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FUNCTIONAL BRAIN CHANGES DURING SEMA MEDITATION: NEURONAL CORRELATES AND THEIR ASSOCIATIONS WITH AFFECTIVE STATES

SEMA MEDİTASYONU SIRASINDKİ İŞLEVSEL BEYİN AKTİVİTESİNDEKİ DEĞİŞİKLİKLER: NÖRAL AKTİVİTELER VE DUGULANIM İLE İLİŞKİSİ

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Abstract

Sufi meditation is a spiritual form of physically active meditation in which performers (Semazens) whirl without losing conscious awareness and while internally focusing on reaching an ecstatic state, thus requiring substantial motor and cognitive control and monitoring. Studies have argued that the experience of the meditator may affect the strength of the brain activations because more experienced meditators may need less cognitive effort to reach the ecstatic state. Despite this, our knowledge about the associations between emotional states of the meditators and activated brain areas during meditation remains unknown. With this in mind, fourteen male Semazens were recruited for this study. All Semazens performed Sema meditation under the scanner using imagined whirling techniques. An active control condition was used to explore brain areas specific to Sema meditation. Measures of affective states and psychiatric symptoms were also collected. Statistical parametric maps were created to compare the meditation vs. control conditions. Accordingly, Sema meditation specifically evoked activations in left anterior cingulate cortex (ACC) and left orbitofrontal areas. Activations in ACC were negatively correlated with the positive affect of the Semazens suggesting that less cognitive effort required to reach the meditative state in Semazens was associated with more positive affect. Despite previous studies highlighting the experience of the meditators as a predictor of brain activation, we found that affective state may also be an important factor that may facilitate emotion regulation and cognitive monitoring in the brain. Our findings may also be applicable to the effects of meditation on psychological and emotional wellbeing.

Keywords: Sufism, Meditation, fMRI, anterior cingulate cortex

Özet

Sufi meditasyonu, uygulayanların (semazenlerin) bilişsel farkındalıklarını kaybetmeden kendi etrafında döndükleri ve bundan dolayı önemli bir motor, kognitif kontrol ve gözlem gerektiren fiziksel hareketli bir manevi meditasyon biçimidir. Bir çok çalışma, meditasyon yapan kişinin deneyiminin, beyin aktivasyonlarındaki kuvvet üzerinde etkili olacağını ileri sürmüştür. Çünkü meditasyon yapan kişinin tecrübesi arttıkça, kiki esrik duruma ulaşmak için daha az kognitif çaba harcamaktadır. Buna karşın, meditasyon yapan kişilerin duygusal durumu ve bunun meditasyon sırasında aktive olmuş beyin alanları arasındaki ilişkisi konusundaki bilgi yeterli değildir. Tüm bu bilgiler ışığında, bizim çalışmamız 14 erkek semazen ile yapılmıştır. Tüm semazenler, MRI cihazı içerisinde, sema dönüşünü zihinlerinde canlandırarak meditasyon yapmışlardır. Bu duruma karşıt olarak, Sema meditasyonunda spesifik olan beyin alanlarını bulmak için aktif kontrol durumu uygulanmıştır. Katılımcılardan duygulanım durumu ve psikiyatrik semptom ölçümleri toplanmış, ve fMRI analizleri, istatiksel parametrik harita, meditasyon ve kontrol durumlarını karşılaştırmak amacıyla oluşturulmuştur. Sonuç olarak, sema meditasyonu sırasında özellikle sol anterior cingulate kortex ve sol orbitofrontal alanda aktivasyon gözlemlenmiştir. Önceki çalışmalarda meditasyon yapan kişinin tecrübesi beyin aktivasyonu için öngörücü olmasına rağmen, bu çalışmada duygulanım durumunun beyinde meditasyon esnasında, duyguları düzenlemeyi kolaylaştırmada ve kognitif gözlemleme süreçlerinde önemli bir etken olduğunu bulunmuştur. Bu bulgular, meditasyonun psikolojik ve duygusal iyilik haline olumlu etkileri perspektifinden de açıklanabilir.

