

Model-free analysis of fMRI

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Topics



**Basic concept of
intersubject
synchrony of
brain activation**



**Methods that
measure
intersubject
synchrony**

1. Intersubject correlation (ISC)
2. Time-window ISC
3. Intersubject phase synchronisation (ISPS)
4. Intersubject functional connectivity (ISFC)



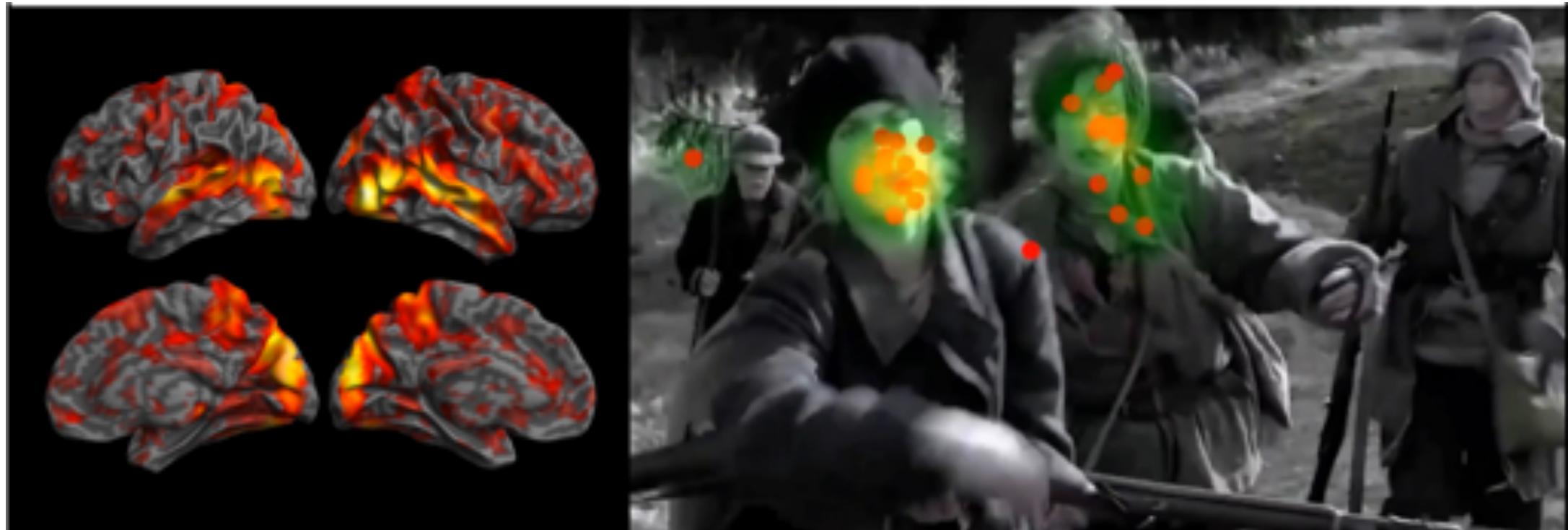
**Statistical testing
in synchrony
analyses**



