Event-related brain potentials reflect increased concentration ability after mindfulness-based cognitive therapy for depression: A randomized clinical trial

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ABSTRACT

Mindfulness-based cognitive therapy (MBCT) effectively prevents relapse/recurrence in major depression. The ability to deploy and maintain attention on a particular focus is considered as a prerequisite for 'mindful', 'metacognitive' awareness, and hence crucial for therapy success. Accordingly, sustained concentration is the skill most extensively taught in MBCT. The goal of the present study was to test whether this ability increases after MBCT, as assumed. The late component of the contingent negative variation (CNV), an event-related brain potential (ERP), known to reflect the allocation of attentional resources, was used as the measure of concentration ability. In the main phase of the study, 91 recurrently depressed patients in remission were randomly assigned to eight-week treatment by either MBCT or waiting (WAIT for delayed MBCT). The CNV response to an auditory test stimulus was measured pre- and post-treatment in a 'mindfulness task', in which patients were instructed to focus on their breath, as taught in MBCT. The late CNV (LCNV) was increased only after MBCT (and not after WAIT). This result reflects patients' improved ability to shift their attention toward current moment experience and away from potentially depressogenic thinking or rumination during mild dysphoric states—a known risk factor for depressive relapse/recurrence.

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1. Introduction

Mindfulness-based cognitive therapy (MBCT), an eight-week group training program based on mindfulness meditation, has been shown to reduce the risk of relapse/recurrence of major depression by 50% (compared to treatment as usual) in patients with history of more than two depressive episodes (Teasdale et al., 2000; Ma and Teasdale, 2004). In their therapy manual, Segal et al. (2002) put concentration at first place (thus leaving mindfulness/awareness second) in the list of skills to be learned in MBCT: "Concentration: The ability to deploy and maintain attention on a particular focus is central to all other aspects of MBCT. This involves sustained, quality attention that is gathered and focused rather than dispersed and fragmented." (p. 93). This heavy emphasis on attentional skills was theory-driven: Teasdale et al. (1995) argued that deploying attention to the conscious perception of neutral objects, such as the physical sensations of breathing, would make attentional resources that fuel depressogenic processing routines less available in times of increased risk of relapse. This notion is based on an empirically well-supported model of attention, which postulates that all central cognitive processes compete for access to common attentional resources of limited capacity (Pashler, 1998, Chapters 6 and 7).

Teasdale (1999a) theorized further that depriving thought processes of access to attentional resources by focusing attention on the breathing for sustained periods of time facilitates the transition to an entirely different mode of mind called 'being mode', as opposed to the usual 'doing mode'. While the doing mode is marked by *thinking about* things, in being mode, sensations, emotions and thoughts are *experienced directly*, 'mindfully': with purposeful, non-judgmental, present-moment attention/awareness (Kabat-Zinn, 1994, p. 4). 'Metacognitive insight' distinguishes mindful being from 'mindless emoting' (Teasdale, 1999b). While mindless emoting means being immersed in and identified with one's own thoughts and affective reactions with little self-awareness, metacognitive insight means 'decentering' or 'disidentification'—being clearly aware of thoughts, emotions and sensations as passing events without confusing them with 'me', 'mine' or 'reality' (Teasdale, 1999b; Teasdale et al., 2002).

In depression, the doing mode is dominated by 'rumination', a cognitive style, marked by circular thinking about one's physical and emotional state (Nolen-Hoeksema, 1987, 1991). As a coping

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response to negative affect, rumination does not improve mood, but, on the contrary, worsens it further, thus maintaining and enhancing depression (Nolen-Hoeksema and Morrow, 1991; Donaldson and Lam, 2004). It is, therefore, considered as a major facilitating factor for relapse (Segal et al., 2002, pp. 35–36).

According to the limited-capacity model, the process of meta-cognitive insight competes for attentional resources with all thought processes running in the doing mode. Consequently, the core skill learned in MBCT is to "step out and stay out" of the doing mode (Segal et al., 2002, p. 91). The most extensively practiced technique is consciously noticing one's thoughts, deliberately withdrawing attention from thinking, focusing attention on breathing, keeping attention focused as long as possible, and then starting again from the beginning as soon as one realizes that the mind has been lost in thought for a while. Teasdale et al. (1995) argued that developing enhanced concentration ability would help to prevent depressive relapse in at least two ways: first, depressogenic thinking/rumination would be deprived of access to attentional resources; second, these resources could be reallocated to metacognitive insight, which is assumed to prevent depression by itself (Teasdale et al., 1995; Teasdale, 1999b). While the hypothesis that MBCT prevents relapse by increasing patients' metacognitive awareness has received empirical support (Teasdale et al., 2002), the core skill of concentration, "the ability to deploy and maintain attention on a particular focus" has never been assessed.