Anahtar Kelimeler: *sufizm, meditasyon, fMRI, ön singulat korteks*

1. Introduction

The term Meditation refers to a broad variety of spiritual practices, including techniques, which instantly promote relaxation and aims to improve well-being and composure as a long-term goal (Davidson et al., 2008). Sufi Whirling as a central practice of Sema Meditation is a form of physically active meditation performed for spiritual purposes by Semazens of the Mevlevi order (Geoffroy,

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2010; Tarhan, 2015). Different from any other meditative practice, Sufi Meditation requires excessive cognitive and motor control as the performers (Semazens) are expected to turn around him/herself while constantly repeating words, experiencing a high spiritual state, without losing their motor and conscious awareness (Geoffroy, 2010; Tarhan, 2015). Today, increasing number of studies are investigating the effects of meditative exercise in the brain using functional neuroimaging techniques (i.e., Cahn and Polich; Baron Short et al., 2010; Holzel et al., 2011; Guleria et al., 2013). Studying the effects of meditation in the brain is important because reaching a "meditative" mental state involves diffuse brain activations. Studying such activations are crucial in understanding more fundamental issues related to the regulation of cognitive and emotional states. This issue may be more challenging when it is expected to take place during Sufi meditation (Nizamie, et al., 2013).

In general, fMRI studies found increased activations in the areas involved in reward processing and emotion regulation, including the orbitofrontal cortex (OFC), cingulate cortex and thalamus during meditation (Fox et al., 2014; Newberg, et al., 2010; Baerentsen et al., 2001). Furthermore, depending on the type of the meditation, activated patterns in the brain have differed in various ways. For instance, a recent fMRI study found that focus-based meditation elicits activity in a wider network of brain regions when compared to breath-based meditations, particularly in frontal regions, the limbic system and anterior cingulate cortex (Wang et al., 2011). Another fMRI study on Soham Meditation, a meditation type that includes verbal rehearsal synchronized with the breathing of the practitioner, found activations in the left middle prefrontal cortex, left inferior frontal gyrus, left supplementary motor area and left precuneus (Guleria et al. 2013). Bilateral hippocampal activations were activated, together with the middle cingulate cortex (MCC) and prefrontal cortex (PFC) during another traditional meditative practice that involves silent repetition of specific words (Engström et al., 2010). It is not only the techniques used in the meditation but also the experience of the meditator which impacts on activation patterns in the brain. Baron-Short et al., (2010) found dorsolateral prefrontal cortex (DLPFC) and an anterior cingulate (ACC) activation that was modulated by the experience of the meditator. The activations in ACC and DLPFC were specifically explained by the fact that meditation requires self-focused attention, which may be achieved by ignoring distracting stimuli, actively monitoring one's own mental and cognitive processes and engaging attentional control (Baron-Short et al., 2010). Based on this explanation, one might conclude that the activity changes in these brain regions could interfere with the quality of meditation, which may also impact on the affective and behavioral benefits of the meditation.

However, the associations between affective and behavioral traits of meditators and their brain activations during meditation are still unbeknown. Investigating this issue is crucial in revealing the neuronal basis of the positive and soothing moods of meditators. Nonetheless, the relationship between the meditative practice and an individual's psychological status has been investigated in a few studies (i.e. Kemeny et al., 2012; Hoffman et al., 2012; Innes (2012) demonstrated the meditation's effect on Alzheimer's patients revealing its positive influences on stress, sleep disturbances and memory functioning. Moreover, it has been demonstrated that meditation can diminish an unbounded anger behavior (Kemeny et al., 2012; Hogffman et al., 2010). In another study, individuals practicing mindfulness were less likely to be aggressive compared with non-practitioners (Singh et al., 2007). A feasible conclusion from the above studies would suggest a strong relationship between meditation and the psychological affective state of the meditators.

Some traditional focus-based meditations rooted in Eastern culture have their unique philosophy that ultimately affects the practitioner's daily functioning in life, and Sufi Meditation may be considered to be one of these. Sufism dominates the individual's ego (i.e., self-nefs), balancing the mental and physical experiences and creating inner harmony (Geoffroy, 2010).

The ceremony of Semazens in Sufi Meditation focuses on the recollection and remembrance of the Divine, which ends in the effacement of the creature and attainment of the limitless state of self being. Sometimes this "state of being" or "ecstasy" already exists at the beginning of the dance, and this dance then becomes the exterior manifestation of an interior state (Michon & Gaetani, 2006). Sometimes the dance appears like an "effort of seeking" which, according to the predisposition of the dancer, may or may not lead to a veritable ecstatic experience (Geoffroy, 2010). Sufism contributes to the regulation of people's mental ego stage and transforms their behavior in a more positive way, while soothing their mood. To date, there are no studies that have investigated the neuronal correlates of Sema Meditation and the relationship between neuronal activations and psychological traits of the practitioners.