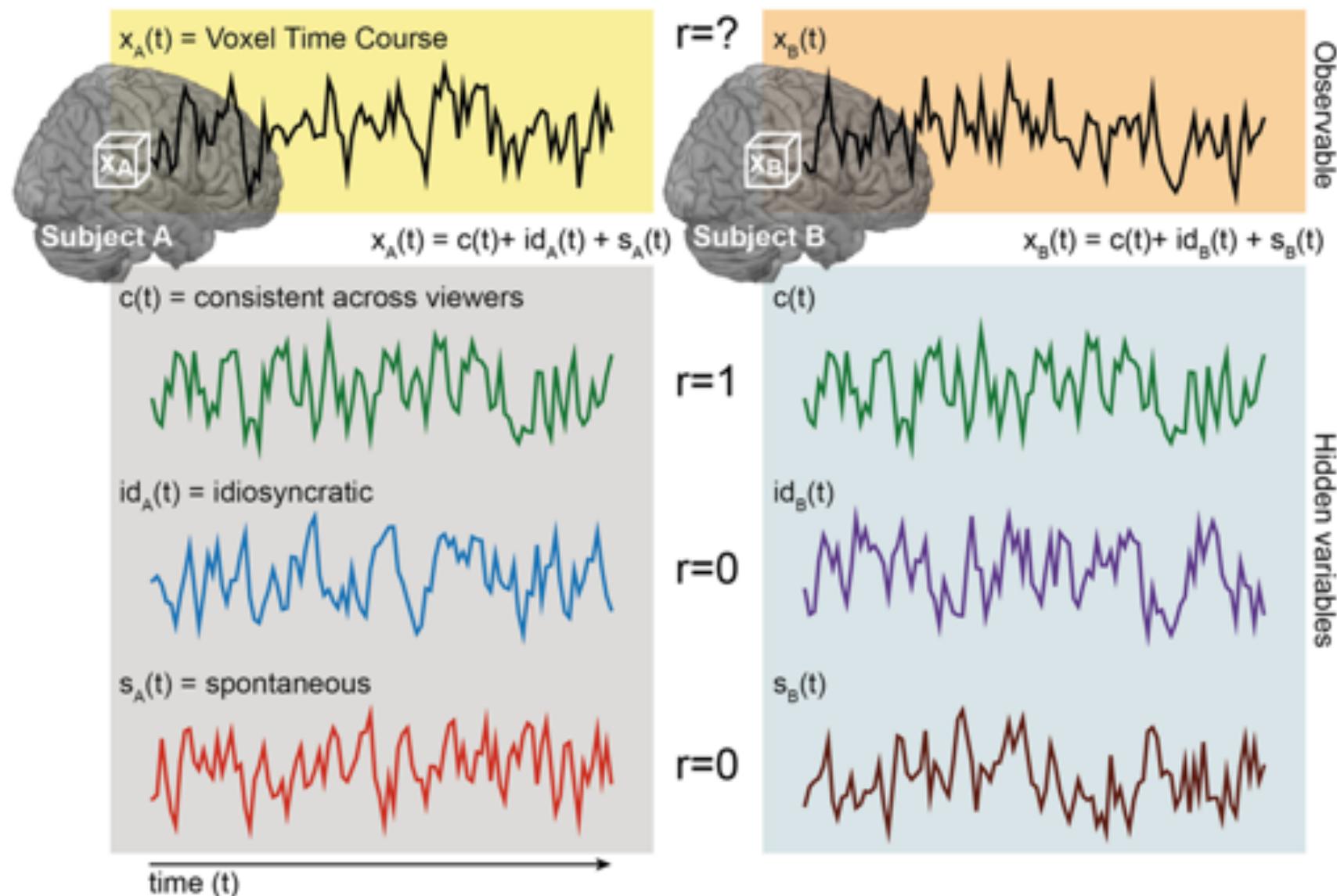
**ISC toolbox for
ISC analysis**

Intersubject synchrony in brain activation

- Films induce consistent brain activation across subjects (Hasson, Nir, Levy, Fuhrmann, & Malach, 2004)
 - Replicability



https://www.youtube.com/watch?v=tC-pPZZn_M



(Nastase, Gazzola, Hasson, & Keysers, 2019)

Benefits of measuring synchrony

synchrony
vs.
hemodynamic (de)activation

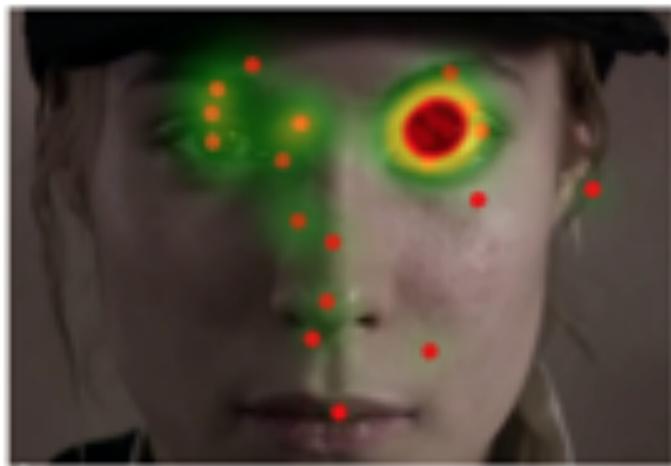
No need for detailed hypothesis/models

Easy to use complex stimuli

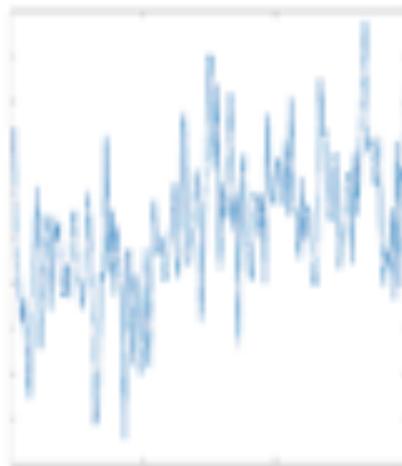
Simple designs
-> better replicability?

Capture shared stimulus dependent signal

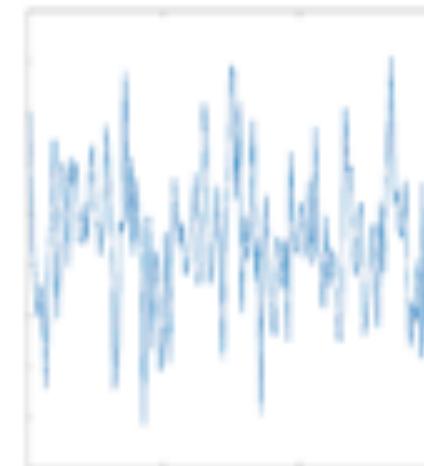
Checklist before ISC analysis



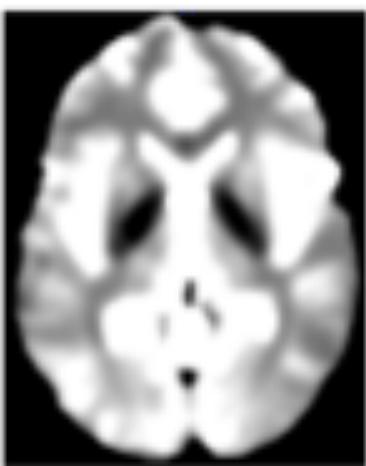
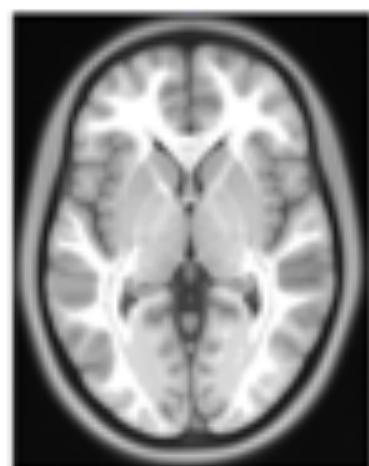
Shared stimulus



High-pass filtering
(detrending)



