Proactive and reactive control processes involve dynamic reorganisation of alpha and theta oscillatory networks

Patrick S. Coopera,b,c, Aaron S.W. Wongb,d, Elise Mansfielda,b,c, W. Ross Fulhama,b,c, Patricia T. Michiea,b,c, Frini Karayanidisa,b,c

**a** School of Psychology, Universtiy of Newcastle

**b** Functional Neuroimaging Laboratory, University of Newcastle

**c** Hunter Medical Research Institute, University of Newcastle

**d** School of Engineering, University of Newcastle

**1. Introduction**

Cognitive control processes allow us to adjust our behaviour flexibly in order to meet nternal motivations or goals. Depending on contextual constraints, this control can be adopted either proactively, pre-setting the system to be sensitive to goal-relevant features of the environment or reactively, responding to such goal-relevant features on a needs basis (Braver, 2012). The implementation of these control processes is known to rely on an extensive and well-described frontoparietal communication architecture (Corbetta and Shulman, 2002; Seeley et al., 2007; Vincent et al., 2008) that is well suited to promote

flexible and rapid information propagation (Dosenbach et al., 2008). Yet, despite the increasing knowledge regarding the anatomical architecture that permits flexible control, the functional properties of this network are less well characterised.

One plausible mechanism by which information can be flexibly adjusted and rerouted in the frontoparietal network is oscillatory synchronisation. Separate populations of neurons are able to exchange information transiently by synchronising the excitability windows in which they are most sensitive to electrical influxes (Fries, 2005; Womelsdorf and Fries, 2006). Such synchronisation produces assemblies of neurons that are functionally connected for a given period of time. The neurons in these assemblies oscillate rhythmically, allowing receiving and transmitting components to precisely time their firing rates, and thereby achieving an efficient mechanism to exchange information within the assembly that is also less sensitive to competing inputs from alternative assemblies (Azouz and Gray, 2003; Engel et al., 2001). Indeed, oscillatory synchronisation has been shown to be functionally relevant in numerous higher-order cognitive processes such as working memory (Huang et al., 2013; Palva et al., 2005; Pesonen et al., 2007; Sauseng et al., 2005; Wu et al., 2007), selective attention (Doesburg and Ward, 2007; Doesburg et al., 2009; Kahlbrock et al., 2012; Maris et al., 2013) and inhibition (Papenberg et al., 2013; Serrien et al., 2004; Tallet et al., 2009). By transiently synchronising activity within the frontoparietal network, goal relevant representations may be afforded an elevated processing status that permits effective cognitive control.

The evidence for the role of oscillatory synchronisation in cognitive control is currently largely restricted to slow wave, theta (4-7Hz) synchronization in goal and response conflict resolution. For example, increases in theta synchronisation have been reported in paradigms requiring error detection and post-error correction (Cavanagh et al., 2009; Luu et al., 2004; Trujillo and Allen, 2007), goal conflict and response selection (Moore et al., 2006,

2012), as well as in task switching (Sauseng et al., 2006). As these goal relevant processes are important contributors to cognitive control (Miyake et al., 2000), these findings suggest that theta oscillations may be a neural signature of goal-directed processes.

Interestingly, the role of theta in cognitive control has been investigated almost exclusively using paradigms that do not differentiate between proactive and reactive control. For example, Sauseng and colleagues reported widespread frontoparietal coherence in the theta band when participants switched randomly between digit magnitude and digit classification tasks compared to repeating one of these tasks (Sauseng et al., 2006). Here, there was no advance information about whether the upcoming trial would require a switch or a repeat in task. Instead, the stimulus had to first be encoded to decide which task needed to be implemented (e.g., repeat the same task or change to alternative task) and secondly to implement that task in the presence of competing information (e.g., respond smaller/greater than 5, ignore parity). Likewise, when participants were searching for a specific rule (i.e. the presentation of four odd digits) frontoparietal theta connectivity was observed during each instance that this rule was not met (i.e. goal conflict) as well as correct detection - response selection (Moore et al., 2006). Other studies investigating the role of theta synchronisation in cognitive control have also used paradigms that do not differentiate between proactive and reactive control (e.g., Flanker tasks in Cavanagh et al. 2009).