The ultimate goal of this study was to explore the regional brain activations during Sufi Meditation in the MRI scanner. Furthermore, we intended to address whether or not activated brain areas were related to affective states of the Sema practitioners. Based on our goals, this study had the following two-fold hypothesis: First, in line with previous studies, we predicted that Sema Meditation could exert significant brain activations that were related to self-focused attention such as ACC and DLPFC. Second, the strength of these activations could be associated with the affective schedule of the practitioners in such a way that those who find the meditation more effortful would benefit less from it in terms of positive affect.

2. Methods

2.1. Participants

Fourteen male Semazens (mean age: 30.43± 5.94 years, mean education: 17.07± 2.5, all right handed) were recruited for this study. Semazens were enrolled from a Meditation Centre in Istanbul, where traditional Sema meditation is taught together with its philosophy. Participants' mean duration of meditation practice was 6.70±3.42 years and the meditators in their first year

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of practice were not included. All Semazens underwent a structural clinical interview for psychiatric disorders (SCID-I), and none received a diagnosis. Any participants with previous neurological disorders, current or previous use of psychotropic medication or previous history of head trauma were excluded. The study received approval by the Institutional Human Research Ethics Committee and all study participants gave written consent before the scanning was initiated

2.2. Task and protocol

Participants were asked to perform Sema Meditation with their eyes open in the scanner. Sema meditation, which usually involves the traditional whirling dance of the Semazen, with their arms stretched and one hand turned towards the soil and the other to sky. Due to the practical limitations of fMRI scanning, we asked the practitioners to perform Sema Meditation by only imagining whirling in the scanner. In general, Sema ceremonies start with a preparatory session in which the Semazen listen to traditional melodies of Sufism. This step is believed to facilitate the recollection and remembrance of Divine (Michon and Gaetani, 2006). In the preparation phase of the current study, all of the Semazens where left in a room for 30 mins while they listened to the recordings of an original traditional preparation ceremony. Following this, we asked to them to perform Sema Meditation as well as a control task under the scanner. Lastly, the session ended after all Semazens completed a likert scale with four questions to evaluate the quality of their ecstatic state during meditation. Each question included evaluations between 1 to 10 and the questions read as follows: 1) "I successfully followed the rituals during meditation", 2) "I successfully concentrated on the meaning of Sema during meditation", 3) "The recollection and remembrance of Divine was successful during meditation" and 4) "I was successful in avoiding to think about daily routines during meditation". This Sema meditation quality scale was prepared by the head of Semazen community in Istanbul for the current study (Fatih Çıtlak).

During the control period, subjects viewed a series of geometric images every four seconds and were asked to determine whether they were blue or yellow and select the appropriate button on a fMRI compatible pad. As a note, a very similar design has been used in several other fMRI studies in meditation (Baron Short et al., 2010; Guleria et al., 2013). An active control task was selected instead of a resting control task as to avoid meditation in the control condition. Each run consisted of two 12 minute meditations and two 6 minute control blocks, which were counterbalanced across participants. Following the scanning session, Semazens completed the Sema meditation quality scale.

2.3. Behavioral assessments

The severity of psychiatric symptoms of Semazens was assessed by using the Symptom Checklist 90 (SCL–90, Derogatis,, 1994). The SCL-90 provides a widely used 90–item measure of general psychiatric distress comprised of nine subscales (somatization, obsessive–compulsive, interpersonal sensitivity, depression, anxiety, anger–hostility, phobic anxiety, paranoid ideation, and psychoticism).

The affective states of the Semazens were evaluated by the Positive and Negative Affect Schedule (PANAS) which includes the two original 10-item adjective checklist subscales (Watson et al., 1988) of positive affect (PA) and negative affect (NA). Using the "moment" instruction (i.e., "right now, that is, at the present moment", Watson et al., 1988), where participants were asked to rate the intensity of each symptom on a scale of 1 (not at all or very slightly) to 5 (extremely).

