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Sensory gating in adult with attention-deficit/hyperactivity disorder: Event-evoked potential and perceptual experience reports comparisons with schizophrenia

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ABSTRACT

Background: In daily life, adults with attention-deficit/hyperactivity disorder (ADHD) report abnormal perceptual experiences that can be related to sensory gating deficit. This study investigated and compared P50 suppression (a neurophysiological measure of sensory gating) and perceptual abnormalities related to sensory gating deficit in ADHD and schizophrenias patients.
Methods: Three groups were compared: 24 adults with ADHD, 24 patients with schizophrenia and 24 healthy subjects. The Sensory Gating Inventory (SGI), a validated self-report questionnaire, was used to measure perceptual abnormalities related to sensory gating deficit. P50 suppression was measured by P50 amplitude changes in a dual-click conditioning-testing auditory event-related potential procedure.
Results: Adults with ADHD had significantly higher scores on the SGI and significantly lower P50 suppression than healthy subjects. These deficits were similar to those found in patients with schizophrenia. A correlation was found between both the SGI and P50 suppression data in adults with ADHD and patients with schizophrenia.
Discussion: The findings confirm previous results found in patients with schizophrenia. Moreover, adults with ADHD, similar to patients with schizophrenia, had abnormal P50 suppression and reported being flooded with sensory stimuli. Abnormal neurophysiologic responses to repetitive stimuli gave rise to clinically abnormal perceptions.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most prevalent psychiatric disorders; the estimated prevalence ranges from 3% to 5% in adults (Caci, Morin, & Tran, 2014; Fayyad et al., 2007; Hudziak, Althoff, Derks, Faraone, & Boomsma, 2005). Inattention, hyperactivity and impulsivity are the core symptoms

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of ADHD (American Psychiatric Association, 2000). Inattention may be related to an inability to control sensitivity to sensory stimuli (Venables, 1964). Patients with ADHD report being flooded with sensory stimuli; therefore, attention and information processing may be deficient in ADHD (Biederman, 2005; Faraone et al., 2000). The attention of patients with ADHD may be involuntarily drowned by many irrelevant environmental stimuli leading to impaired attention on relevant stimuli (Olincy et al., 2000). This hypothesis can be related to a sensory gating deficit. Sensory gating is the ability to filter intrusive sensory information, which is a specific and elementary form of pre-attentive information processing (Braff & Geyer, 1990). Sensory gating may protect higher cognitive function from flooding by irrelevant sensory information (Venables, 1964). Sensory gating has been largely investigated in schizophrenia (Micoulaud Franchi, Vion Dury, & Cermolacce, 2013) but very few investigated in ADHD.

A sensory gating deficit can be assessed with auditory event-related potentials (ERP) (Freedman et al., 1987) and with a self-report questionnaire (the Sensory Gating Inventory, SGI) (Hetrick, Erickson, & Smith, 2012). Auditory ERP measure the suppression of the P50 component (a middle latency positive ERP component occurring approximately 50 ms after the onset of a brief auditory stimulus) in a dual-click *conditioning-testing* paradigm (Freedman et al., 1987). P50 suppression refers to the decrement of the P50 amplitude after the second stimulus (testing stimulus, S2) versus the P50 amplitude after the first stimulus (conditioning stimulus, S1) (Adler et al., 1982). The decrement of the P50 amplitude is considered as a neurophysiological measure of the ability to filter intrusive sensory information (Light & Braff, 2003). The SGI is composed of 36 items addressing a broad range of subjective daily perceptual experiences related to sensory gating. The psychometric properties of the SGI indicate that it provides valuable information on four dimensions of perceptual anomalies: Perceptual Modulation (PM; linked to 16 items, *e.g.*, "My hearing is so sensitive that ordinary sounds become uncomfortable"), Over-Inclusion (OI; 7 items, *e.g.*, "I notice background noises more than other people"), Distractibility (D; 8 items, *e.g.*, "There are times when I can't concentrate with even the slightest sounds going on"), and Fatigue–Stress Modulation (FS; 5 items, *e.g.*, "It seems that sounds are more intense when I'm stressed") (Hetrick et al., 2012; Micoulaud-Franchi et al., 2014b).

Many studies on schizophrenia have identified a P50 suppression deficit (Adler et al., 1982; Clementz, Geyer, & Braff, 1997). Patients with schizophrenia scored higher than healthy subjects did on the SGI and report being flooded with sensory stimuli (Micoulaud-Franchi et al., 2014a). In addition, patients with high P50 suppression deficits report the most perceptual abnormal experiences (Micoulaud-Franchi et al., 2014a). These data confirm an inability to control the sensitivity to sensory stimuli in schizophrenia (McGhie & Chapman, 1961; Venables, 1964). Thus, a sensory gating deficit can be considered a core psychophysiological deficit in schizophrenia (de Wilde, Bour, Dingemans, Koelman, & Linszen, 2007), with a relationship between abnormal neurophysiological (ERP) and clinical (SGI) features of sensory gating (Micoulaud-Franchi et al., 2014a).

