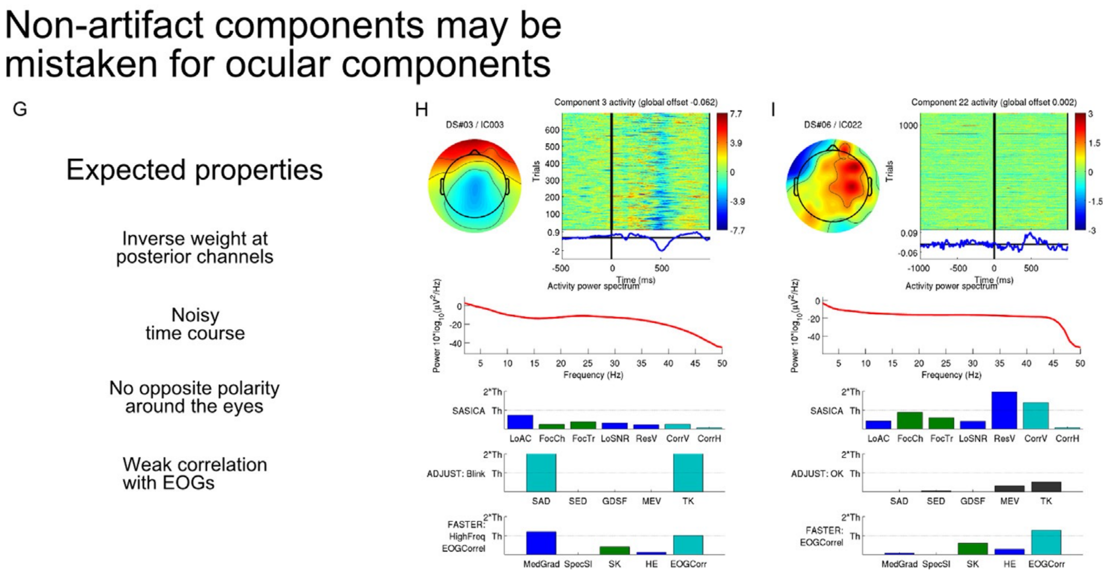


(A) Properties to pay particular attention to in order to determine if a component captures activity of a rare event.
(B) Example rare event component, where the event occurred at one electrode. This component thus qualifies for the Bad channel component category as well.
(C) Example rare event component, where the event occurred at many electrodes.

Ambiguous components

Finally, it is important to keep in mind that not all ICs may be neatly and unequivocally classified as neural or artifactual. Rather, some components reflect an ambiguous mixture of signals, and should be handled with care. We do not recommend systemat- ically rejecting such components, since part of their signal may be of neural origin.