2.3. Functional MRI data acquisition

Data was collected on a 1.5 Tesla Philips Achieva scanner at the Istanbul Neuropsychiatry Hospital. We used foam padding to minimize head movement within the coil. T1 weighted MPRAGE type structural images were collected (TR/TE = 8.6/4.0 s, flip angle=8°, FOV = 240 mm, matrix=192×192, 1 mm isotropic voxels, sagittal sections, scan duration = 4.30 min per volume). T2 weighted functional images were acquired using a gradient-echo EPI sequence (TR=4000 ms, TE=30 ms, flip angle=90°, FOV=208 mm, matrix=64×64, 30 slices with thickness of 3 mm, 3 mm × 3 mm in-plane spatial resolution, and FOV 230 mm, in total 541 dynamic scan, scan duration = 36.16 min).

2.4. Statistical analysis

The preprocessing and analyses of functional MRI images were conducted using Statistical Parametric Mapping software (SPM 8, Wellcome Department of Cognitive Neurology, London, UK,using Matlab version 2013a). Anatomical images were spatially normalized using the SPM segmentation procedure for parameter estimation and re-sliced to a voxel size of 1×1×1mm. The single subject preprocessing of fMRI images consisted of the following steps: slice time correction, realignment of all EPIs to the first volume, normalization based on the T1 segmentation parameters, re-slicing to a final voxel size of 3x3x3 and lastly smoothing with a Gaussian kernel of 8 mm full width half maximum (FWHM). The first level of analysis was performed using a fixed effect model to construct the General Linear Model using a canonical hemodynamic response function (HRF) (Friston et al., 1999). In the resulting GLM, motion parameters created during the realign process were used as six user-specified regressors to account for any activity related to head movement. A high pass filter of double the length of the longest trial (720 s) was used to remove low-frequency noise without sacrificing the signal of interest. In the statistical model, individual t-maps were created using two contrasts of interest: meditation>control task and control>meditation. These individual t-maps were taken into the second level of group analyses. For the second level of group analyses, we employed one-sample t-test to identify the brain regions significantly activated during meditation using multiple comparison with a cluster level threshold of $p < 0.05$, with voxel-level threshold of $p < 0.01$ and a minimum cluster size (k) of 58 voxels, using the AlphaSim software (http://www.restfmri.net/forum/REST_V1.4), which applied Monte Carlo simulation (parameters: individual voxel p = 0.01; rmm = 5; 5.000 simulations).

Lastly, we extracted the beta values for the significant brain regions in the meditation condition using the MarsBaR toolbox together with AAL templates. Pearson correlation analyses were performed to identify the association between beta values and the behavioral measures. Correlations between the behavioral scales were also performed in this step.

3. Results

3.1. Meditation vs. Control task

Compared with the active control condition, stronger activations were found in the left anterior cingulate including the dorsal regions and left inferior orbitofrontal cortex during mediation. All local maxima in the activated cluster, t and z values together with the MNI coordinates are summarized in table 1. These results are based on the anatomical location of the peak voxel in the activated cluster.

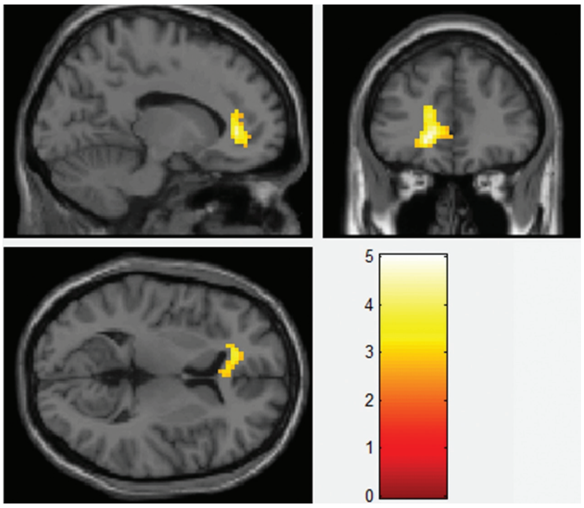

Figure 1: SPM t-map of significant activations in the meditation > control contrast in (alphasim corrected with a cluster level threshold of $p < 0.05$, with voxel-level threshold of $p < 0.01$ and a minimum cluster size (k) of 58 voxels)

Table 1: Brain regions activated by the Sema meditation

Brain areas	Peak voxel coordinates (MNI) x	y	z	T value	Z value
Left anterior cingulate cortex	-18	41	-2	5.03	3.68
Left anterior cingulate cortex / BA 32	-15	38	13	3.94	3.14
Left inferior orbitofrontal	-21	32	-11	4.55	3.46

Notes for Table 1: MNI; Montreal Neurological Institute. Results were alphasim corrected at voxel level 0.001 (cluster level =<.05 FWE; Extent threshold = 58 voxels; df = 1,45)

3.2. Control task vs. Meditation

Compared with meditation, stronger activations were found in the left postcentral gyrus, left inferior parietal cortex, left post central gyrus, right precuneus, left cuneus and left inferior parietal cortex in the active control condition. All local maxima in the activated cluster, t and z values together with the MNI coordinates are summarized in table 2. These results are based on the anatomical location of the peak voxel in the activated cluster.