In fact, studies that have specifically targeted proactive control, by examining electrophysiological activity in the cue-target interval, i.e., the interval between an informative cue to switch or repeat task and the subsequent target, have shown changes not in theta, but in alpha (8-13Hz) power (Mansfield et al., 2012) and oscillatory synchronisation (Serrien et al., 2004). Together, these findings suggest that proactive and reactive cognitive control modes may involve distinct neural processes. As functionally relevant neural coupling often occurs between frequencies (Jensen and Colgin, 2007), perhaps the frontoparietal control architecture dynamically shifts between theta and alpha oscillatory synchronisation depending on contextual demands.

The current study aimed to investigate the potential mechanistic dissociation between proactive and reactive control via alpha and theta oscillatory synchronisation respectively. To do so, we utilised a cued-trials task switching paradigm where we manipulated the ability to prepare for a repeat or switch between simple classification tasks (Karayanidis et al. 2009; see Methods). This manipulation allowed us to disentangle proactive, reactive and switch-related processes to explore the role of alpha and theta oscillatory synchronisation in cognitive control. Based on this separation of control processes, if theta synchronisation is associated with switching (cf. Sauseng et al. 2006) then we expect to see increases in frontoparietal coherence during switch aniticpatory processes and/or target-based switch processes specifically. However, if theta synchronisation is an index of reactive control, extensive frontoparietal connectivity should occur only after target onset in those conditions advance preparation was insuficient for. Given previous findings suggestive of a role of alpha oscillatiory activity in switch preparation, we also expect to see the frontoparietal network utilize alpha frequencies when preparing for any switch in task rather than a task repeat.

**2. Methods**

*2.1. Participants*

Twenty-nine (13 male, mean age 25.69 **fi**5.64 years) young adults from the Newcastle community took part in the current study as part of a larger project (http://www.age-ility.org.au) and received $20 per hour reimbursement. All participants were asked to abstain from caffeine and alcohol prior to testing, were right-handed and had no current neurological or psychiatric disorder. The University of Newcastle Humans Ethics Research Committee approved the current study.

*2.2. Stimuli and Task*

To characterise proactive and reactive control networks, we utilised a cued-task switching paradigm containing task-repetition and task-set changes with varying degrees of preparation. A grey wheel (5 fi diameter) was presented continuously with six equal-sized segments. Two adjacent segments were considered a major sub-division of the wheel and were associated with one of three classification tasks: a letter classification task (vowel/consonant), a digit classification task (odd/even) and a colour classification task (hot/cold; see Figure 1). Participants were presented a bivalent target in one of the two segments associated with the task and were instructed to classify the task-relevant features using a left or right button press. Targets contained one task-relevant dimension (e.g. for the letter task, the vowel 'A'), one incongruently response-mapped feature (e.g. an even digit '4') and a third neutral feature (e.g. a grey target 'A4'). The same target could not appear on successive trials, the same trial type could not be repeated more than four consecutive times and response mappings were counterbalanced between participants (Figure 1).

To assist in preparing for the upcoming target, two adjacent segments of the wheel were bolded for 1000 ms prior to target onset, with the target appearing in one of the two cued sections. If the cue highlighted two segments that exclusively belonged to only one of the three classification tasks, these cues were considered to be informative. An informative cue could indicate a repetition of a task, a repeat trial or a change in task, a switch-to trial. If the two cued segments overlapped with more than one classification task (e.g. a section belonging to the digit and a section belonging to the colour task were highlighted) then complete preparation for the upcoming target was unable to occur. If the two sections cued were from tasks that were not completed on the previous trial, this indicated a change in task-set but not the identity of the task - a switch-away trial. On these trials, switch but not task-set reconfiguration processes could occur. Alternatively, if the sections cued were from both the previous trial's task and another classification task, no maintenance, switch or task-set anticipation could occur and so these trials were deemed noninformative. Taken together, proactive control was able to be employed for repeat and switch-to trials; switch-away and noninformative classification relied on reactive control and switch-to and switch-away trials reflected varying degrees of informative switching processes.

