Autogenic Training Alters Cerebral Activation Patterns in fMRI

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AUTOCGENIC TRAINING ALTERS CEREBRAL ACTIVATION PATTERNS IN fMRI

Marc Schlamann, Ryan Naglatzki, Armin de Greiff, Michael Forsting, and Elke R. Gizewski

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Abstract: Cerebral activation patterns during the first three autosuggestive phases of autogenic training (AT) were investigated in relation to perceived experiences. Nineteen volunteers trained in AT and 19 controls were studied with fMRI during the first steps of autogenic training. FMRI revealed activation of the left postcentral areas during AT in those with experience in AT, which also correlated with the level of AT experience. Activation of prefrontal and insular cortex was significantly higher in the group with experience in AT while insular activation was correlated with number years of simple relaxation exercises. Specific activation in subjects experienced in AT may represent a training effect. Furthermore, the correlation of insular activation suggests that these subjects are different from untrained subjects in emotional processing or self-awareness.

Functional magnetic resonance imaging (fMRI) studies are increasingly used to assess conscious states. Autogenic training (AT) is a common and clinically used relaxation and auto-hypnotic technique essentially based on auto-suggestion (Ernst & Kanji, 2000; Kanji, White, & Ernst, 2006b; Stetter & Kupper, 2002). It is a psychophysiological form of psychotherapy, which can be performed by an individual through passive concentration augmented with certain combinations of psychophysiologically adapted stimuli. However, it is a therapy that is specifically aimed at stress prevention/reduction and has the advantage that once learned an individual can use it without further intervention from a therapist.

The AT technique, developed by Johannes Schultz in 1932, consists of two stages of exercises (Schultz, 1973). The first stage of the autogenic process is focused on relaxation and comprises a series of six exercises:

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1. Tranquility exercise: Should create a state of silence and concentration. Typical imagination: “I am calm. Nothing can disturb me.”
2. Heaviness exercise: Should create a sense of heaviness in the limbs. Typical imagination: “My arms and legs are heavy.”
4. Breath exercise: Concentrated breathing. Typical imagination: “My breath is calm and regular.”
6. Solar plexus exercise: Concentration on the celiac plexus should deepen the relaxation. Typical imagination: “The center is warm.”

The second stage of autogenic training is more abstract. It works on self-awareness and development of the character. It again comprises six exercises: experience of color; perception of objects; perception of morals (e.g., hope, love, and courage); development of the character, “Who am I?” “What should I do?”; journey to the ocean floor; and a trip to a mountaintop.

There are interesting psychological changes ascribed to AT. One study reported greater improvement in trait anxiety but not state anxiety, compared with untreated controls. Further, the AT group showed a statistically significant greater reduction immediately after treatment in systolic and diastolic blood pressure and pulse rate compared to the control group (Atkinson, Thomas, & Cleeremans, 2000). A meta-analysis revealed consistent and significant efficacy of relaxation training in reducing anxiety (Manzoni, Pagnini, Castelnuovo, & Molinari, 2008). In addition, psychoimmunobiological influences seemed to be demonstrated in a study with early stage cancer patients where the women receiving AT showed a strong statistical difference for improvement in their Hospital Anxiety and Depression Scale (HADS) scores. Those women observed in a meditative AT state as opposed to a relaxed state were found to have an increase in their immune responses (Hidderley & Holt, 2004). In summary, AT has been shown to restore the balance between activity of the sympathetic and parasympathetic branches of the autonomic nervous system with important health benefits, as parasympathetic activity promotes digestion and bowel movements, lowers the blood pressure, slows the heart rate and promotes the functions of the immune system. Using this auto-suggestive method can provide a clue to what influences the vegetative nervous system, which can be modulated to a more relaxed state. For example, suggesting a warm arm leads to a dilation of blood vessels, which are associated with a relaxed state, as opposed to a stressful situation where blood vessels are constricted.
Therefore, treatment of such disorders as hypertonia, chronic fear, migraine, chronic pain, Raynaud’s disease, and chronic diarrhea should have positive effects with AT.

The purpose of our study was to investigate cerebral activation patterns due to the first three parts of AT in relation to the degree of experience with this method. Given that Del Gratta et al. (2000) demonstrated that sensory imagination leads to activation of cerebral areas known to be involved in sensory processing and given that it is known, for example, that motor training can lead to altered or, in this case, reduced activation in primary motor brain areas (Krings et al., 2000), our first hypothesis was that all volunteers would be able to activate the somatosensory and motor brain areas while imaging a warm temperature and arm movement.

Our second hypothesis was that AT training should alter the cortical activation patterns. Given that AT training is only mental and does not involve real movements, an extended activation could be more likely than a reduction in activation.

**Method**

*Subjects*

Seven female and 12 male healthy, right-handed volunteers (M = 36 years; range = 22–48) familiar with AT and 11 male and 8 female right-handed volunteers (M = 37 years; range = 19–62) with no AT experience served as subjects. None showed any brain tissue abnormality on a structural MRI nor had a history of neurological disease. In the AT group, only subjects with more than 3 years of regular (more than twice a week) AT practice were included. The experienced volunteers had a mean time of practice of 12 years and a range of 5 to 21. Thirteen of the 19 subjects with AT experience were AT course instructors.

