a spatial working memory (SWM) task. About 80% of schizophrenia patients show profound deficits in SWM. We were able to facilitate SWM by manipulating the target type without changing the task itself. In 80% of the trials, we presented a black circle as the target. In remaining trials, we presented unusual stimuli (e.g., Korean letters or faces) and found that accuracy of schizophrenia patients on SWM was increased in these trials: Schizophrenia subjects benefited from the contextual information embedded within the target (Lee & Park 2002a; Park et al. 2000). Schizophrenic subjects are also sensitive to the perceptual context surrounding the target.

We asked subjects to remember a random configuration of spatial locations, one of which was probed with a cue after a short delay. Performance on this task is best when the global spatial configuration of the display is preserved from the encoding to retrieval stages. Schizophrenic subjects were just as sensitive to global spatial configurations as controls. These results indicate that, at least in SWM tasks, schizophrenics may exhibit intact perceptual grouping and normal contextual processing (Lee et al. 2003a).

Cognitive context. We found that by manipulating the salience of the target to maximize the role of stimulus-driven attention at the encoding stage, we could improve AX-CPT performance in schizophrenic patients. The working memory component within the AX-CPT was manipulated by varying the interstimulus interval (ISI). Salient cue (e.g., red A) improved the performance of schizophrenia patients in AX-CPT with long ISI, relative to normal controls, but not in AX-CPT with short ISI. In other words, strengthening the context without changing the meaning of the target improved AX-CPT performance in schizophrenia. (Lee & Park 2002b).

Socio-affective context. Our data show that SWM deficits in schizophrenic subjects can be ameliorated by manipulating socio-affective input. For example, giving positive feedback in a social context improved SWM in schizophrenic patients. SWM was also facilitated by introducing direct social interaction context prior to the memory task (Park et al. 2000).

When context is "uncoordinated." While coordination allows a conventional cognitive trajectory, lack of it may be the key to creative output. Thought disorder, which is the hallmark of disorganized syndrome, may be viewed as a creative, unconventional way of using language; however, there is little empirical evidence for the speculative relationship between creativity and madness (Prentky 1979). The concept of cognitive coordination gives us a framework for deriving concrete methodology and for explaining the relationship. Unconventional solutions may occur when coordination is fragmented or randomized, or during periods of intuition when the initial context has been temporally and semantically removed from the stimulus event (Bowers et al. 1990). The facilitation of creativity in "pathological" states may result from an inherent loosening or associative elimination of contextual relationships. Here lies a potential empirical link between madness and creativity.

In sum, we laud the target article for bringing the concepts of cognitive coordination and context into a sharp focus and thereby generating specific, testable hypotheses. Once one delves into multiple levels of context, it is possible to find pockets of intact context processing in schizophrenia. The challenge is in coordinating these performance profiles across multiple levels of context to derive a coherent model of the disorder.

Inferring contextual field interactions from scalp EEG

Mark E. Pflieger
Source Signal Imaging, Inc., San Diego, CA 92102.
mep@sourcesignal.com

Abstract: This commentary highlights methods for using scalp EEG to make inferences about contextual field interactions, which, in view of the target article, may be specially relevant to the study of schizophrenia. Although scalp EEG has limited spatial resolution, prior knowledge combined with experimental manipulations may be used to strengthen inferences about underlying brain processes. Both spatial and temporal context are discussed within the framework of nonlinear interactions. Finally, results from a visual contour integration EEG pilot study are summarized in view of a hypothesis that relates receptive field and contextual field processing to evoked and induced activity, respectively.

Phillips & Silverstein (P&S) propose that diverse impairments associated with schizophrenia may be traced to disruptions in some basic mechanisms of intraregional and interregional cortical coordination. In particular, the idealized distinction between receptive field (RF) and contextual field (CF) connections (Phillips & Singer 1997a) may be useful, considering that CF connections function principally to coordinate multiple RF modules that process signals bearing primary content. Under the headings of "cortical rhythms" and "issues arising," P&S review some relevant EEG studies, and project that EEG techniques are poised to play a role for imaging fast neuroelectric activity that reflects cognitive coordination and its impairments. This commentary discusses further considerations that arise in this context.