The goal of the present study was to develop an assessment procedure for measuring concentration during mindfulness meditation and to apply it to recurrently depressed patients before and after the MBCT training. We chose event-related brain potentials (ERPs) as measures of mindful concentration for the following reasons. First, ERPs are brain responses extracted from the electroencephalogram (EEG) that can reflect (re-)allocation of attentional resources in real time (Tecce, 1972; Pribram and McGuinness, 1992; Tecce and Cattanach, 1993) and can therefore be applied as direct psychophysiological measures of concentration during meditation (Cahn and Polich, 2006; Ivanovski and Malhi, 2007). Second, ERPs can be elicited under passive conditions, i.e. without an active task (Polich, 1987; Baranov-Krylov et al., 2003), which makes them particularly valuable for measurements in the being mode of mind. The concentration developed in only eight weeks (the duration of an MBCT course) is unlikely to be stable enough to be maintained during tasks requiring active motor response, because such tasks are strongly associated with the achievement-oriented doing mode. In contrast to active tasks, passive ERP tasks require only conscious attention to the presented stimuli, without any kind of reaction (Polich, 1987; Baranov-Krylov et al., 2003). In the present study, we went one step further and developed a special 'mindfulness task', in which attention is focused on the breath, and the ERP elicited by a test stimulus is taken as measure of the attention withdrawn from thinking/rumination (doing mode) and redeployed to mindful perception of sensory input (being mode).

Our mindfulness ERP paradigm is based on the spontaneous brain response to a neutral test stimulus eliciting a 'contingent negative variation' (CNV), an ERP component, which is particularly sensitive to (re-)allocation of attentional resources (Tecce, 1972; Tecce and Cattanach, 1993). CNV is elicited by a warning stimulus (S1) that always precedes an imperative stimulus (S2) in a sequence of S1–S2 pairs. While the early CNV, measured in the 0.5–0.8-s time interval after S1, reflects automatic orienting processes, the late CNV (LCNV), measured in the 0.2-s window before S2, reflects mobilization of attentional resources (Pribram and McGuinness, 1992; Tecce and Cattanach, 1993; Travis et al., 2002). In particular, the LCNV amplitude is diminished by inattention caused by thinking, daydreaming or active distraction by some other task (Tecce, 1972; Travis and Tecce, 1998).

A review of the ERP studies on meditation showed that compared to other ERP components, the LCNV has provided the most consistent information about meditative concentration: "Simple CNV tasks yield an increase in amplitude … reflect changes in attentional resource allocation" (Cahn and Polich, 2006, p. 196). For instance, Travis et al. (2000, 2002) assessed the concentration ability of experienced meditators using the LCNV elicited in active tasks including motoric reactions to S2, and found a positive relationship between the LCNV amplitude and the number of years of meditation practice. To the best of our knowledge, CNV tasks have not been used in studies on mindfulness meditation (Ivanovski and Malhi, 2007). For this reason, and because the existing CNV results were obtained from experienced meditators who had practiced for years, we developed a new 'mindfulness CNV paradigm' to measure small changes in concentration ability acquired during an eight-week MBCT course. Our hypothesis, based on the results of the pilot phase of the study, was that in the main phase of the study patients' LCNV would increase in a group treated with MBCT, but not in a waiting-list control group.

2. Methods

2.1. Design and general procedure

Our study comprised two phases: explorative pilot phase and main assessment phase. In the pilot phase (2006), we developed the mindfulness ERP paradigm and in the main phase (October 2008–July 2010), we used this paradigm to assess the concentration ability of recurrently depressed patients before and after MBCT in a single-center, single-blind, balanced-randomization, waiting-list-controlled, parallel-group trial (registered at ClinicalTrials.gov, Reg. No. NCT00974077). In both phases, participants' ERPs were measured twice, pre- and post-treatment, i.e. before and after an eight-week period, in which an experimental MBCT group received mindfulness training, while a control WAIT group received no training. In the main phase, baseline assessment was completed by a member of the research team who enrolled eligible patients and assigned them personal codes, thus concealing their identity. Another researcher assigned personal codes to treatments (MBCT or WAIT) using a computer generated simple 1:1 random sequence. Within each group, patients were additionally assigned to one of the experimental conditions, 'Rumination Challenge' or 'Mindfulness Support' (see 'Mindfulness ERP task'). Patients' EEG data sets were named after the personal codes, thus keeping the outcome assessor (a third team member) blinded.

2.2. Participants

In the main phase, 91 recurrently depressed patients currently in remission were recruited through announcements in local newspapers and psychiatrists in private practice according to the following eligibility criteria (for comparison, see, Teasdale et al., 2000; Ma and Teasdale, 2004):

Inclusion criteria: (a) age between 18 and 65 years, right-handedness, normal hearing ability; (b) history of recurrent major depression with three or more previous episodes and (c) commitment to MBCT homework compliance and to not initiating any changes in medication (starting, suspending, changing dosage) unless a relapse made it necessary.

Exclusion criteria: (a) current major depressive episode, or the presence of dysthymic disorder; (b) the presence of substance abuse, eating disorder, or obsessive-compulsive disorder; (c) the presence or history of one or more of the following: bipolar disorder, borderline personality disorder, schizophrenia or schizoaffective disorder, epilepsy or other neurological disorder, organic mental disorder, pervasive developmental delay; and (d) significant experience with any kind of practice including mindfulness and/or concentration as important element (e.g. meditation, meditative prayer, autogenic training, meditative yoga, etc.).

In the preceding pilot phase, the MBCT group comprised 22 recurrently depressed patients, while the WAIT group comprised 20 university students and staff. MBCT participation criteria were the same as in the main phase (except for right-handedness).

2.3. Treatment

2.3.1. MBCT
Therapy was delivered by a certified MBCT therapist, following the standard protocol (Segal et al., 2002). MBCT comprises eight weekly two-hour group