*2.3. Procedure and EEG Recording*

Prior to the experimental session participants learnt and practiced both single-task and switching blocks over two training sessions, one on initial contact and one prior to the EEG recording comprising 1320 practice trials total. Initial task learning occurred no more than 14 days before the experimental session. For the experimental session, participants performed ten mixed task blocks and three single task blocks, in a dimmed testing room with simultaneous EEG recorded. Mixed task blocks comprised 72 trials (plus five dummy trials) and single task blocks 48 trials (plus five dummy trials). For each trial a cue was presented for 1000 ms which disappeared at target onset where the target remained until response (or a five second timeout). A 600 ms interval was inserted between response and the next cue. Error feedback was provided to participants via a tone. Reaction times and accuracy for each block were presented during inter-block feedback alongside a brief entertaining video. These breaks were semi-self paced, with participants informing the experimenter when they were ready to proceed to the next block. This was done to minimise fatigue effects.

EEG was recorded continuously at a sampling rate of 2,048 Hz from 64 scalp electrodes and eight external leads (two outer canthi of the eyes, two supraorbital, two infraorbital, and left and right mastoids) using an ActiveTwo Biosemi EEG system. Data was recorded with reference to the common mode signal (CMS) and right driven leg (DRL) electrodes.

*2.4. Data Analysis*

Behavioural and EEG data were processed offline. Responses faster than 200ms or slower than three standard deviations from each individual's mean RT were excluded from analyses. Post-error trials and those with unsuitable noise levels (see below) were additionally excluded from EEG analyses.

*2.5. EEG Analysis*

EEG data were processed using MATLAB 2011b (The Mathworks, Inc.) through a custom-built pipeline utilising Fieldtrip (Oostenveld et al., 2011), EEGLab (Delorme and Makeig, 2004) and in-house functions (see Figure 2). EEG data were initially read into Fieldtrip, using a common average reference and filtered (high pass: 0.1Hz, forward phase, 50Hz notch, zero phase). Data were visualised for noisy channels and if any were detected, interpolated using a k nearest-neighbour approach. Trials (repeat, switch-to, switch-away, noninformative) were defined with respect to cue onset (from -1,000 ms to +3,500 ms). Independent components analysis (ICA) was performed to remove EOG-related artefact using the fastica function (Hyvarinen & Oja, 2000). Before ICA was ran, trials were inspected and removed if their variance suggested they were an outlier, they had a value of over 1,000 **fi**V or a z-value **>**4, in an attempt to make the strongest ICA derived components EOG-related. After EOG signals were removed from the data, trials underwent a second phase of artefact rejection where they were filtered with a low pass filter of 30Hz to remove remaining EKG artefacts, trials larger than **fi**100**fi**V automatically removed and a final inspection of trial variance to remove any remaining outliers. This approach typically resulted in 6% (**fi**9.1 SD) of trials removed. Finally, as coherence analyses were undertaken at sensor space, trials were transformed using scalp surface Laplacian estimates or current source density (CSD). CSD minimises volume conduction efiects at EEG sensor space by removing large common signals across sites (spatial autocorrelation). Additionally, CSD is a reference-free montage which eliminates artificial coherence between electrodes due to a shared reference site(s) across sensors, providing a more sensitive connectivity measure that is relatively uninfluenced by common sources and reference montage problems.

*2.5.1. Power Analysis*

The power for each condition was calculated by transforming single trial data into its time-frequency representation. To do so, we multiplied the power spectrum derived from a fast-Fourier transform (FFT), where frequencies were analysed across 80 logarithmically-spaced frequency bins, ranging from 2 Hz to 50 Hz, and time from 400 ms pre-cue to 2,200 ms post cue, by the power spectrum of Morlet wavelets:

**ei**2**fif e**

􀀀**t**2

(2**fi**2) (1)

where f = the current frequency, t = time and **fi** = the width of each frequency band (n/(2**fi**f )), n increases logairthmaicllay from 3 to 14 with respect to f. An inverse FFT (iFFT) was performed on the output of the above steps. The output of the iFFT for each trial was normalised with a decibel transformation (normalised power = 10\*log10[power/baseline] ) where baseline referred to the average activity from 200 ms pre-cue to cue onset.

