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Event-related potentials to auditory and visual selective attention in schizophrenia

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Abstract

Background: Prior studies have shown a consistent reduction of the auditory P300 in schizophrenia, while the visual attention findings have been mixed. Both the auditory and visual N2b, an earlier, modality-specific attention index, are reduced in schizophrenia, sometimes despite sparing of the visual P300. Thus there may be a dissociation between the N2b and P300 attention effects in auditory and visual modalities in schizophrenia.
Methods: Thirteen patients and thirteen controls observed symbols appearing on a screen, paired with simultaneous tones. In some blocks subjects responded to one of the symbols, in others to one of the tones. The N2b was predicted to be reduced in the patient group in both auditory and visual attention but the P300 reduced only while attending to tones.
Results: Results showed a reduction of the N1 component in the patient group in the auditory condition but not in the visual. There was a reduction of the N2b target-minus-non-target difference wave in the patients in both auditory and visual target conditions. The P300 component was larger overall in the control group in both modalities, but did not show the usual enhancement to auditory targets in the control group.
Conclusions: These findings suggest that the ability to selectively attend to a target in one modality while ignoring the other is compromised in patients with schizophrenia. Perceptual processing appears to be impacted in the auditory modality while remaining intact in the visual. The N2b appears more vulnerable than the P300 in both auditory and visual attention in schizophrenia.

Keywords: Schizophrenia; Event-related potentials; Auditory attention; Visual attention; Bimodal stimuli

1. Introduction

Event-related potentials (ERPs) have been used extensively to study the disruption of neural systems of attention in patients with schizophrenia. One consistent finding is an amplitude reduction of the auditory P300 component (for a review see Ford, 1999). This reduction is often reported as larger over left, compared to right, temporal leads, and has been associated with reduction in the volume of the left superior temporal gyrus (see McCarley et al., 1993, 1997). The P300 is a large centroparietal positivity that is larger to infrequent stimuli, particularly when those rare stimuli are task-relevant, and serves as a general-purpose index of

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attention function (for a review see Donchin and Coles, 1988). There are earlier, primarily negative ERP components, which are also sensitive to aspects of attention, including the N1, mismatch negativity (MMN), and N2 (Naatanen, 1992). The auditory N1 has been reported reduced in schizophrenia (Ford et al., 2001), as have the MMN (Hirayasu et al., 1998; Oades et al., 1997) and the N2 (O'Donnell et al., 1993; Salisbury et al., 1994; Potts et al., 1998). Given that all these components are reduced in the patients, one interpretation is that there is a general reduction in ERP amplitude in schizophrenia, indicating a global decrement in information processing. However, there is evidence that the P300 reduction in schizophrenia may be dissociable from the earlier negative components (Kayser et al., 2001).

The majority of studies reporting attention-related ERP effects in schizophrenia have used the auditory oddball task, in which rare, sometimes task-relevant tones are interspersed into a stream of frequent irrelevant tones. The visual version of the task replaces the tones with visually presented letters, number, or other items. Similar attention effects are seen on the N2b and P300 components in the auditory and visual versions, with enhanced amplitude to the rare, task-relevant items (e.g. Courchesne et al., 1975; Potts et al., 1996), although a visual analog of the MMN is less consistently reported. Schizophrenic patients have shown reduction of both the N1 and N2b in a visual-spatial attention task (Bruder et al., 1998), however the visual P300 is sometimes unaffected by schizophrenia (Ford, 1999). A recent visual object/spatial selective attention task study found both visual object and visual spatial attention target effects on the N2b and P300, but showed that while the N2b was reduced in schizophrenic patients in both attention to visual feature and attention to visual location, the P300 was of normal amplitude in the patients in both feature and location attention (Potts et al., 2002).

The above findings suggest a differential impact of schizophrenia on auditory and visual attention, as indicated by the ERP, specifically a reduction of both the auditory and visual N2b but only of the auditory P300 in the patients. The ERP components index different stages in information processing, with the early components (e.g. P1 and N1) primarily indexing raw perceptual processing, the negativities between approximately 150–300 ms indexing attention-specific operations like novelty detection (MMN), orienting (N1), and stimulus classification (N2), and the late positivity (P300) indexing more complex cognitive operations like working memory/context updating (Donchin and Coles, 1988). It is unclear if the differential findings in schizophrenia in auditory and visual tasks represent impaired auditory perception in schizophrenia, with secondary attention effects, or a differential impact of schizophrenia on later stages of auditory attention. Previous studies have used different stimuli, different experimental designs, and different patient groups to study the auditory and visual ERP effects, making direct comparisons difficult. The current study investigated attention disruption in schizophrenia using an audio-visual selective attention task in which visual and auditory stimuli were simultaneously presented, and subjects responded to targets in one modality at a time. This design held the perceptual demands and participants constant, modulating only the attentional demands of the task from one stimulus modality to the other, and examined the N1, N2b, and P300 components. If patients with schizophrenia have global deficits in information processing, then all three components should be reduced in both the auditory and visual tasks, however if the deficits are confined to some stages of information processing and/or more severe in one modality (i.e. auditory), then there should be a dissociation between the component reductions depending on the attended modality.

2. Methods

2.1. Participants

Thirteen medicated male patients between the ages of 44 and 67 were recruited from an outpatient treatment group at the Michael E. DeBakey Veteran's Administration Medical Center in Houston, Texas (the VA schizophrenic population is 98% male). The patients were evaluated using the Structured Clinical Interview for DSM-IV (SCID-P) (First et al., 2001a,b), and met diagnostic criteria for schizophrenia or schizoaffective disorder based on DSM-IV, supplemented by chart and record information. The patients' symptoms were also evaluated using the Structured Clinical Interview for the Positive and Negative Symptom Scale (SCI-PANSS) (Kay et al., 1987). Each patient's subtype diagnosis, daily medication (with chlorpromazine equivalents) and relevant clinical symptom information are provided in Table 1.

Volunteer control subjects ($n=13$) between the ages of 34 and 65 were recruited from newspaper ads in local papers in Houston, Texas. Control subjects were evaluated using the Structured Clinical Interview for the DSM-IV-Non-Patient Version (SCID-NP) (First et al., 2001a,b). Subjects in both groups were screened for neurological insult or illness, electro-convulsive shock therapy, alcohol or drug abuse in the last 5 years or lifetime history of addiction, and alcohol use 24 h prior to testing, with the addition of no Axis I disorders for the control participants. All subjects exhibited a desire to participate as evidenced by giving their written informed consent. Participants were tested for handedness using the Edinburgh Handedness Test (Oldfield, 1971) and rated for parental socio-economic status using an average between the parents' scores on the categories of the Hollingshead Two-Factor Index of Social Position (Hollingshead, 1957). There were no significant differences between the groups for age, handedness or parental socio-economic status (see Table 2).