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Dispositional mindfulness and semantic integration of emotional words: Evidence from event-related brain potentials

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ABSTRACT

Initial research shows that mindfulness training can enhance attention and modulate the affective response. However, links between mindfulness and language processing remain virtually unexplored despite the prominent role of overt and silent negative ruminative speech in depressive and anxiety-related symptomatology. Here, we measured dispositional mindfulness and recorded participants' event-related brain potential responses to positive and negative target words preceded by words congruent or incongruent with the targets in terms of semantic relatedness and emotional valence. While the low mindfulness group showed similar N400 effect pattern for positive and negative targets, high dispositional mindfulness was associated with larger N400 effect to negative targets. This result suggests that negative meanings are less readily accessible in people with high dispositional mindfulness. Furthermore, high dispositional mindfulness was associated with reduced P600 amplitudes to emotional words, suggesting less post-analysis and attentional effort which possibly relates to a lower inclination to ruminate. Overall, these findings provide initial evidence on associations between modifications in language systems and mindfulness.

1. Introduction

Mindfulness, in its secular form, is often described as a meditation-based practice developing a mode of awareness, which involves the ability to monitor and intentionally bring attention to the present-moment experience with an attitude of acceptance and curiosity (Kabat-Zinn, 2003). However, there is no broadly agreed definition of mindfulness and discussions about what mindfulness is often highlight differences between secular and Buddhist notions of mindfulness (Dorjee, 2010; Dreyfus, 2011; Dunne, 2011). While the conceptual questions about mindfulness remain open, outcome-focused research over the last two decades documented beneficial effects of secular mindfulness programs, such as mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT), across a wide range of clinical conditions ranging from anxiety and recurrent depression (Hofmann et al., 2010; Piet and Hougaard, 2011) to cancer (Shennan et al., 2011). Initial evidence also highlights well-being enhancing and illness preventing potential of mindfulness training in contexts such as education (Meiklejohn et al., 2012). With increasing rigor and sophistication of studies evaluating mindfulness-based interventions, there is also growing interest in cognitive and neural mechanisms underlying their therapeutic and well-being enhancing effects.

Neurocognitive research into mindfulness has so far mostly focused on modifications in attention and emotion processing, mirroring theoretical proposals conceptualizing attention and attitude (the affective quality) as the two main aspects of mindfulness (Bishop et al., 2004). Specifically, it has been shown that secular mindfulness training improves selective attention (Jha et al., 2007; Jensen et al., 2012), diminishes negative effects of stress on working memory capacity (Jha et al., 2010), and enhances efficient use of limited cognitive resources (Moore et al., 2012). With regard to emotion processing, training in MBSR has been found to regulate over-reactivity of the amygdala in participants with social anxiety disorder (Goldin and Gross, 2010), and decrease gray matter density in the right amygdala concurrent with a reduction in perceived stress (Hölzel et al., 2009). Disposition to mindfulness has also been associated with less neural reactivity to highly arousing positive and negative stimuli (Brown et al., 2013).

Overall, increased activation in lateral and medial prefrontal areas (PFC), linked to attention monitoring and executive control, seems to underpin the positive effects of mindfulness (e.g.,

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Creswell et al., 2007; Goldin et al., 2013), even though the underlying mechanisms may differ amongst beginners and experienced meditators (Taylor et al., 2011). Tang and Posner (2009), in particular, suggested that improvement in executive control resulting from meditation-based training is distinct from other attention enhancing methods in its broad impact on cognition, including attention and emotion regulation (see also Teper et al., 2013), which in turn translates into better regulation of the autonomous nervous system and overall in better self-control. In the case of secular mindfulness training, the improvement in executive control likely reflects enhancement in the ability to monitor mental processes and voluntarily shift attentional focus from emotionally salient contents and thoughts to non-elaborative perceptions such as sounds and bodily sensations (Bishop et al., 2004) coupled with the development of de-centered metacognitive perspective of cognition – perceiving mental phenomena as transient events rather than facts (Teasdale et al., 2002).

Such changes in executive control induced by mindfulness arguably impact on language processing as well. Monitoring mental contents involves awareness of thoughts expressed in silent speech, while shifting of attention toward bodily sensations often includes disengagement from ruminative overt or silent speech. Indeed, there is a documented inverse relationship between mindfulness and rumination (Brown and Ryan, 2003; Feldman et al., 2007). Importantly, a decrease in rumination is considered one of the primary mediators of improvement in psychological distress (Jain et al., 2007) and depressive symptomatology after mindfulness training (Shahar et al., 2010). This is not surprising given that overt and silent negative ruminative speech plays a pivotal role in development and maintenance of depressive and anxiety-related symptoms (e.g., Nolen-Hoeksema, 2000; Watkins, 2008).