*2.5.2. Coherence Analysis*

We used imaginary coherence as our measure of oscillatory synchronisation. Coherence refers to the normalised cross-spectral correlation between two time series, containing information relating to a) the absolute magnitude of the relationship and b) the complex component representing phase information. If we look solely at the complex component of coherence, we can explore phase coupling between two time series. As phase information

is not sensitive to volume conduction effects (Nolte et al., 2004), we can use this information to explore neural interactions confidently at sensor space. Imaginary coherence was calculated by first computing the cross-spectral power density between each pair of electrodes (**Sij**(f )) for each time point across the 80 frequency bins. We then divided the derived power by the the cross-spectral power for each pair of electrodes to compute imaginary coherence, using the following expression:

**Cij**(**f**) =

**Sij**(**f**)

(**Sii**(**f**)**Sjj**(**f**))1**=**2

(2)

and extracting the complex component.

We then defined a connectivity matrix for frequencies delta (**fi**; 2-4 Hz), theta (**fi**; 4-7 Hz), loweralpha (**fi**1; 8-10 Hz), upperalpha (**fi**2; 10-13 Hz) and beta (**fi**; 13-30 Hz) by averaging the imaginary coherence output across the frequency band using a 100 ms sliding window (window size = 200 ms) from cue onset to 600 ms post target. This resulted in 15 time ranges for each frequency (5) and each condition (4). As CSD correction can produce artefacts at edge electrodes, our final connectivity matrices included only those sites not on the cap peripherals (i.e. AF3, F1, F3, F5, AF4, AFz, Fz, F2, F4, F6, FC5, FC3, FC1, FC6, FC4, FC2, FCz, C1, C3, C5, Cz, C2, C4, C6, CP5, CP3, CP1, CP6, CP4, CP2, CPz, P1, P3, P5, P7, Pz, P2, P4, P6, P8, PO7, PO3, O1, Oz, POz, PO8, PO4 and O2). Finally, as our paradigm lacked a pure baseline condition, we converted each connectivity matrix into a difference matrix which compared connectivity in the current frequency\*time\*condition interaction to connectivity during the current frequency\*time\*repeat condition.

*2.6. Statistical Analyses*

Statistics on coherence results were performed using map-wise t -tests, with effects considered statistically significant using an false-discovery rate (FDR) correction of p **<**0.005 (Benjamini and Yekutieli, 2001), following the multiple comparison correction guidelines of Nolte et al. (2004). Our FDR correction reflects a confidence that 99.5% of values observed are true observations. We present findings from an early preparatory window (100-300 ms) in the cue to target interval and a post target period between 200 to 400 ms. As our hypotheses targeted theta and alpha synchronisation we only report results from these frequencies here.

**3. Results**

3.1. Behavioural Results

Behavioural data were analysed using a repeated- measures ANOVA (TRIAL TYPE (4) \* TASK (3)) in SPSS. For RT there were significant main effects for TRIAL TYPE, F(3**;**84) = 120.005, p **<**0.001 and TASK, F(2**;**56) = 24.454, p **<**0.001 but their interaction did not reach significance. Repeat trials were performed faster than switch-to, F(1**;**28) = 63.66, p **<**0.001, switch-away, F(1**;**28) = 192.988, p **<**0.001 and noninformative trials, F(1**;**28) = 423.066, p **<**0.001. Switch-to trials were faster than switch-away F(1**;**28) = 152.19, p **<**0.001 and noninformative trials F(1**;**28) = 11.37, p = 0.002, and noninformative were performed faster than switch-away F(1**;**28) = 32.435, p **<**0.001 (see Figure 3). Overall our participants were very accurate, with significant main effects only for TRIAL TYPE F(3**;**84) = 7.362, p **<**0.001, driven primarily by repeat trial performance being more accurate than switch-to, switch-away and non-informative.