Spatial normalization



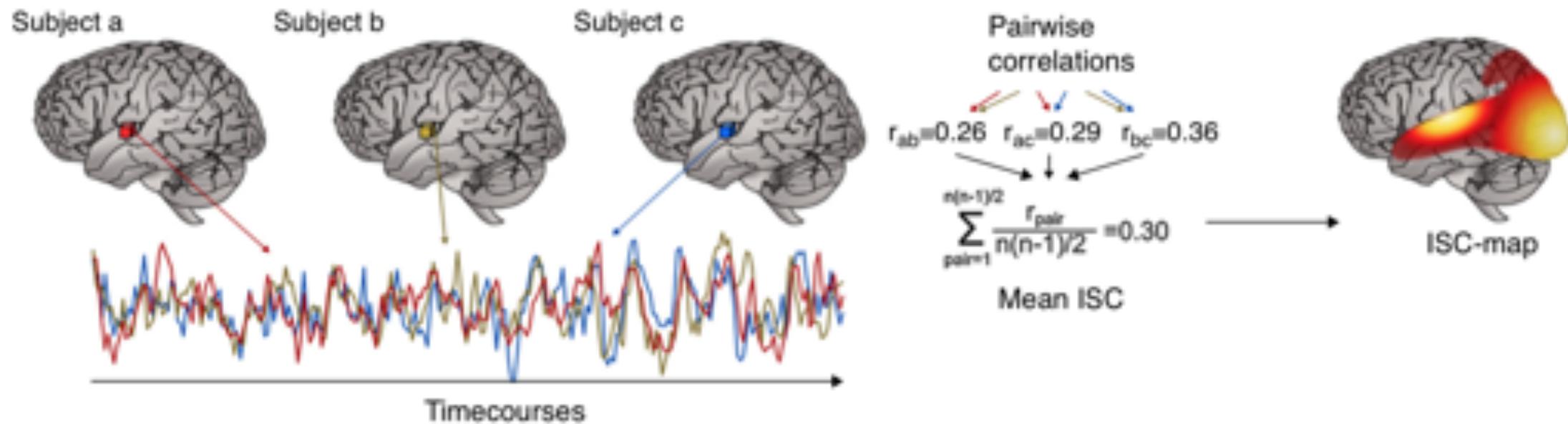
Smoothing

Measure	Time scale of the measured synchrony
ISC	Over the whole experiment (minutes-hours)
Time-window ISC	Specified time-windows (15sec - minutes)
ISPS	Instantaneous (seconds)

Shorter time scale

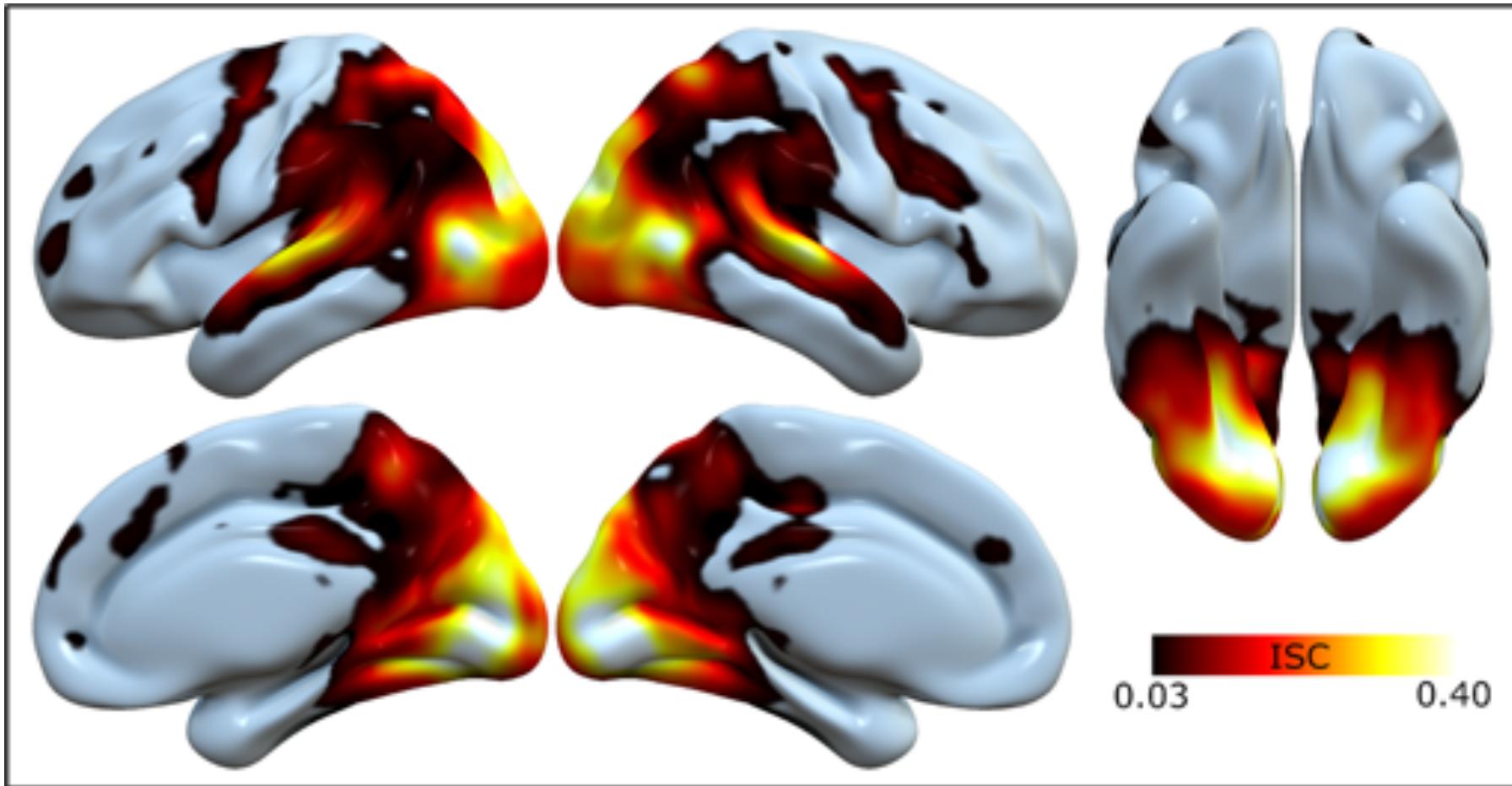


Basic concept of intersubject correlation (ISC)

