Schizophrenia: Putting context in context

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Abstract: Although context-processing deficits may be core features of schizophrenia, *context* remains a poorly defined concept. To test Phillips & Silverstein's model, we need to operationalize context more precisely. We offer several useful ways of framing context and discuss enhancing or facilitating schizophrenic patients' performance under different contextual situations. Furthermore, creativity may be a byproduct of cognitive uncoordination.

Current neurobiological theories of schizophrenia mirror the dominant, localizationistic trends in neuroscience. Yet, after decades of "lobe-trotting" under intense scrutiny, no single region has emerged as the clear culprit. Similarly, psychological models tend to favor omnipotent single mechanisms (e.g., context processing, working memory, inhibitory control, sensory gating, etc.) to explain a bewildering range of symptoms that characterize schizophrenia. Alas, the glass slipper does not fit.

Reasonable theories of schizophrenia must address multiple cortical and subcortical interactions that can explain a wide range of symptoms under different conditions. Phillips & Silverstein's (P&S's) hypothesis that the disorganized syndrome is the clinical manifestation of deficits in cognitive coordination caused by NMDA-hypoactivity is a great leap forward in demystifying the heterogeneity of schizophrenia. One major contribution of the target article is a stimulating and thoughtful discussion of the concept of *context.* Although context-processing deficit has been proposed to be a core feature of schizophrenia (Cohen & Servan-Schreiber 1992), it is not entirely clear what is included or excluded in this *context.* Extending the definitions of context presented in the target article, we will discuss several ways of framing context (see Fig. 1) and examine the hypothesis that context processing is impaired in schizophrenia.

Perceptual context. Focusing on the role of the attended versus unattended features (or stimuli) against the background is helpful in understanding the relationship between the selected target (or feature) and the background (or context). Context can, but does not necessarily, influence target processing.

1. Context represented within the target stimulus. A stimulus consists of multiple dimensions and features. If the task is to process one feature of the target (e.g., color), other unattended features provide the contextual environment (e.g., location, identity, size, speed, etc.). The same is true with auditory stimuli.

2. Context surrounding the target stimulus. The layout (whether visual or auditory) around the target provides contextual information and may influence the processing of the target. (e.g., perceptual grouping). Context can also influence the target processing across modalities.

3. Temporal relationship between the target event and the contextual background. The interval between the target onset and the contextual element may determine the extent of interaction. For example, lexical disambiguation depends on the temporal proximity between the target and the context. In associative conditioning, temporal contiguity is crucial.

Cognitive context. *1. Long-term memory, skills, and habits provide the context.* There is an "influence of stored memories of regularities of previous input on current perception" (Gray et al. 1991). The contextual influence can be direct, explicit, and aware or indirect, implicit, and subconscious. For example, in a semantic priming task, experiences and associations play a key role in determining the speed of lexical decision. The Kamin blocking effect and latent inhibition also depend on the context.

2. Task-relevant information in working memory is identified as providing context (Cohen & Servan-Schreiber 1992). For example, in a AX-type Continuous Performance Task (AX-CPT) task, subjects must respond to an *X* only if it follows an *A.* In the Stroop task, the correct response depends on the inhibition of overlearned relationship in context.

Socio-affective context. A more global context is set by the affective state of the individual. The target article is focused on cognitive coordination, but affect is likely to influence all levels of perceptual and cognitive processing. Moreover, NMDA-hypoactivity or PCP-psychosis is accompanied by changes in affect. Positive affect alters a wide range of cognitive processes via moderately increasing dopaminergic action (Ashby et al.1999). Different affective states can either facilitate or reduce prefrontal functions (Gray et al. 2002).

Do schizophrenia patients have deficits in context processing? Deficits in context-processing are central to major theories of schizophrenia, but data from our laboratory suggest that context processing may depend on the context.

Perceptual context. We found that schizophrenia patients are sensitive to the context represented within the target stimulus in



Figure 1 (Park et al.).

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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

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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

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