*3.2. Power Analyses*

Power was computed for theta, lower alpha and upper alpha. No switch specific features were identified for theta power across the cue to target interval but were observed in both lower and upper alpha ranges. Figure 3 highlights the strongest of these effects, showing the increase in parietal power for switch-to and switch-away conditions in the upper alpha band (see Supplementary Materials for equivalent plots for theta and lower alpha bands). Both switch-to and switch-away show marked increases in parietal power relative to the repeat baseline condition during the 400-600 ms preparation interval that is largely absent for the noninformative condition. The strongest power is observed during this 400-600 ms window but for switch-away trials in particular it is seen to wax and wane in the two adjacent time

windows (200-400 and 600-800 ms).

*3.3. Imaginary Coherence Analyses*

4. References

Azouz, R., Gray, C. M., 2003. Adaptive coincidence detection and dynamic

gain control in visual cortical neurons in vivo. Neuron 37, 513{523.

Benjamini, Y., Yekutieli, D., 2001. The control of the false discovery rate in

multiple testing under dependency. The Annals of Statistics 29 (4).

Braver, T. S., 2012. The variable nature of cognitive control: a dual mechanisms

framework. Trends Cogn Sci 16 (2), 106{13.

Cavanagh, J. F., Cohen, M. X., Allen, J. J., 2009. Prelude to and resolution

of an error: Eeg phase synchrony reveals cognitive control dynamics

during action monitoring. J Neurosci 29 (1), 98{105.

Corbetta, M., Shulman, G. L., 2002. Control of goal-directed and stimulusdriven

attention in the brain. Nat Rev Neurosci 3 (3), 201{215,

10.1038/nrn755.

Delorme, A., Makeig, S., 2004. Eeglab: an open source toolbox for analysis of

single-trial eeg dynamics using independent component analysis. Journal

of Neuroscience Methods 134, 9{21.

Doesburg, S. M., Green, J. J., McDonald, J. J., Ward, L. M., 2009. From local

inhibition to long-range integration: a functional dissociation of alphaband

synchronization across cortical scales in visuospatial attention. Brain

Res 1303, 97{110, doesburg, Sam M Green, Jessica J McDonald, John J

Ward, Lawrence M Netherlands Brain Res. 2009 Dec 15;1303:97-110. doi:

10.1016/j.brainres.2009.09.069. Epub 2009 Sep 24.

Doesburg, S. M., Ward, L. M., 2007. Long-distance alpha-band meg synchronization

maintains selective visual attention. International Congress

Series 1300, 551{554.

Dosenbach, N. U., Fair, D. A., Cohen, A. L., Schlaggar, B. L., Petersen,

S. E., 2008. A dual-networks architecture of top-down control. Trends

Cogn Sci 12 (3), 99{105.

Engel, A. K., Fries, P., Singer, W., 2001. Dynamic predictions: Oscillations

and synchrony in top-down processing. Nature Reviews Neuroscience 2,

704{716.

Fries, P., 2005. A mechanism for cognitive dynamics: neuronal communication

through neuronal coherence. Trends in Cognitive Science 9 (10),

474{480.

11

Huang, L. Y., She, H. C., Chou, W. C., Chuang, M. H., Duann, J. R., Jung,

T. P., 2013. Brain oscillation and connectivity during a chemistry visual

working memory task. Int J Psychophysiol 90 (2), 172{9, huang, Li-Yu

She, Hsiao-Ching Chou, Wen-Chi Chuang, Ming-Hua Duann, Jeng-Ren

Jung, Tzyy-Ping Netherlands Int J Psychophysiol. 2013 Nov;90(2):172-9.

doi: 10.1016/j.ijpsycho.2013.07.001. Epub 2013 Jul 9.

Jensen, O., Colgin, L. L., 2007. Cross-frequency coupling between neuronal

oscillations. Trends Cogn Sci 11 (7), 267{9, jensen, Ole Colgin, Laura L

England Trends Cogn Sci. 2007 Jul;11(7):267-9. Epub 2007 Jun 4.

Kahlbrock, N., Butz, M., May, E. S., Schnitzler, A., 2012. Sustained gamma

band synchronization in early visual areas re

ects the level of selective

attention. Neuroimage 59 (1), 673{81, kahlbrock, Nina Butz, Markus May,

Elisabeth S Schnitzler, Alfons Neuroimage. 2012 Jan 2;59(1):673-81. doi:

10.1016/j.neuroimage.2011.07.017. Epub 2011 Jul 19.