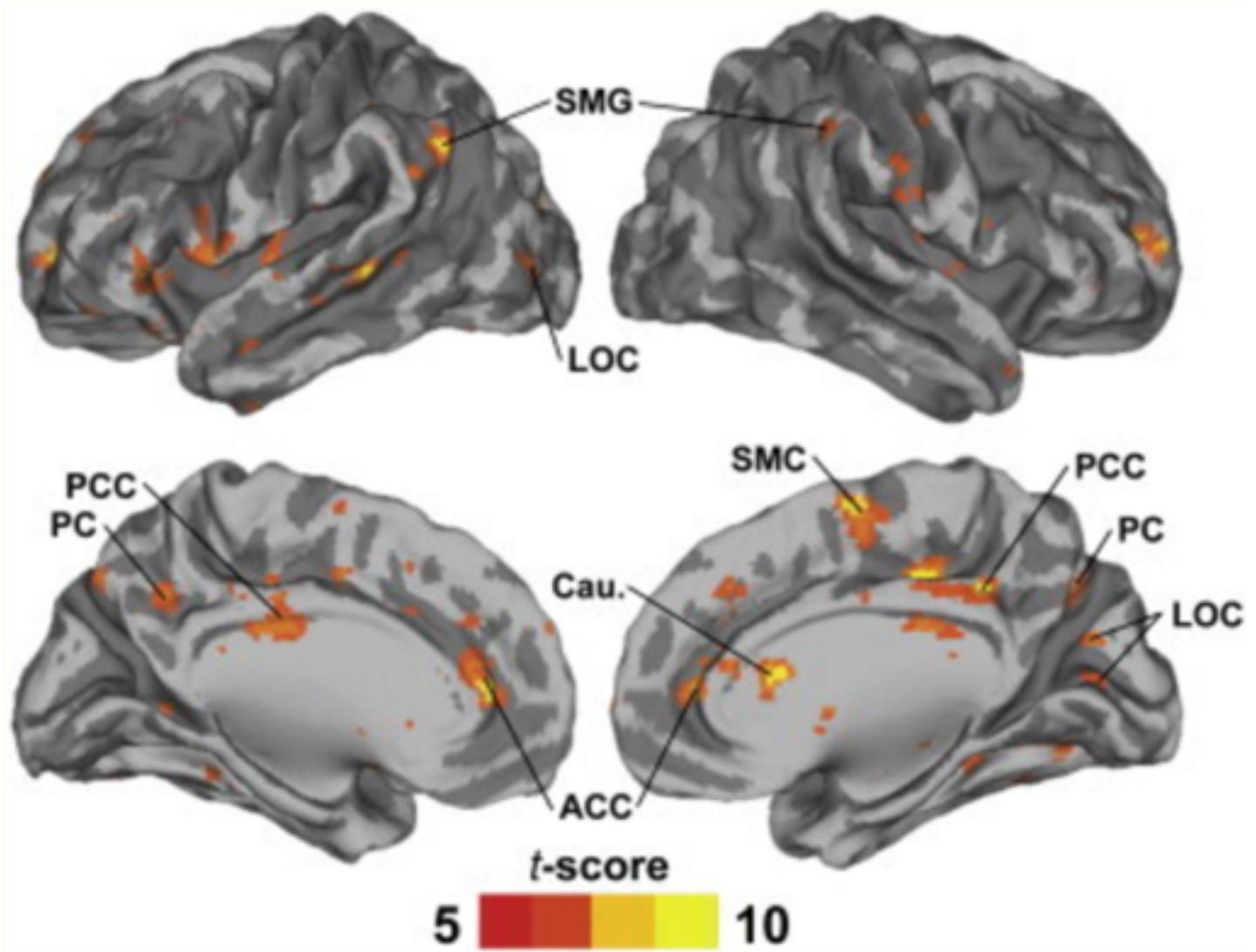


(Nummenmaa, Lahnakoski, & Glerean, 2018)

