PSYCHIATRY RESEARCH

Psychiatry Research 96 (2000) 99–115

www.elsevier.com/locate/psychres

Auditory sensory memory in schizophrenia: inadequate trace formation?

Juanita Todd[a,b,c,*], Patricia T. Michie[a,b,c], T. William Budd[a], Danny Rock[c], Assen V. Jablensky[b,c]

[a]*Department of Psychology, University of Western Australia, Nedlands, Perth, Western Australia, 6907, Australia*
[b]*Department of Psychiatry and Behavioural Sciences, University of Western Australia, Nedlands, Perth, Western Australia, 6907, Australia*
[c]*Centre for Clinical Research in Neuropsychiatry, University of Western Australia, Private Mail Bag No. 1, Claremont, Western Australia, 6010, Australia*

Received 28 December 1999; received in revised form 6 July 2000; accepted 1 August 2000

Abstract

This study explored duration mismatch negativity reductions observed in individuals with schizophrenia, in particular, the relationship to behavioural measures of temporal discrimination and two event-related potential (ERP) components occurring during the first phase of auditory sensory memory. Twenty-two patients with a DSM-IV and ICD-10 diagnosis of schizophrenia and 25 healthy comparison volunteers participated in a behavioural and an ERP testing session. Both groups performed equivalently on behavioural estimates of filled interval duration discrimination and gap detection. In contrast, electrophysiological measures revealed a significant reduction in patients' duration mismatch negativity and a significant difference in patients for the pattern of N100 facilitation over short stimulus onset asynchronies. Whilst behavioural results indicate intact temporal processing of filled intervals and equal temporal resolution limits in schizophrenia, both ERP measures indicated differences in auditory processing that may be traced to activity occurring during the first 250 ms. Results highlight the possibility of abnormalities in the process of auditory trace formation and temporal summation in schizophrenia.

Keywords: Evoked potentials; Mismatch negativity; N100; Temporal summation; Loudness summation

* Corresponding author: Centre for Clinical Research in Neuropsychiatry, University of Western Australia, Private Mail Bag No. 1, Claremont, Western Australia, 6010, Australia. Tel.: +61-8-9347-6412; fax: +61-8-93845128.
E-mail address: jtodd@cyllene.uwa.edu.au (J. Todd).

PII: S0165-1781(00)00205-5

1. Introduction

This study explored perceptual and electrophysiological processes that may underlie the reduction of an event related potential (ERP) component known as mismatch negativity (MMN) in patients with a diagnosis of schizophrenia. MMN refers to additional negativity with an onset latency as short as 50 ms, peaking at approximately 150–250 ms after the occurrence of deviation from an expected sound or sound sequence (Näätänen, 1990). The MMN is elicited by an auditory stimulus when the auditory system recognises the sound as 'deviant' relative to a standard background of stimulation. The MMN is revealed by subtracting the ERP to standard tones from that to deviants. A mismatch response can occur to a change in any physical property of a repeated auditory stimulus or even higher order properties such as spectrotemporal patterns or phonemes (Näätänen et al., 1978; Aaltonen et al., 1987; Paavilainen et al., 1989; Schröger et al., 1992).

Shelley et al. (1991) were the first to provide evidence that the MMN component of the auditory ERP is reduced in schizophrenia. In this study, participants were exposed to a standard background of repeating 50-ms tones randomly interrupted by the occurrence of deviant tones of 100-ms duration. The response to the 100-ms deviant tone was significantly smaller in patients with schizophrenia than in control subjects, but there was no difference in the response to standard tones. When the response to standards was subtracted from this smaller response to deviants, the size of the resultant MMN was significantly reduced in the patient group.

Subsequent MMN studies in schizophrenia have focused mainly on mismatch responses elicited by duration or frequency changes. A significant reduction in the size of the MMN response to a frequency deviant has been observed in most (Javitt et al., 1993, 1995; Shutara et al., 1996; Oades et al., 1997; Alain et al., 1998; Hirayasu et al., 1998; Javitt et al., 1998; Kreitschmann-Andermahr et al., 1999), but not all studies (O'Donnell et al., 1994; Kathmann et al., 1995; Michie et al., 2000). All duration MMN studies employing a short standard/long deviant MMN paradigm have also observed a significant reduction in MMN amplitude in patients with schizophrenia (Shelley et al., 1991; Catts et al., 1995; Lembreghts and Timsit-Berthier, 1993; Michie et al., 2000). It would therefore appear that a reduced duration MMN to long duration deviants is a very robust finding.

To produce an adequate MMN response to stimulus deviation, the auditory system must fulfil a number of criteria. Firstly, it must establish a neural representation of the features of the standard and deviant stimuli that suitably encodes the difference between them. The more distinctive these representations or traces, the larger the MMN response. A second prerequisite is to be able to retain the trace of the standard stimulus in memory long enough to compare it to the deviant stimulus. Both of these requirements are achieved through auditory sensory memory (ASM).

Cowan (1984) reviewed the literature on behavioural studies of sensory memory and concluded that ASM comprises two phases: a short phase extending from the stimulus onset up until approximately 300 ms; and a longer phase extending from the first phase up to approximately 10 s. During the first phase of ASM, the auditory system registers that a stimulus has occurred, encodes its physical properties and integrates these to form a percept of the sound. Over the first phase of ASM, the auditory system retains unprocessed information about the stimulus that is susceptible to interference by subsequent events. For example, results from behavioural studies of auditory backward recognition masking indicate that if a second auditory stimulus is presented within approximately 250–300 ms, the auditory system may confuse the properties of the first tone with those of the second, weighted in favour of the latter (Massaro, 1972). Whilst behavioural indices of ASM function estimate the first phase to be up to 300 ms in length, subsequent electrophysiological studies (e.g. Yabe et al., 1998; Winkler et al., 1998) indicate that this phase, often referred to as the window of temporal integration, probably only extends to approximately 200 ms. During the second phase of ASM, the