Few studies investigated sensory gating deficit in adults with ADHD. Only two studies investigated P50 suppression (Holstein et al., 2013; Olincy et al., 2000). Olincy et al. (2000) were the first to investigate P50 suppression in adults with ADHD compared to healthy subjects and reported no significant differences. The authors suggested that the lack of significance may have be due to the small sample size of the their study (16 adults with ADHD) (Olincy et al., 2000). Holstein et al. (2013) investigated P50 suppression in 26 adults with ADHD and reported a significant P50 suppression deficit compared to healthy subjects. The same result was found in 22 children and adolescents with ADHD (Durukan et al., 2011). These contradictory studies highlight the need for further investigations of P50 suppression in adults with ADHD. Only one study investigated the abnormal perceptual experience of being flooded with sensory stimuli in adults with ADHD (Sable et al., 2012). Using a short version of the SGI (17 items), Sable et al. (2012) confirmed that adults with ADHD (22 subjects) reported higher scores in the SGI than healthy subjects, particularly on the Distractibility dimension. However, the short version of the SGI did not investigate the Fatigue–Stress Modulation dimension that could be important in ADHD because of the role of fatigue (Yoon, Jain, & Shapiro, 2013), stress (Purper-Ouakil, Wohl, Michel, Mouren, & Gorwood, 2004) and vigilance alterations (Hegerl & Hensch, 2014; Philip et al., 2005). Finally, to the best of our knowledge, no study investigated both P50 suppression and abnormal perceptual experiences with all 36 items of the SGI in adults with ADHD, as has been performed with patients with schizophrenia (Micoulaud-Franchi et al., 2014a). Thus, the relationships between abnormal neurophysiological (ERP) and clinical (SGI) features of sensory gating need to be investigated in adults with ADHD.

Therefore, the aim of the present study was to investigate both P50 suppression and SGI scores in adults with ADHD compared to patients with schizophrenia and healthy subjects to get a better understanding of sensory gating deficit in adults with ADHD (Johannesen, Bodkins, O'Donnell, Shekhar, & Hetrick, 2008; Kisley, Noecker, & Guinther, 2004). The primary hypotheses were that adults with ADHD in comparison with healthy subjects: (i) would exhibit P50 suppression deficit (Holstein et al., 2013) and (ii) would report higher overall SGI scores (Sable et al., 2012). The secondary hypotheses were that adults with ADHD in comparison with patients with schizophrenia: (i) would report more abnormal perceptual experiences on the Distractibility dimension (Sable et al., 2012) and the Fatigue–Stress dimension of the SGI, in line with the core inattention symptom in ADHD (American Psychiatric Association, 2000) and the role of fatigue and stress in this disorder (Purper-Ouakil et al., 2004; Yoon et al., 2013), and (ii) would exhibit the same relationship found between P50 suppression deficit and SGI scores (Micoulaud-Franchi et al., 2014a).

2. Methods and materials

2.1. Participants

Twenty-four adult patients with ADHD (30.2 ± 7.9 years, female: 8) were recruited from the Department of Psychiatry, Marseille University Hospital, France. Comparison subjects were 24 outpatients with chronic and clinically stable schizophrenia (31.3 ± 10.8 years, female: 8) and 24 healthy subjects (36.5 ± 11.2 years, female: 8). Patients with ADHD were diagnosed by a psychiatrist according to the Conners adult ADHD diagnostic interview for DSM-IV-TR (CAADID) (Conners, Epstein, & Johnson, 2001). Patients with schizophrenia were diagnosed by a psychiatrist according to the Structured Clinical Interview for DSM-IV interviews (SCID) (American Psychiatric Association, 2000; First, Gibbon, & Williams, 1997). Healthy subjects were not taking any psychotropic medications and were screened for any current or lifetime history of a DSM-IV axis I disorder, using the Mini-International Neuropsychiatric Interview (MINI) (Sheehan et al., 1998) and for any current or lifetime history of ADHD based on the CAADID (Conners et al., 2001). We ensured that healthy subjects had no affected family members with ADHD, schizophrenia or bipolar disorder (Gottesman & Gould, 2003). We ensured that adults with ADHD, patients with schizophrenia and healthy subjects were similar in age, sex, and educational level. Exclusion criteria were reduced capacity to consent, mental retardation, auditory impairment, current depression, current or lifetime history of bipolar disorder,