Typical ISC when watching films



Decreased
ISC in autism
spectrum
disorders

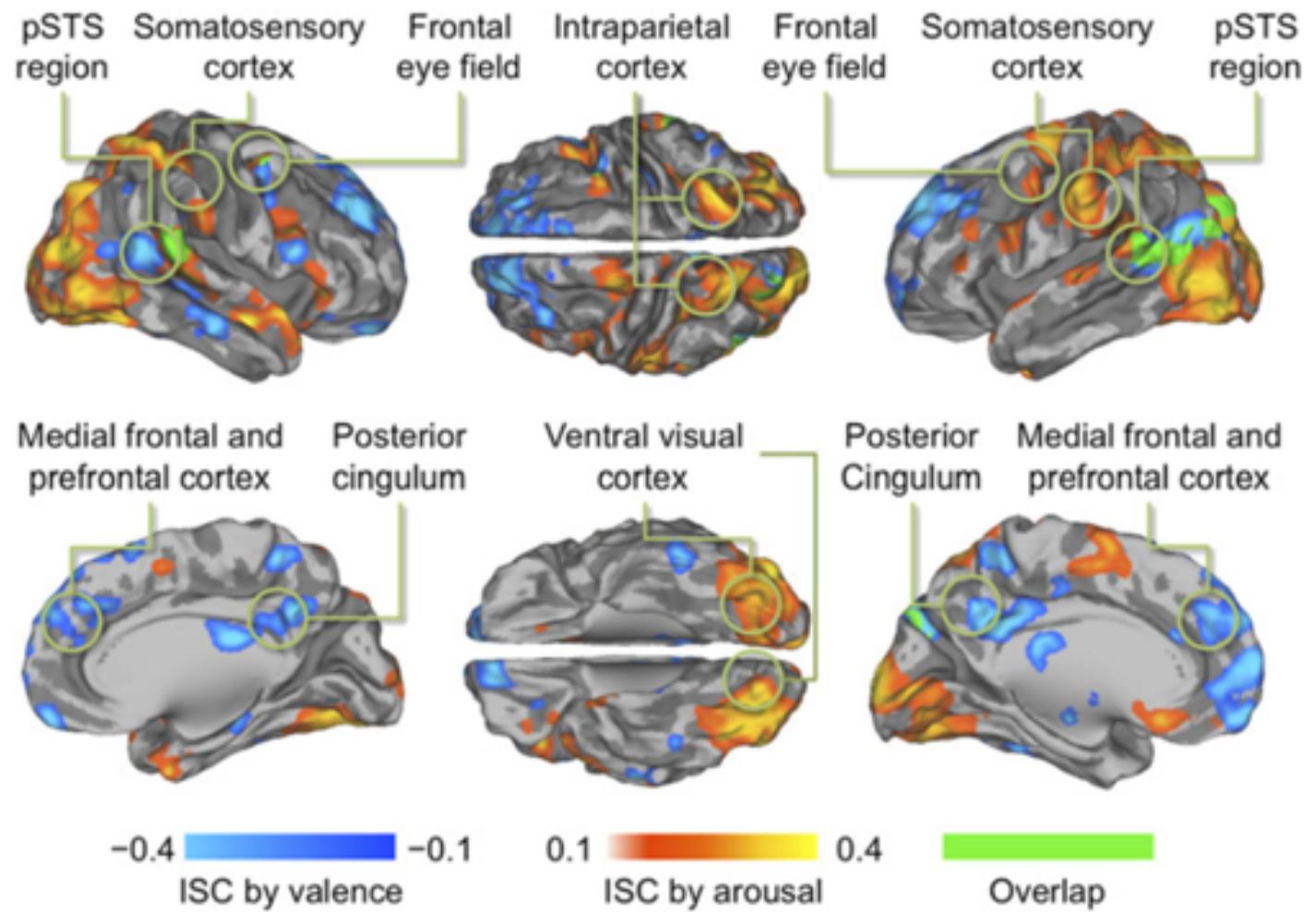


(Salmi et al., 2013)

Time-window ISC

- Dynamic measure of the intersubject synchrony
- Sliding window approach
 - Reflects the moving average of ISC
- How to choose a proper window length?

Valence and
arousal
predict time-
window ISC



(Nummenmaa et al., 2012)

Intersubject phase synchronisation (ISPS)

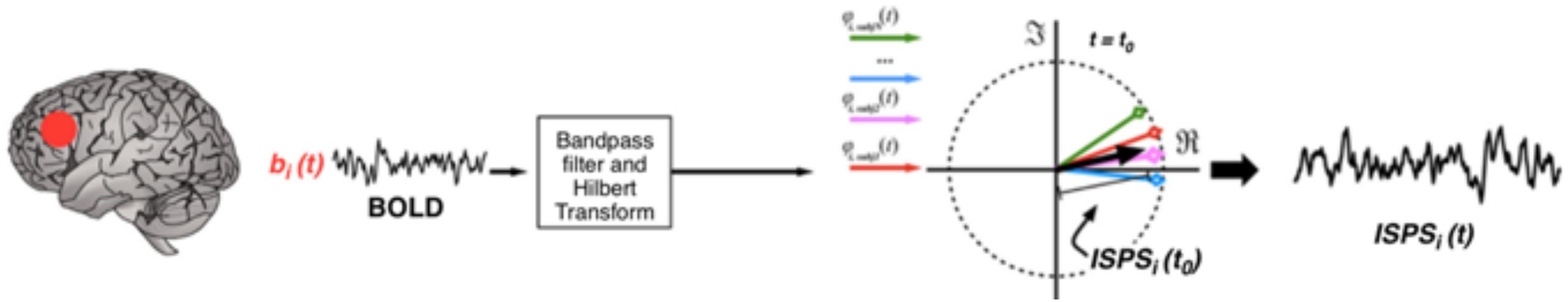
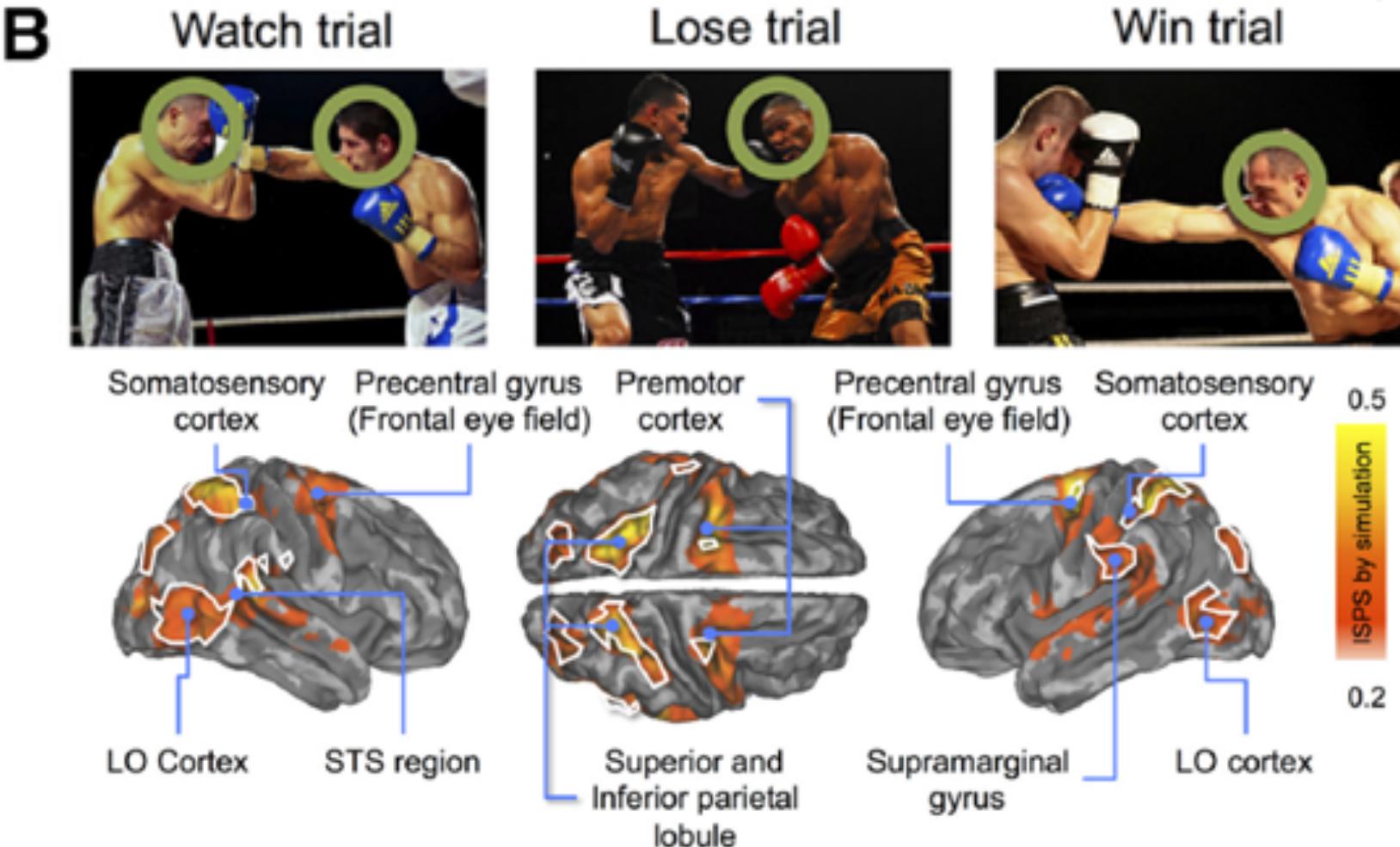