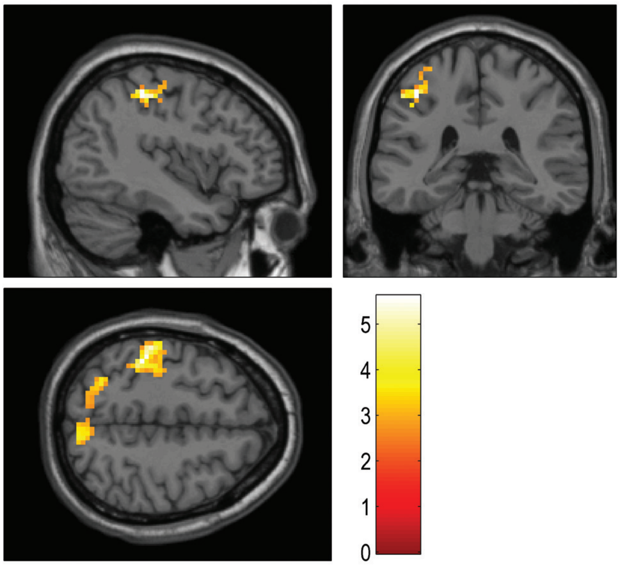

Figure 2: SPM t-map of significant activations in the meditation < control contrast in (alphasim corrected with a cluster level threshold of $p < 0.05$, with voxel-level threshold of $p < 0.01$ and a minimum cluster size (k) of 58 voxels)

Table 2: Brain regions activated by the control condition

Brain areas	Peak voxel coordinates (MNI) x	y	z	T value	Z value
Left postcentral gyrus	-42	34	52	5.60	3.93
Left inferior parietal cortex	-51	-31	49	5.58	3.92
Left postcentral gyrus	-48	-22	43	4.33	3.35
Right precunes	9	-76	49	3.94	3.14
Left cuneus	1	-82	40	3.86	3.10
Left inferior parietal cortex	-30	-61	49	3.84	3.08

Notes for Table 2: MNI; Montreal Neurological Institute. Results were alphasim corrected at voxel level 0.001 (cluster level =<.05 FWE; Extent threshold = 58 voxels; df = 1,45)

3.3. Correlational analyses

According to the correlational analyses; beta values in the left anterior cingulate cortex were negatively correlated with the Positive Affect (PA) subscale of PANAS (r=.723; p<.01; see figure 3 for the scatterplot). Such correlations were not present with inferior orbital cortex

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and PANAS. No correlations were found between SCL-90 subscales and the activity in the brain regions for Sema condition. Regarding correlations between behavioral scales, significant associations were observed between Negative Affect (NA) subscale of PANAS and the anger-hostility subscale of SCL-90-R ($r=.80$; $p<.01$), but not for the PA subscale ($p>.05$). No associations were found between the quality of ecstatic state under the scanner and all behavioral and neuroimaging findings (all p values >.05). Lastly, the experience of meditation practice was not correlated with the outcome variables (all p values >.05).

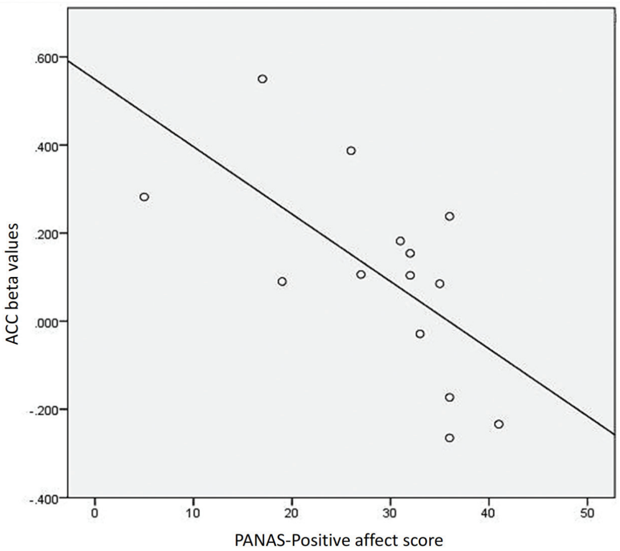

Figure 3: Scatterplot showing the associations between the ACC activity and PA subscale of the PANAS.

