TRANSITORY NETWORKS SUPPORTING COGNITIVE CONTROL

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BRAIN FUNCTION: A MATTER OF INTEGRATION



COGNITIVE CONTROL

NEURAL PROCESSES INVOLVED IN FLEXIBLY INTEGRATING INFORMATION TO ACHIEVE INTERNAL GOALS IN A NOISY AND CHANGING ENVIRONMENT

DOSENBACH ET AL (2006, 2007, 2008)



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z +40



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DOSENBACH ET AL (2006, 2007, 2008)

In

2. Verb gen & reading 3. Object naming 4. Reading aloud 5. Matching Δ \diamond 6. Living/non-living 7. Physical & semantic 8. Visual search + -X. 9. Motor timing 0 10. Abstract/concrete

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Initiate and adapt control on a trialby-trial basis

Control through the stable maintenance of task sets



Out

BRESSLER AND MENON TICS, 2010



- fMRI time-resolved analyses
- Granger causality analyses

INTERIM SUMMARY

CONTROL RELIES ON SEGREGATED OR ANTAGONISTIC NETWORK DYNAMICS

CONTROL COMPLEXITY AND TRANSITORY CROSS NETWORK DYNAMICS



Cocchi et al., Cerebral Cortex, 2013

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CONTROL COMPLEXITY AND TRANSITORY CROSS NETWORK DYNAMICS



CONTROL COMPLEXITY AND CROSS NETWORK DYNAMICS



TASK-DEPENDENT DMN-CCN INTERACTIONS



Leech et al., J. Neuro., 2011

GOAL-DIRECTED RECOLLECTION



TRANSITORY META-SYSTEMS

Meta(stable)-system: Transitory, task-induced changes in integration between *brain regions* encompassing specialized functional systems.

This cross-systems interaction allows the resulting metasystems to support functions that transcend those of specialized networks.

(Cocchi et al, TICS, 2013; see also Tognoli and Kelso, Neuron, 2014)

EXAMPLES OF META-SYSTEMS

Low cognitive control (e.g. diffuse attention)





High cognitive control (e.g. task-based selective attention)







Link between non-stationary endogenous fluctuations and emergence of meta systems?



Consider the spatio-temporal multidimensionality of the processes supporting control

A. Beta-coherence 0.55 05 0.45 0.4 0.35 5 03 0.25 02 0.15 0.1 B. Gamma-coherence 06 0.55 0.5 0.45 0.4 0.35 0.3 0.25 02 0.15 0.1

A. Beta-coherence

Connection 1: Dorsofrontal - occipital connection (red in Fig. 2A)



B. Gamma-coherence

Connection 4: Inferior frontal - occipitoparietal connection (Fig. 2B)



Cocchi et al. Plos One, 2011 15

Structure-function relationship: What impact for the emergence of meta-systems?



Cocchi et al., NeuroImage: Clinical, 2014 16

TAKE HOME

Control emerge from the *transitory* ability to flexible integrate segregated neural functions.

Overall network-structure is preserved, the task-induced reconfiguration of endogenous patterns of integration support complex cognitive functions.

Transient dynamics supporting control are likely to involve multiple temporal and spatial scales.

THANKS

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EXAMPLES OF META-SYSTEMS

Low working memory load, diffuse attention





High working memory load, selective attention