The RF/CF model distinguishes activity within and between cortical columns and cortical layers (see Fig. 2 of the target article). However, scalp EEG potentials (and MEG fields) are generated at each temporal instant by the net summation (weighted by sensor sensitivities) of macroscopic currents oriented throughout the gray matter volume: Currents within layers or columns cannot be distinguished directly. On the other hand, experimental manipulations combined with prior knowledge may enable some inferences about the activity of layers or columns. For example, knowledge gained from invasive studies about the local effects and mechanisms of neuromodulators (e.g., al-Amin & Schwarzkopf 1996), particularly experiments that measure stimulus-related cortical current source density profiles as modulated by local neurochemical infusions (e.g., Javitt et al. 1996), could be combined with systemic neuropharmacological manipulations in humans (e.g. Duncan et al. 2001; Pekkone et al. 2002; van Berckel et al. 1998) to enable qualified inferences from scalp potentials about the relative contributions of activity in different cortical layers.

Potentials produced by simultaneous disjoint generators in the brain sum linearly at the scalp – a fact which enables inferences about spatial interactions in cortex based on observations of spatial nonlinearities of evoked potential responses at the scalp. If the evoked response to stimuli *A* and *B* presented simultaneously differs from the sum of responses to *A* and *B* presented separately, then the brain regions that process *A* and *B* interact. A prime example of this logic for making inferences about CF interactions based on scalp potential measurements is provided by the psychophysics-based VEP studies of Polat and colleagues (Polat & Norcia 1996; Polat et al. 1997). Similarly, a study recently reported by Kim et al. (2002) used nonlinear interactions of partially contrast-reversing windmill-dartboard stimuli to infer that "significantly greater short-range lateral interactions and significantly less long-range lateral interactions were found in patients with schizophrenia compared to controls."

An analogous logic may be used to infer temporal interactions based on observations of temporal nonlinearities. For example, the P50 suppression effect (Boutros et al. 1995; Clementz et al. 1997) is a temporal nonlinearity whereby an auditory evoked component at about 50 msec post-stimulus is modified by the precedence (within about 500 msec) of an identical click stimulus. In other words, the brain system generating the evoked response is not linearly characterized by the response to a single stimulus: Temporal context affects the evoked response to primary stimulus information. Mismatch negativity (MMN) is another temporal context effect: Auditory cortex responds differently to the same physical stimulus as a function of its frequency or infrequency of occurrence relative to a physically different stimulus. Although both P50 and MMN may be altered in schizophrenia, MMN depends crucially on NMDA-receptors (Javitt et al. 1996), whereas P50 suppression possibly may not (van Berckel et al. 1998).

Phillips & Pflieger (2000) hypothesized that evoked EEG responses, which are phase-locked to the stimulus, reflect RF processing; whereas induced EEG responses, which are event-related but not phase-locked to the stimulus, reflect CF processing. Grounds for thinking that this may approximately hold, are: (a) phase-locking to the stimulus naturally suggests external event-driven processing; and (b) non-phase-locking with respect to the stimulus may reflect ongoing cortical coordinating activity with intrinsic timing. We devised a high-density EEG pilot study (unpublished) that used complex visual contour integration stimuli consisting of many small Gabor patches (Field et al. 1993), as specially modified by George Lovell (see his submitted doctoral thesis [Lovell 2002]). Pairs of stimuli were presented simultaneously to the right and left visual fields. One stimulus consisted of structured sets of Gabor patches with perceived contours embedded in a background of randomly oriented patches. The second stimulus consisted of the same configuration with 40-degree random jittering of patch orientations (which obliterated perceived contours). The subject's task was to detect "structure right" or "structure left." Average reaction times were about 400 msec with nearly 100% accuracy. Between-condition differences for the broadband average event-related potentials (about 275 epochs per condition) were subtle at best for all scalp locations up to about 250 msec. Evoked and induced responses were calculated using the method of complex demodulation for the following symmetric bands: 10 Hz ± 5 Hz, 20 Hz ± 10 Hz, 30 Hz ± 15 Hz, and 40 Hz ± 20 Hz. A nonparametric permutation procedure was used to convert all differences to uncorrected *p*-value waveforms, with low values (close to 0) indicating left>right visual field differences, and high values (close to 1) indicating right>left visual field differences. Significant induced and evoked 40 Hz differences were observed: Right>left at left para-occipital locations at about 32 msec (induced) and 34 msec (evoked), and left>right at right para-occipital locations at about 76 msec (induced) and 58 msec (evoked). Similar induced, but not evoked, 30 Hz response differences were observed. No induced 20 Hz or 10 Hz differences attained significance, nor did the evoked 20 Hz differences. Evoked 10 Hz differences were about 36 msec for right>left (left para-occipital) and about 26 msec for left>right (right para-occipital). Therefore, both induced and evoked differences were found at the expected sides, with generally slower latencies for structure on the left.