4. Discussion

According to the results, our hypotheses were partially confirmed. Here, we found significant activations in the ACC during meditation as compared to the control condition. Moreover we demonstrated an association between the neuronal efforts during meditation and psychological state of the Semazens. Specifically, participants with greater ACC activation exerted less positive affect in this study.

ACC is a part of frontal cortex that is primarily involved in conflict monitoring and emotion regulation (Mathalon,, et al., 2003; van Veen, 2001). Studies have confirmed that it is mainly activated during tasks evoking significant response conflict and tasks requiring mental effort (Croxson et al., 2009). In addition, the activity in ACC decreases as the subjective value of the effortful option increases. Thus, ACC evaluates whether or not it is worth producing a given effort for the reward at stake. (Prévost et al., 2010). Taken together, a plausible interpretation of our results could be that those Semazens who were in a positive and soothing state before the session took place may have experienced less cognitive conflict when getting into the meditative state and thus, spending less effort in the scanner. Alternatively, Sema practitioners who perceived the meditation more effortful, as reflected in greater ACC activation, would also have shown less affective benefit from the meditation. Therefore, meditators who were engaged in the meditation, and with less ACC activity, were more likely to show affective benefit. Similarly, Baron-Short et al. (2010) argues that the experience of the meditators may affect the ACC and DLPFC activity. They showed that experienced meditators didn't need as much error-monitoring as the inexperienced meditators, and could focus their attention more easily. Here, we did not find any correlation between the duration of practice and other study measures. As a note, the Baron-Short study did not evaluate the affective state of the meditators in addition to the duration of practice which ultimately effected the ACC activations in this study.

In addition to ACC, OFC was significantly activated during meditation. OFC is primarily related to reward expectancy and decision making (Kringelbach, 2005). In fMRI studies, it has been shown that OFC activation correlates with values of both social and monetary rewards (Lin et al. 2012). OFC activations were reported in previous neuroimaging studies on meditation and this finding might suggest that meditation is perceived as a self-stimulating reward condition (Hölzel et al., 2008; Kang et al., 2013). In this study, we did not find a significant correlation between PANAS scores and OFC activation. Besides, the quality of ecstatic state during meditation was not correlated with OFC activations. Here, we have some explanations for the lack of correlations. Firstly, the quality of ecstatic state scale for Sufi Meditation may not have been suitable to identify the rewarding features of Sufi Meditation (Geoffroy, 2010). Alternatively, the affective schedule of the Semazens may directly relate to conflict monitoring processes, whereby the internal rewarding features of meditation may not reach conscious awareness. This is also because; the philosophy of Sufism is based on neither social nor monetary reinforcements. It has been referred as the journey to the understanding of Divine, a spiritual contemplation with internal rewarding features (Michon and Gaetani, 2006).

This study had certain limitations. First only 14 individuals participated and recruiting more participants would have increased the power of the study. Second, we only could evaluate the affective traits that were associated with the Sufi Meditation. However, in the literature several other behavioral benefits of meditation were investigated, including increased quality of life and reduced anxiety and depressive symptoms (i.e. Kemeny et al., 2012). Third, using an active control task may have masked more subtle activation patterns in the meditation condition. Notably, the active control condition in our study resulted in several areas that had greater activation than the meditation condition. The activation of the inferior parietal cortex were also demonstrated in another study using a very similar control condition (Baron-Short et al. 2010). In addition, activations in the postcentral areas are mostly related to the expected motor response and have also been shown in other previous studies (i.e. Tomczak et al., 2000). Lastly, we asked the Semazens to imagine whirling during meditation, which may have also lead to activation of motor areas. However, the active control condition in this study, which includes a motor response, may have masked the activations related to the imagination of whirling.

In conclusion, this is the first study investigating the brain correlates of Sema Meditation. In addition to the activations in ACC and OFC, we also found that the activations in ACC may moderate the daily positive affect of the Semazens. To further investigate the behavioral effects of meditation, longitudinal studies are required to reach confident conclusions. This is also important in understanding the role of ACC and related network activity in the course of Sufi Meditation practices such as the whirling dance of Semazens.

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