Karayanidis, F., Mansfield, E. L., Galloway, K. L., Smith, J. L., Provost,

A., Heathcote, A., 2009. Anticipatory reconfiguration elicited by fully

and partially informative cues that validly predict a switch in task.

Cogn Afiect Behav Neurosci 9 (2), 202{15, karayanidis, Frini Mansfield,

Elise L Galloway, Kasey L Smith, Janette L Provost, Alexander Heathcote,

Andrew Cogn Afiect Behav Neurosci. 2009 Jun;9(2):202-15. doi:

10.3758/CABN.9.2.202.

Luu, P., Tucker, D. M., Makeig, S., 2004. Frontal midline theta and the errorrelated

negativity: neurophysiological mechanisms of action regulation.

Clin Neurophysiol 115 (8), 1821{35.

Mansfield, E. L., Karayanidis, F., Cohen, M. X., 2012. Switch-related and

general preparation processes in task-switching: evidence from multivariate

pattern classification of eeg data. J Neurosci 32 (50), 18253{8, mans-

field, Elise L Karayanidis, Frini Cohen, Michael X J Neurosci. 2012 Dec

12;32(50):18253-8. doi: 10.1523/JNEUROSCI.0737-12.2012.

Maris, E., Womelsdorf, T., Desimone, R., Fries, P., 2013. Rhythmic neuronal

synchronization in visual cortex entails spatial phase relation diversity

that is modulated by stimulation and attention. Neuroimage 74, 99{116.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter,

A., Wager, T. D., 2000. The unity and diversity of executive functions

and their contributions to complex "frontal lobe" tasks: a latent variable

analysis. Cogn Psychol 41 (1), 49{100, miyake, A Friedman, N P

12

Emerson, M J Witzki, A H Howerter, A Wager, T D Cogn Psychol. 2000

Aug;41(1):49-100.

Moore, R. A., Gale, A., Morris, P. H., Forrester, D., 2006. Theta phase

locking across the neocortex re

ects cortico-hippocampal recursive communication

during goal con

ict resolution. Int J Psychophysiol 60 (3),

260{73, moore, Roger A Gale, Anthony Morris, Paul H Forrester, Dave

Netherlands Int J Psychophysiol. 2006 Jun;60(3):260-73. Epub 2005 Sep

15.

Moore, R. A., Mills, M., Marshman, P., Corr, P. J., 2012. Behavioural

inhibition system (bis) sensitivity difierentiates eeg theta responses during

goal con

ict in a continuous monitoring task. Int J Psychophysiol

85 (2), 135{44, moore, Roger A Mills, Matthew Marshman, Paul Corr,

Philip J Netherlands Int J Psychophysiol. 2012 Aug;85(2):135-44. doi:

10.1016/j.ijpsycho.2012.06.006. Epub 2012 Jun 23.

Nolte, G., Wheaton, O., Vorbach, S., Hallet, M., 2004. Identifying true brain

interaction from eeg data using the imaginary part of coherency. Clinical

Neurophysiology 115, 2292/2307.

Oostenveld, R., Fries, P., Maris, E., Schofielen, J. M., 2011. Fieldtrip: Open

source software for advanced analysis of meg, eeg, and invasive electrophysiological

data. Comput Intell Neurosci 2011, 156869, oostenveld,

Robert Fries, Pascal Maris, Eric Schofielen, Jan-Mathijs Comput Intell

Neurosci. 2011;2011:156869. doi: 10.1155/2011/156869. Epub 2010 Dec

23.

Palva, J. M., Palva, S., Kaila, K., 2005. Phase synchrony among neuronal

oscillations in the human cortex. J Neurosci 25 (15), 3962{72, palva, J

Matias Palva, Satu Kaila, Kai J Neurosci. 2005 Apr 13;25(15):3962-72.

Papenberg, G., Hammerer, D., Muller, V., Lindenberger, U., Li, S. C., 2013.