Illustration: (Nummenmaa, Lahnakoski, & Glerean, 2018)

Theory: (Glerean, Salmi, Lahnakoski, Jaaskelainen, & Sams, 2012)

ISPS in passive watching vs. perspective taking

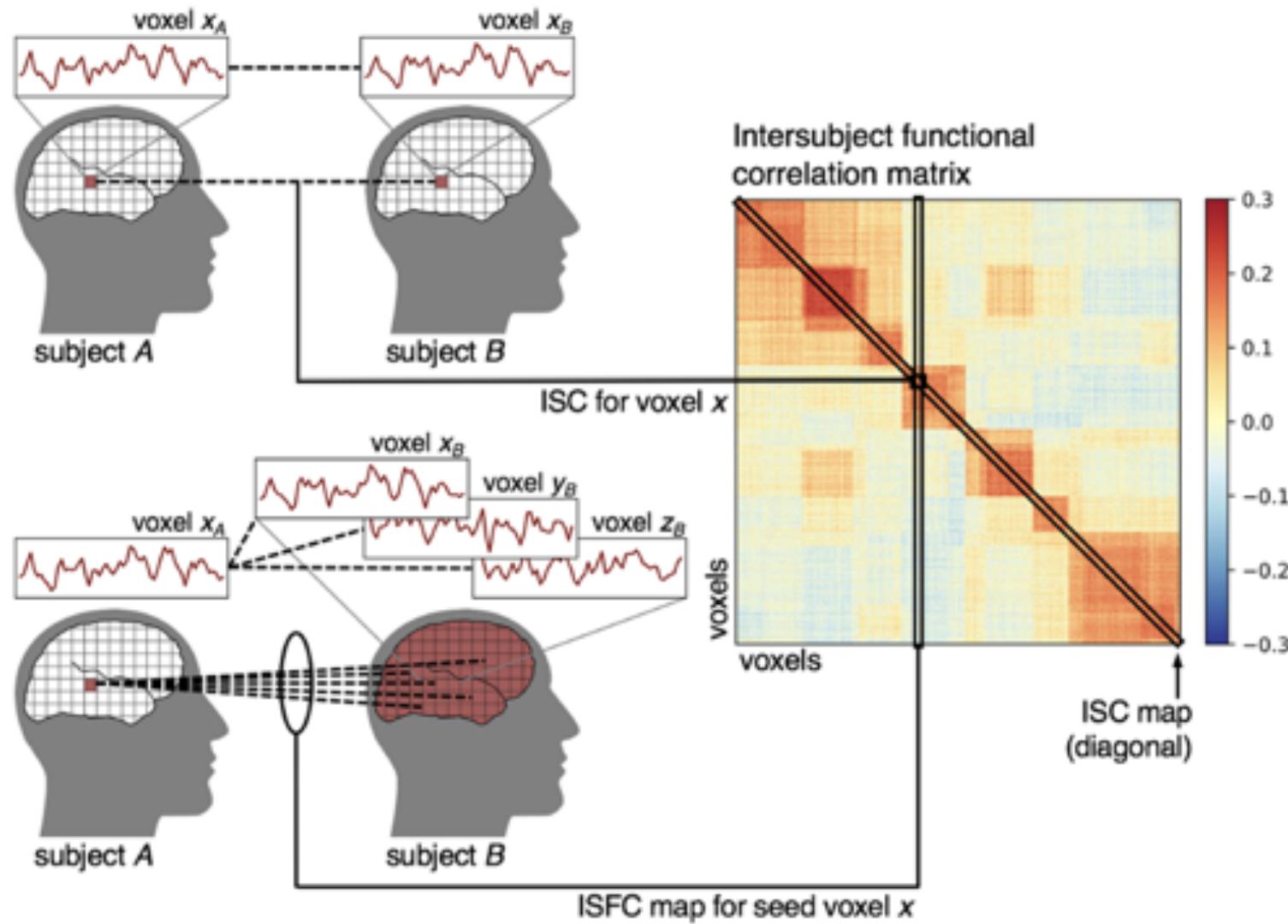


(Nummenmaa et al., 2014)

