

## Perceptual grouping in disorganized schizophrenia<sup>☆</sup>

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### Abstract

This study evaluated visual perceptual grouping in schizophrenia to test the hypothesis that the disorganization syndrome in schizophrenia is related to a deficit in cognitive coordination. Perceptual grouping was examined with three psychophysically well-controlled tasks in patients with disorganized schizophrenia ( $n=11$ ), non-disorganized schizophrenia ( $n=24$ ), psychotic disorders other than schizophrenia ( $n=31$ ) and non-psychotic psychiatric disorders ( $n=35$ ). These measures assessed processing of both concurrent and preceding stimulus context. Deficits in perceptual grouping were observed on all three tasks in disorganized schizophrenia patients. Dysfunctional perceptual grouping mechanisms produced both enhanced and impaired task performance suggesting that the pattern of performance observed was the result of a specific deficit in the grouping of stimulus elements. We interpret these data as further support for the hypothesis that the disorganization syndrome in schizophrenia reflects a widespread deficit in the cognitive coordination of contextually related stimuli, leading to dysfunctional grouping of stimulus features in vision, thought and language.

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### 1. Introduction

Earlier work tried to account for cognitive deficits in schizophrenia by postulating a localized structural or

biochemical abnormality. Recent models of cognition (Andreasen, 1999; Friston, 1999; Parnas et al., 1998), however, have laid emphasis upon pathophysiological mechanisms which involve multiple cortical areas and their coordination. Phillips and Silverstein (2003), for example, have proposed that diverse cognitive dysfunctions may be related to dysfunctional coordination of the neural activity associated with contextually related stimuli, and that this underlies the phenomenological disorganization of mental processes in schizophrenia. Coordinating processes are defined as those that modulate neural activity by changing the timing and salience of feed-forward neuronal signals without changing what

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they mean (e.g., what sensory features are coded). At the cognitive level, coordinating processes are thought to be involved in contextual interactions, selective attention and dynamic (perceptual) grouping in cognition (Phillips and Singer, 1997). At the neural level, *N*-methyl-D-aspartate (NMDA) receptor functioning and synchronized correlated activity within the gamma frequency band (30–80 Hz) have been proposed to be the basis of coordinating interactions, and both have been found to be abnormal in schizophrenia (see Lee et al., 2003, for a review; Olney and Farber, 1995).

Grouping of stimulus elements into coherent object representations according to Gestalt principles is a paradigmatic example of coordinating processes as demonstrated by the fact that the surrounding visual context determines which features are grouped together to define emergent object representations while the stimulus elements remain basically the same. As emphasized early on by the Gestalt theorists, perceptual grouping is not confined to visual perception, but occurs in other sensory domains as well, and characterizes memory, language and affect (Koehler, 1929). More recent research supports this view by demonstrating that principles of perceptual grouping also apply to other domains of cognition, such as working memory, episodic memory, the formation of linguistic representations, and problem solving (Chechile et al., 1996; Glezer, 1995; Phillips and Silverstein, 2003; Stoet and Hommel, 1999; Waters et al., 2004).

Despite extensive research on perceptual grouping in schizophrenia the studies carried out so far have produced conflicting evidence regarding the nature, extent, mechanisms and clinical correlates of dysfunctional perceptual grouping in schizophrenia (reviewed in Uhlhaas and Silverstein, 2005). There is evidence to suggest, for example, that deficits in perceptual grouping in schizophrenia patients vary as a function of the degree to which organization must be actively imposed on the stimuli (and conversely, the degree to which the stimuli contain prepotent cues to grouping). Thus, processing of stimulus elements with fewer configural properties and where perceptual groups are determined by past experience, current context and other top-down factors are impaired in schizophrenia (Knight and Silverstein, 1998; Place and Gilmore, 1980; Silverstein and Phillips, 2003, Silverstein et al., 1998a, 2000). Conversely, processing of stimuli with prepotent structure and other stimuli with strong configural properties (e.g., configural stimuli without continuous contours) is intact (Chey and Holman, 1997; Knight et al., 2001; Silverstein et al., 1998b).

Deficits in perceptual grouping in schizophrenia have involved a number of principles of perceptual

organization, including closure (Buchanan et al., 1994; Snyder, 1961; Doniger et al., 2001), proximity (Silverstein et al., 1996a), prägnanz (Silverstein et al., 1998a, 2000, in press-a) and figure-ground perception (Liddle, 1987). These deficits are not an epiphenomenon of antipsychotic medication since dysfunctions in perceptual grouping have been demonstrated in neuroleptic naïve patients (Frith et al., 1983; Snyder, 1961) and there is no relationship between level of depot medication and performance on perceptual grouping tasks in schizophrenia patients (Knight, 1992).

Dysfunctions in perceptual grouping in schizophrenia may be related to the physiology and anatomy of visual processing in the human brain. Theoretical and empirical data indicate that synchronized correlated activity within the gamma frequency band (30–80 Hz) may serve as a temporal code for coherent object representations (von der Marlsburg and Schneider, 1986; Singer and Gray, 1995; Singer, 1999). Probability and strength of synchronization, for example, reflect elementary Gestalt criteria for perceptual grouping, such as proximity, collinearity and common fate (Singer, 1999). There is evidence to suggest that schizophrenia may be characterized by abnormalities in gamma frequency oscillations, and that dysfunctional perceptual organization in schizophrenia is related to these abnormalities (Spencer et al., 2003). Anatomically, visual processing involves two distinct but complementary and somewhat overlapping processing pathways of visual information in the brain. One is the *dorsal* processing stream which extends from visual areas in the occipital lobe though to the parietal lobe. This pathway is sensitive to onset and offset of stimuli and to motion cues. In contrast, the *ventral* visual pathway, which extends from early visual cortical areas to the infero-temporal cortex, is involved in stimulus identification processes, and is involved in the processing of detail, form, and color (Creem and Proffitt, 2001). The role of perceptual grouping in object recognition suggests the primary involvement of the ventral pathway and recent fMRI evidence suggests that this so (Altmann et al., 2003).

Although the large majority of findings suggest that schizophrenia patients are characterized by deficits in perceptual grouping, Parnas et al. (2001) found that prodromal patients displayed enhanced grouping abilities. In addition, perceptual grouping deficits have not been observed in high-risk individuals identified using psychometric (Silverstein et al., 1992) or close-in (Silverstein et al., in press-b) strategies, or among first-episode patients (Silverstein et al., 2004). Rather, impaired perceptual grouping has been linked to more

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