Lower theta inter-trial phase coherence during performance monitoring is

related to higher reaction time variability: A lifespan study. Neuroimage

83, 912{20, papenberg, Goran Hammerer, Dorothea Muller, Viktor

Lindenberger, Ulman Li, Shu-Chen Neuroimage. 2013 Dec;83:912-20. doi:

10.1016/j.neuroimage.2013.07.032. Epub 2013 Jul 19.

Pesonen, M., Hamalainen, H., Krause, C. M., 2007. Brain oscillatory 4-30

hz responses during a visual n-back memory task with varying memory

load. Brain Res 1138, 171{7, pesonen, Mirka Hamalainen, Heikki Krause,

13

Christina M Netherlands Brain Res. 2007 Mar 23;1138:171-7. Epub 2007

Jan 4.

Sauseng, P., Klimesch, W., Freunberger, R., Pecherstorfer, T., Hanslmayr,

S., Doppelmayr, M., 2006. Relevance of eeg alpha and theta oscillations

during task switching. Exp Brain Res 170 (3), 295{301, sauseng,

P Klimesch, W Freunberger, R Pecherstorfer, T Hanslmayr, S Doppelmayr,

M P 16849-B02/Austrian Science Fund FWF/Austria Germany

Exp Brain Res. 2006 Apr;170(3):295-301. Epub 2005 Nov 30.

Sauseng, P., Klimesch, W., Schabus, M., Doppelmayr, M., 2005. Frontoparietal

eeg coherence in theta and upper alpha re

ect central executive

functions of working memory. Int J Psychophysiol 57 (2), 97{103, sauseng,

Paul Klimesch, Wolfgang Schabus, Manuel Doppelmayr, Michael P 16849-

B02/Austrian Science Fund FWF/Austria Netherlands Int J Psychophysiol.

2005 Aug;57(2):97-103.

Seeley, W. W., Menon, V., Schatzberg, A. F., Keller, J., Glover, G. H.,

Kenna, H., Reiss, A. L., Greicius, M. D., 2007. Dissociable intrinsic connectivity

networks for salience processing and executive control. J Neurosci

27 (9), 2349{56.

Serrien, D. J., Pogosyan, A. H., Cassidy, M. J., Brown, P., 2004. Anticipatory

cortico-cortical interactions: switching the task configuration

between efiectors. Exp Brain Res 154 (3), 359{67, serrien, Deborah J

Pogosyan, Alek H Cassidy, Michael J Brown, Peter Germany Exp Brain

Res. 2004 Feb;154(3):359-67. Epub 2003 Nov 15.

Tallet, J., Barral, J., Hauert, C. A., 2009. Electro-cortical correlates of motor

inhibition: a comparison between selective and non-selective stop

tasks. Brain Res 1284, 68{76, tallet, Jessica Barral, Jerome Hauert,

Claude-Alain Netherlands Brain Res. 2009 Aug 11;1284:68-76. doi:

10.1016/j.brainres.2009.05.058. Epub 2009 Jun 2.

Trujillo, L. T., Allen, J. J., 2007. Theta eeg dynamics of the error-related

negativity. Clin Neurophysiol 118 (3), 645{68, trujillo, Logan T Allen,

John J B Netherlands Clin Neurophysiol. 2007 Mar;118(3):645-68. Epub

2007 Jan 16.

Vincent, J. L., Kahn, I., Snyder, A. Z., Raichle, M. E., Buckner, R. L.,

2008. Evidence for a frontoparietal control system revealed by intrinsic

functional connectivity. J Neurophysiol 100 (6), 3328{3342.

14

Womelsdorf, T., Fries, P., 2006. Neuronal coherence during selective attentional

processing and sensory-motor integration. J Physiol Paris 100 (4),

182{93, womelsdorf, Thilo Fries, Pascal France J Physiol Paris. 2006

Oct;100(4):182-93. Epub 2007 Jan 17.

Wu, X., Chen, X., Li, Z., Han, S., Zhang, D., 2007. Binding of verbal and

spatial information in human working memory involves large-scale neural

synchronization at theta frequency. Neuroimage 35 (4), 1654{62, wu, Xiang

Chen, Xiangchuan Li, Zhihao Han, Shihui Zhang, Daren Neuroimage.

2007 May 1;35(4):1654-62. Epub 2007 Feb 15.

15