A decrease in uncontrollable rumination, rather than rumination in general, seems to be at the core of the positive effects of mindfulness on depression (Raes and Williams, 2010) – evidence which makes the possible links between the enhancement of executive control and the modulation of language processing more explicit. This raises interesting hypotheses about the impact of mindfulness practice on language, particularly with regards to the processing of negative ruminative contents. It is for example possible that de-centered monitoring of overt and silent ruminative speech and shifting of attention from negative rumination to bodily sensations result in diminished activation of semantic representations of negative words both in terms of intensity and frequency.

The current study aimed to investigate neural differences in semantic processing associated with dispositional mindfulness in order to evaluate their semantic integration and cognitive appraisal by participants. Event-related brain potentials (ERPs) locked to the onset of positive and negative words embedded in congruous and incongruous word pairs targeted the N400 and P600 components. The N400 is a negative wave peaking around 400 ms post-stimulus onset and is sensitive to meaning integration across sensory and coding modalities (e.g., written words, pictures or environmental sounds; Hagoort, 2008). It also reflects ease of lexical access from long-term memory (Kutas and Federmeier, 2000; Lau et al., 2008). Target stimuli unrelated in meaning to preceding stimuli elicit more negative N400 amplitudes than semantically related stimuli. This effect is enhanced by a mismatch in emotional valence (Zhang et al., 2006).

The other ERP component of interest – the P600 – is a positive wave peaking approximately 600 ms after stimulus onset. The P600 is a marker of attention processing and is part of the P300 family indexing attention-related stimulus reevaluation and working memory updating (Sassenhagen et al., 2014). Specifically, increased P600 amplitude is observed for both syntactic (Kaan et al., 2000) and semantic (Van Herten et al., 2005) reprocessing of information within a given context. Late positivity in the P600 range has also been linked to affective processing, with more positive amplitudes elicited to negative words (Holt et al., 2009). And a possible link to ruminative processing has been suggested in a study with fibromyalgia patients who showed more positive responses to pain-related words in comparison to healthy participants (Sitges et al., 2007).

Several previous studies have successfully used associations between mindfulness disposition and neurocognitive indices of emotion processing (Creswell et al., 2007; Brown et al., 2013). Dispositional mindfulness reflects individual differences in the spontaneous propensity to mindfulness which are measurable even without mindfulness training. The present study is the first to investigate the relationship between dispositional mindfulness and processing of emotionally valenced words. Self-report questionnaires assessed levels of dispositional mindfulness, and we recorded the ERPs elicited by the second word (target) in emotionally valenced pairs. Target words were either congruous in meaning and emotional valence with the primes (e.g., holiday-sun or coffin-funeral), or incongruous (e.g., holiday-funeral, coffin-sun). We have predicted that higher mindfulness would be associated with more negative N400 amplitudes to negative words, because of weaker associations between negative semantic representations and other items in the mental lexicon due to less negative rumination. We have also expected reduced P600 amplitudes in participants with higher mindfulness disposition due to less reliance on rumination and thus, less stimulus reevaluation.

2. Materials and methods

2.1. Participants

Thirty five healthy young adults, undergraduates at Bangor University, participated in the study. They had no prior training in meditation including secular mindfulness practices. All participants were native speakers of English, had normal or corrected-to-normal vision and normal hearing, and reported no reading difficulties. All participants, except one, whose data were excluded from the study, stated that they were not taking any medication, which could influence their performance and did not have psychiatric problems. According to the self-report results of the Edinburgh Handedness Inventory (Oldfield, 1971), all but two participants were predominantly right-handed. To ensure homogeneity of the sample, the data from the two left-handed participants were excluded. Additionally, data from two participants had to be excluded because of high loss of experimental trials due to excessive movement. One more participant was excluded due to at chance performance on the task. The final group consisted of 29 participants (average age 21.8, age range 18–28 years; 16 women). The study was approved by the ethics committee at Bangor University prior to participant recruitment and all participants provided informed consent before the start of their experimental sessions. Participants received payment for their participation.

2.2. Assessment of mindfulness

A one-dimensional measure of mindfulness, the Mindful Attention Awareness Scale (MAAS; Brown and Ryan, 2003), was used to collect ratings of self-reported mindfulness. The scale consists of 15 items assessing mindful experience and uses a 6-point Likert scale. Mindfulness scores assessed with MAAS have been shown to correlate negatively with measures of rumination, anxiety and depression in a healthy adult sample (Brown and Ryan, 2003). The MAAS score has been used as a measure of mindfulness disposition