Reverse correlation approach

- Traditional analysis:
 - Hypothesis → Model design → GLM → Results
- “Let’s turn the analysis upside down”
- Find new hypotheses
 1. Measure dynamic brain synchronisation (time-window ISC/ISPS)
 2. Identify time points with high synchrony
 3. Figure out what is happening in the stimulus at the time of high synchrony
 4. Test new hypothesis in future studies.

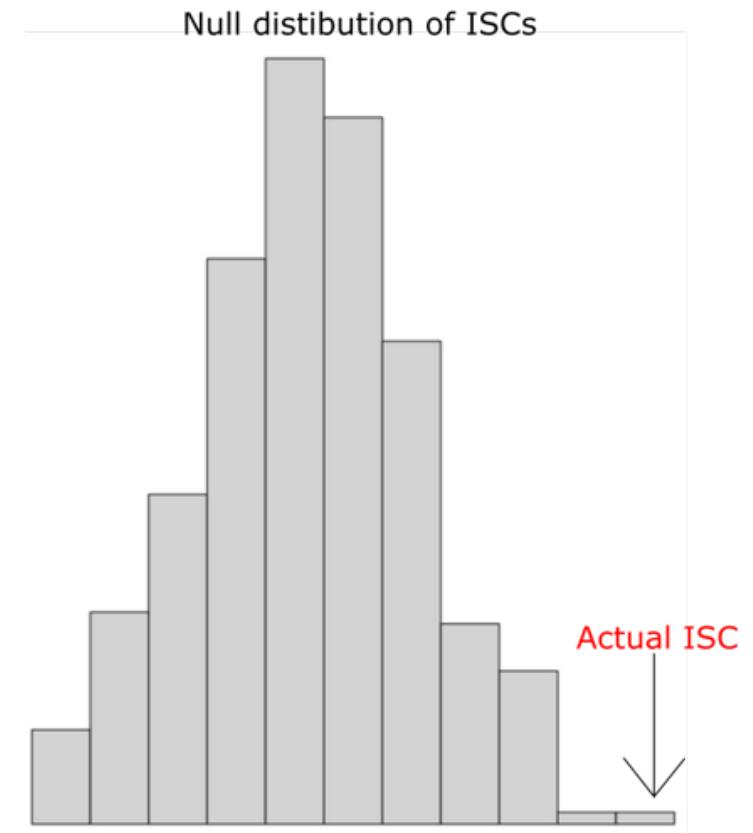
Intersubject functional connectivity (ISFC)



(Nastase, Gazzola, Hasson, & Keysers, 2019)

Statistical significance of ISC

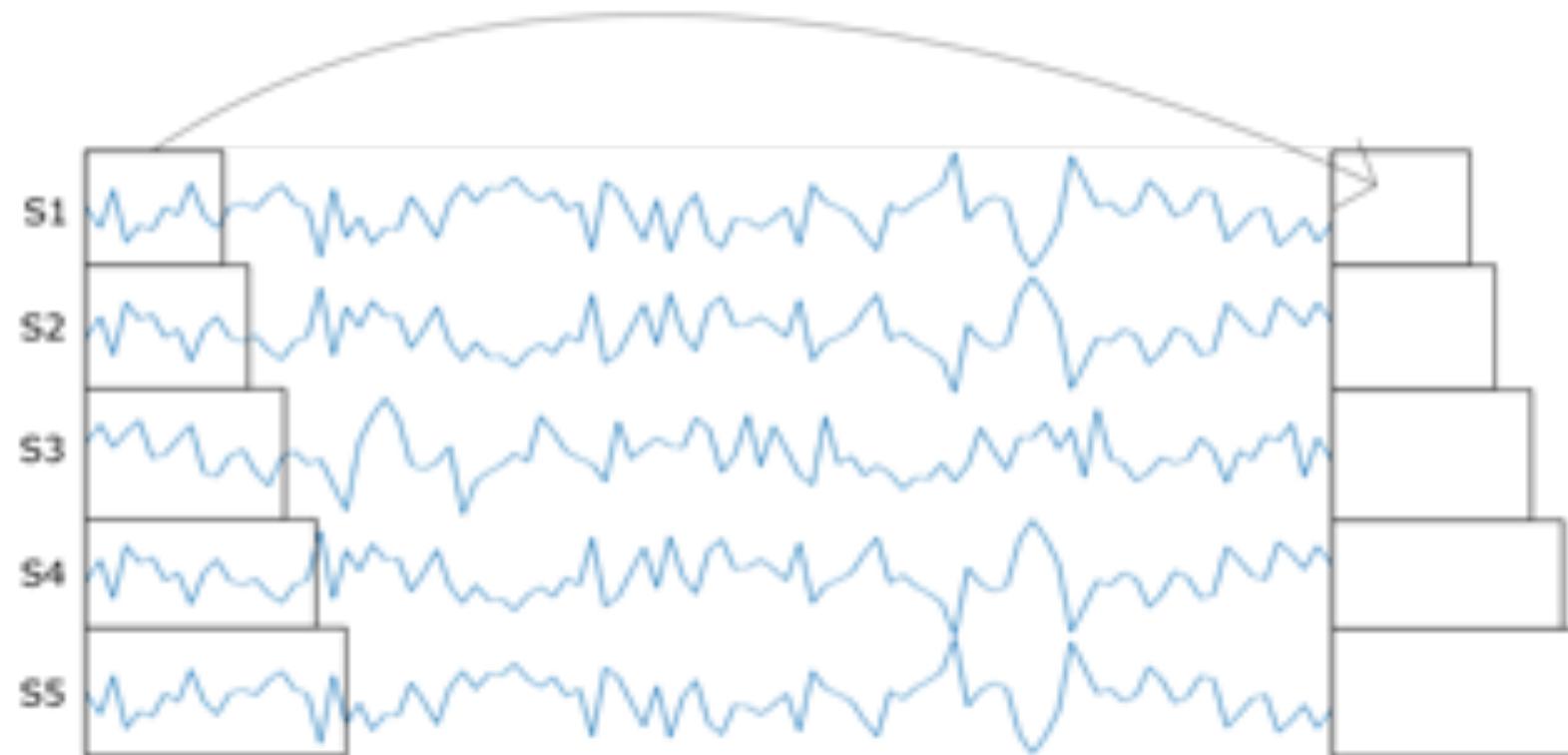
- Does ISC differ statistically from zero?
- Pairwise r-values are not independent
 - Parametric tests should not be used
- Non-parametric permutation based test
 - Circular block-resampling
- Multiple comparisons correction