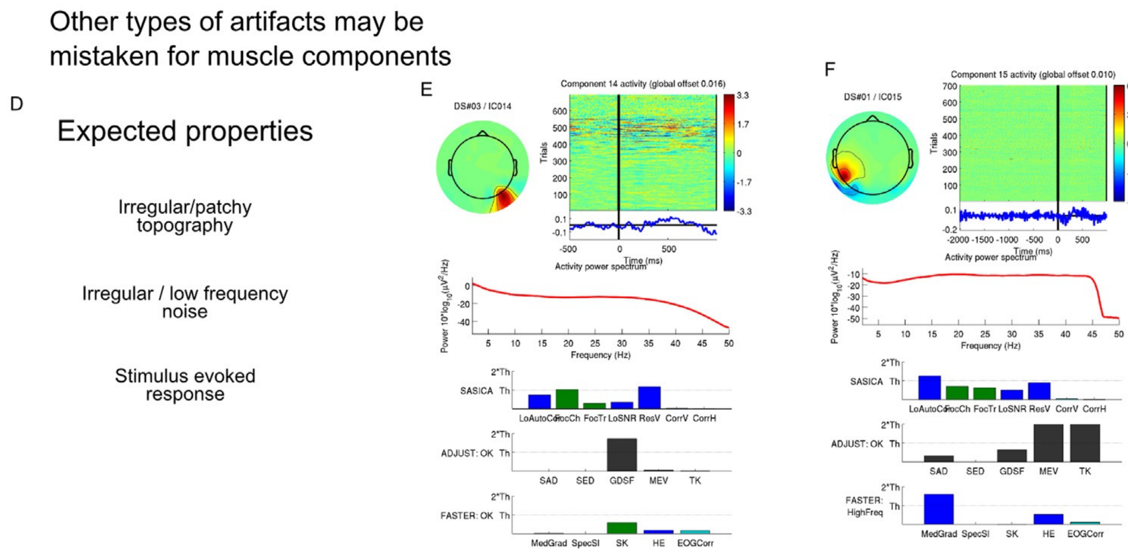
Possible Confusions



(G) Properties that can be found in non-artifact components that may be mistaken for ocular components.

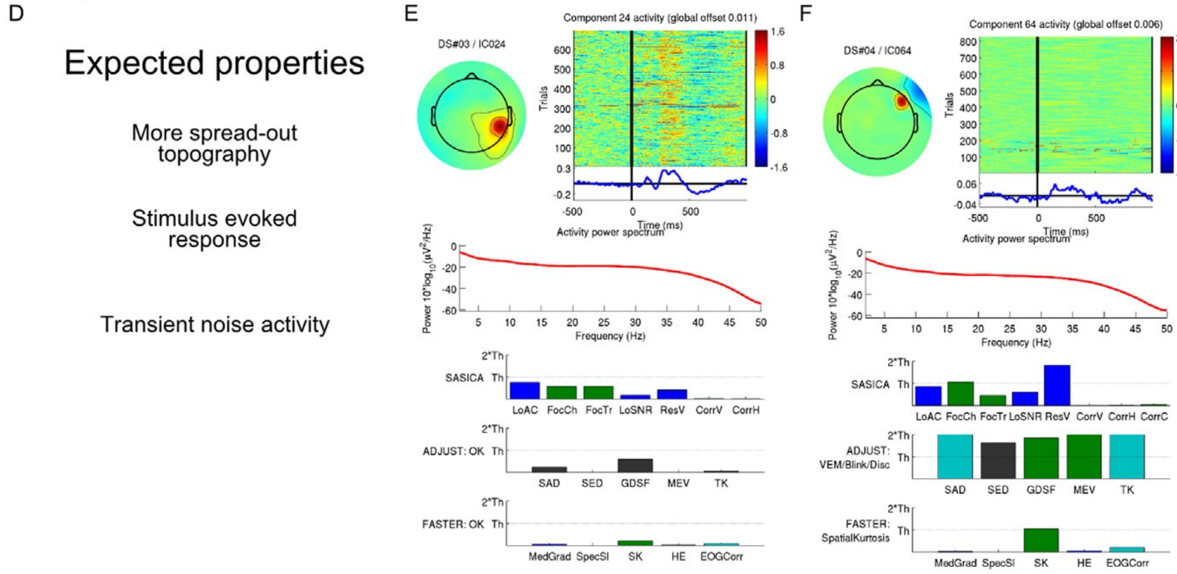
(H) Component mistaken for a blink component due to large inverse weights at frontal electrodes (actually an ERP!)

(I) Component whose high correlation with horizontal EOGs induced erroneous selection by SASICA and FASTER.



(D) Properties that can be found in non-muscle components mistaken for muscle components.
(E) Example of component that in spite of a focal topography, fails to qualify as muscle component because it does not show the expected steady noise activity characteristic of muscle components.
(F) Some components reflect mixtures of signals. This component captures at the same time a noisy and very focal activity pattern with low autocorrelation and median gradient measure, characteristic of muscle activity, but also some very high brief events and evoked activity that led the experts to categorize it as capturing rare events.

Ambiguous mixture components



(D) Properties that can be found in ambiguous components mistaken for bad channel components. (E) Example component with a smooth (although focal) topography, and a clear evoked response, mistaken by some users for a bad channel component. (F) Example component illustrating the overlap between the Bad channel and the Rare events component categories. This component captures activity of one bad channel that occurred mostly during a few trials, leading to ambiguous classification.