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Research Report

Methylphenidate normalizes emotional processing in adult patients with attention-deficit/hyperactivity disorder: Preliminary findings

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ABSTRACT

Emotional–motivational dysfunctions may significantly contribute to symptoms of attention-deficit/hyperactivity disorder (ADHD). Hyperactive–impulsive symptoms and sensation seeking could be the result of a search for reinforcers, and cognitive dysfunctions might be due to a low motivational drive. Emotional-motivational dysfunctions could also explain social dysfunctions in ADHD patients because they may lead to misinterpretations of emotional and social clues. Since methylphenidate (MPH) is the first choice as a pharmacological treatment in ADHD, we examined its influence on dysfunctional emotional processes. 13 adult ADHD patients were examined twice, without and after intake of MPH according to their personal medication regimen. The affect-modulated startle paradigm was used to assess physiological (affect-modulated startle response) and subjective (valence and arousal ratings) responses to pleasant, neutral and unpleasant visual stimuli. Healthy controls displayed affective startle modulation as expected, with startle attenuation and potentiation while watching pleasant and unpleasant pictures, respectively. In contrast, unmedicated ADHD patients displayed deficient responses to pleasant stimuli; no startle attenuation during the exposure to pleasant pictures was observed. However, MPH reinstated a normal affective startle modulation, as indicated by attenuation and potentiation associated with pleasant and unpleasant pictures, respectively. Valence and arousal ratings of patients were not affected by MPH. The data suggest that MPH as first choice treatment in ADHD has a positive impact on emotional processes in adult ADHD patients and points to the clinical relevance of emotional-dysfunctions in ADHD.

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1. Introduction

With 3–9% of school-aged children suffering from symptoms like hyperactivity, impulsivity and inattention, attention deficit-/hyperactivity disorder (ADHD) is one of the most common diseases during childhood. Thirty to sixty percent of these patients still show residual ADHD symptoms as adults (Barkley, 1990).

The etiology of ADHD is not clearly understood but there is growing evidence that emotional–motivational deficits play an important role. Hyperactivity, impulsivity and sensation seeking might be interpreted as the search for reinforcers (Johansen et al., 2002) or might result from a steeper and shorter reinforcement gradient (Sagvolden et al., 1998). These ADHD symptoms might also be associated with a reduced reactivity towards punishment or negative consequences (Williams et al., 2008). ADHD patients were reported to have interpersonal problems (Rapport et al., 2002) as well as deficient social and emotional competences. According to Barkley (1997), ADHD patients do have accurate interpersonal perceptual awareness but cannot respond appropriately to emotional clues. However, Casey (1996) pointed out that ADHD children have difficulties in identifying their own emotional expressions compared to healthy controls, and Becker et al. (1993) found evidence for deficits not only in terms of emotional self-regulation but also in terms of interpersonal perceptual awareness. Consequences of these deficits in emotional processes may be lateness, absenteeism and significantly more errors during work as well as instable relation and friendships or increased risks of substance or drug abuse (Harpin, 2005). In addition, it was found that executive functions in ADHD can be positively influenced by incentives (Kohls et al., 2009; Andreou et al., 2007) and ADHD patients benefit from emotion regulation trainings and token system in ADHD therapy (Philipsen et al., 2007; Reitman et al., 2001).

We (Conzelmann et al., 2009) recently found clear evidence for emotional dysfunctions in adult ADHD as reflected in a lack of startle attenuation in response to positive stimuli in patients of the combined and the hyperactive types. The latter group also exhibited deficits in startle potentiation in response to negative stimuli. Dopaminergic dysfunctions are supposed to underly these emotional deficits. Generally agreed are ADHD related dysfunctions in the meso-limbo-cortical and in the nigro-striatal dopamine branch (Castellanos et al., 1996; Hesse et al., 2009; Rubia et al., 1999; Vaidya et al., 1998). Confining this assumption, neuroimaging studies revealed increased dopamine transporter level density in adult ADHD patients (Dougerthy et al., 1999; Krause et al., 2000), and never medicated adults with ADHD were found by PET to show diminished F-DOPA reuptake in the left and medial side of the cortex (Ernst et al., 1998). It is speculated that elevated dopamine levels in ADHD patients could lead over lifetime to increased dopamine transporter levels as an adaptive mechanism. Alternatively, initially increased dopamine transporter density could result in a decreased dopaminergic level (Solanto, 2000). Animal studies support both trajectories. Rats with artificially induced dopaminergic hyperfunction show the same hyperactive behavior as animals with induced dopaminergic hypofunction (Castellanos and Tannock, 2002).

Despite several discussions about the etiology of ADHD, there is no doubt about the efficacy of methylphenidate (MPH) treating the major symptoms of ADHD. Like cocaine, MPH increases extracellular dopamine levels by mainly blocking the dopamine transporter (Seeman and Madras, 1998; Volkow et al., 1995). Due to dopaminergic projections of the nucleus accumbens to prefrontal areas, ADHD symptoms like inattention, hyperactivity and impulsivity improve in children (Kempton et al., 1999; Lawrence et al., 2005) and adults (Medori et al., 2008; Spencer et al., 2005). According to Schultz (1994), the dopaminergic system plays an important role in emotional processing and this may explain ADHD related emotional dysfunctions and a positive impact of MPH on emotional dysfunctions in ADHD. Concerning the impact of methylphenidate on emotional processing, several studies indicated some positive effects in patients suffering from major depressive symptoms and in older, somatically ill patients resulting in a higher quality of life (e.g., Wallace et al., 1995). In bipolar depression, methylphenidate was found to have a stabilizing mood effect (El-Mallakh, 2000). Concerning ADHD, most studies focused on MPH effects on social dysfunctions. Negative social behaviors could be significantly reduced by MPH treatment which also seemed to be more effective than any behavioral training (e.g., Gillberg et al., 1997).

To get objective information about emotional processes, the affect-modulated startle response is a well suited biopsychological measure (Amrhein et al., 2004), also because its neurobiological foundation is well-known (Yeomans and Frankland, 1996). Acoustic startle responses can be measured in humans with electromyography (EMG) of the orbicularis oculi muscle elicited by a sudden noise triggering an eyeblink. Healthy subjects normally exhibit a startle response modulation related to their affective state: the startle response is attenuated during positive and potentiated during negative emotional states. Structures like the nucleus accumbens and the amygdala seem to be relevant for the acoustic affect-modulated startle response (Pissiota et al., 2003) and importantly, both structures are discussed as relevant for emotional–motivational deficits in ADHD (Barkley, 1997). Hence, we used the affect-modulated startle paradigm to examine emotional dysfunctions in ADHD and found deficient emotional processing in adult ADHD patients from the combined and hyperactive/impulsive type (Conzelmann et al., 2009).

To assess whether MPH, the pharmacological treatment of choice for ADHD, affects emotional deficits related to ADHD, we reinvestigated 15 adult ADHD patients; they were firstly examined by Conzelmann et al. (2009) without any medication. These reinvestigated 15 patients were selected on the basis of deficits in startle modulation during the first examination. This strategy seems appropriate as a first step to effectively explore the impact of MPH on emotional processing. Positive findings would justify a large double blind randomized study with all its impact on patients and their treatment. Startle responses and verbal rating data of both test sessions, one with and one without MPH, were compared with the data of matched healthy controls who also took part in the study of Conzelmann et al. (2009). We expected that MPH normalizes the emotional deficits related to ADHD leading to a startle response modulation comparable to healthy controls.