By definition, these subtle differences reflect contextual field processing. Because evoked differences sometimes precede induced differences, this single subject pilot study does not support our hypothesis. However, the finding of relatively early 40 Hz band differences may be meaningful in the context of P&S.

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NMDA synapses can bias competition between object representations and mediate attentional selection

Antonino Raffone[a], Jaap M. J. Murre[b], and Gezinus Wolters[c]

[a]Department of Psychology, University of Sunderland, St. Peter's Campus, SR6 0DD Sunderland, United Kingdom; [b]Department of Psychology, University of Amsterdam, 1018 WB Amsterdam, and University of Maastricht, The Netherlands; [c]Department of Psychology, Leiden University, 2300 RB Leiden, The Netherlands. **antonino.raffone@sunderland.ac.uk** **jaap@murre.com** **wolters@fsw.leidenuniv.nl**

Abstract: Phillips & Silverstein emphasize the gain-control properties of NMDA synapses in cognitive coordination. We endorse their view and suggest that NMDA synapses play a crucial role in biased attentional competition and (visual) working memory. Our simulations show that NMDA synapses can control the storage rate of visual objects. We discuss specific predictions of our model about cognitive effects of NMDA-antagonists and schizophrenia.

Phillips & Silverstein's (P&S's) target article is a major step in the development of a coherent theoretical framework for understanding how spatially distributed brain activity is coordinated or integrated in normal function, and how this coordination may be impaired in schizophrenia. Their perspective reconciles localist and holist approaches to brain function into a dialectic functional scheme, in which invariant local (modular) processing operations or neural representations are flexibly integrated into larger context- or task-dependent processing or representational units.

We endorse P&S's view on the crucial role of NMDA synapses in cognitive coordination and control, based on their amplifying voltage-dependent properties. Specifically, the gain-control properties of NMDA synapses on ongoing processing discussed in the target article may be plausibly involved in selective encoding and maintenance of task-relevant information in cortical networks of (visual) working memory.

In our neurocomputational approach to maintenance and control in visual working memory (Raffone & Wolters 2001; Raffone et al. 2001), the neural representations of features and objects are kept active after stimulus-offset by feedback connections from prefrontal cortex to posterior cortical areas. In this model, object features are integrated by synchronizing connections (*within-chunk integration*), and different objects are segregated by fast mutual inhibition (*between-pattern segregation*). The storage capacity reflects the equilibrium point between these two neural representational forces. In a current study (Raffone et al., in preparation), cortical feedback, within-chunk integration, and between-pattern segregation are combined with NMDA synapses. In this commentary we will outline how NMDA synapses can play a crucial role in *biased attentional competition* (Desimone & Duncan 1995) between neural representations of objects, and discuss specific implications and predictions from our model consistent with P&S's general perspective.

Competition between object representations is a fundamental aspect in many theories of visual attention. For instance, in Bundesen's (1990) Theory of Visual Attention (TVA), the units of visual representation are parallel categorizations of visual elements in limited-capacity visual short-term memory. These categorizations compete in terms of parallel processing speed (affecting the storage probability), which depends on the relative *attentional weight* of visual elements. Theories of attention often refer to the concept of *biased competition* principle between object representations (Desimone & Duncan 1995). According to the biased competition model, the attentional weights (saliency or priority values) of different objects (saliency or priority values) are correlated with selectively biased firing rates of associated competing neural representations in the visual cortex.

It is generally assumed that attentional weights are encoded in terms of firing rate modulation by top-down cortical feedback, plausibly from prefrontal cortex. NMDA synapses, because of their voltage-dependent properties, can implement a gain mechanism in which bottom-up signals are selectively amplified, de-