(Kauppi, Jaaskelainen, Sams, & Tohka, 2010)

Circular block-resampling method

Circular resampling



1. Circular resampling
--> Break the temporal synchrony

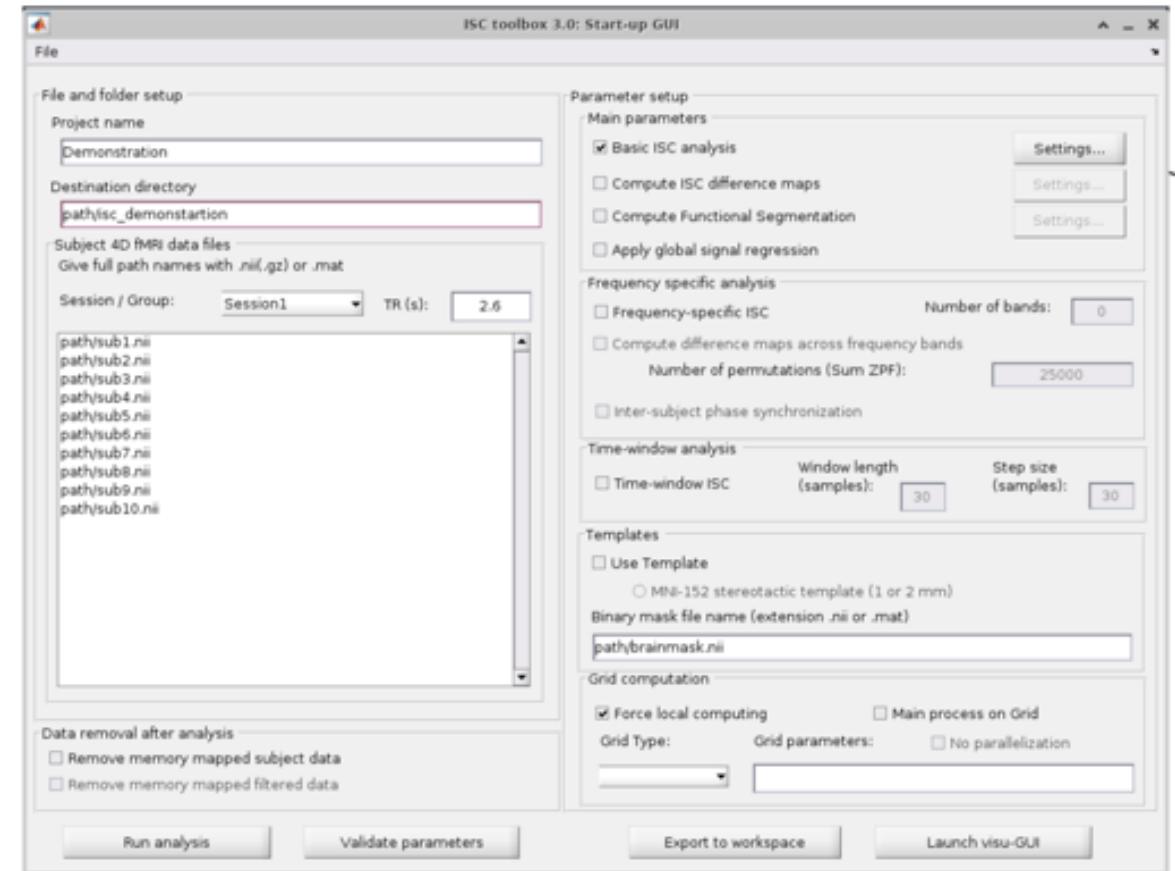
2. Calculate group ISC based on resampled data
--> Chance level ISC estimate

3. Resample many times (millions)
--> Null distribution of ISC values

4. Rank actual ISC value in the null distribution
-->p-value

ISC-toolbox

- Easy to use ISC analysis toolbox for brain fMRI data.
 - <https://www.nitrc.org/projects/isc-toolbox/>
 - Graphical user interface
- Runs on MATLAB
- Analyses
 - Basic one group analysis
 - Which brain areas synchronise across subjects?
 - Group comparison analysis
 - In which brain regions the synchronisation is different between two groups (e.g. patients against healthy controls)?
 - Frequency specific ISC analysis (advanced)
 - Compute ISC analysis separately for different frequency bands in fMRI signal.
 - Time-window ISC / ISPS
 - Multiple comparisons correction



(Kauppi, Pajula, & Tohka, 2014)

References

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