All subjects filled out a short questionnaire concerning handedness, relaxation level while in the scanner, subjective feelings during AT, and degree of relaxation during AT, as well as a motor imagination task using visual analog scales from 0 to 10 with 10 the highest conformity to the question.

*Experimental Design*

All MR images were acquired using a 1.5 Tesla (T) Magnetic Resonance (MR) system (Sonata, Siemens Medical Systems, Erlangen, Germany) with a standard head coil. A three-dimensional longitudinal relaxation time (T1)-weighted FLASH sequence (relaxation time [TR] 10 ms, echo time [TE] 4.5 ms, flip angle 30°, field of view [FOV] 240 mm, matrix 512, slice thickness 1.5 mm) was acquired for individual coregistration.
of functional images. BOLD contrast images were acquired using an echo-planar technique (TR 3100 ms, TE 50 ms, flip angle 90°, FOV 240 mm, matrix 64) with 34 transverse slices with a thickness of 3 mm and 0.3 mm slice gap covering the whole brain. Three “dummy” scans were eliminated prior to data analysis to account for T1 relaxation effects.

Each subject underwent two functional sessions in a typical block design. The first session consisted of AT (calmness, arm heavy and warm) imagination alternating with a resting period without instructions for imagination every 31 seconds. The second session was motor imagination (bending the right arm) alternating with the resting period every 31 seconds. Each run was divided into seven epochs starting with the resting condition. During the scanning, subjects were asked to lie relaxed with eyes closed inside the scanner.

Data Analysis

For fMRI data analysis, statistical parametric mapping (SPM) 02 software (Wellcome Department of Cognitive Neurology, London, UK) was used. Prior to statistical analysis, images were realigned utilizing sinc interpolation and normalized to the standard stereotactic space corresponding to the template from the Montreal Neurological Institute. Bilinear interpolation was applied for normalization. The images were smoothed with an isotropic Gaussian kernel of 8 mm. A voxel-by-voxel comparison according to the general linear model was used to calculate differences in activation between active and resting conditions. The model consisted of a box-car convolved with the hemodynamic response function (hrf) and the corresponding temporal derivative. High-pass filtering with a cutoff frequency of 128 s and low-pass filtering with the hrf were applied.

For group analysis, single-subject contrast images were entered into a random effects model. Significant signal changes for each contrast were assessed by means of t statistics on a voxel-by-voxel basis (Friston et al., 1995). The resulting set of voxel values for each contrast constituted a statistical parametric map (SPM) of the t statistic. The threshold was set to $p < .001$ (corrected for multiple comparisons). Second-level analyses for group differences were performed with a two-sample t test. A random effects analysis was performed using the years of AT experience as a confounding variable. The threshold for sensory-motor areas was then set to $p < .001$ (uncorrected for multiple comparisons).

Results

The results of the first items of the questionnaire revealed no significant t test differences ($p > .05$) between the two groups; the subjective
Table 1

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration during AT</td>
<td>7.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Concentration during neutral task</td>
<td>6.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Concentration during motor task</td>
<td>7.7</td>
<td>7.4</td>
</tr>
<tr>
<td>Subjective success AT</td>
<td>6.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Subjective success motor task</td>
<td>6.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Relaxation during AT</td>
<td>7.6</td>
<td>8.1$^a$</td>
</tr>
<tr>
<td>Relaxation during neutral task</td>
<td>7.1</td>
<td>6.8$^a$</td>
</tr>
</tbody>
</table>

Note. The mean values for each group and condition are given as rated using a visual analogue scale from 0 to 10. The questionnaire was completed immediately after the scanning session.

$^a$The comparison of these items was significant with $p < .002$. The other comparisons were not significant at $p < .01$.

influence of the setting within the MR scanner and claustrophobic feelings were rated similar in both groups. All subjects were right-handed. The specific ratings for each session are summarized in Table 1. Significant differences were found ($p < .01$) in subjective relaxation during AT and neutral task in the group with experience in AT. The subjective success of the AT and motor task showed a trend to higher ratings in the AT group.

Group analysis in a one sample $t$ test revealed activation of the left pre- and postcentral cortex during the first two steps of AT in contrast to resting state in the group of volunteers experienced in AT (Figure 1a). Group analysis in a one-sample $t$ test revealed activation of the left parietal cortex during the first two steps of AT in contrast to resting state in the group of volunteers without experience in AT (Figure 1b). In addition, activation of prefrontal and insular cortex was found in both groups but with a slightly higher degree in the group of subjects with experience in AT. In the control task with imagination of movement of the right arm, activations in the corresponding sensory-motor areas in both groups was revealed (see Table 2). Again, the group of volunteers with AT experience revealed a higher degree of activation and additional postcentral activation at the same uncorrected $p < .001$ that was used for the control group.

The activation of the left insular cortex correlated with the years of experience in the group of volunteers exercising AT (coordinates: $-40$, $-6$, $14$; $t = 4.55$).

Comparison analysis of the AT group and the control group revealed activation in the prefrontal cortex and the postcentral cortex on the left side and in the postcentral cortex on the right side in the group with
CEREBRAL ACTIVATION DURING AUTOGENIC TRAINING

Figure 1. Statistical parametric maps of activation within the groups of volunteers during AT overlaid on a 2D standard brain. Group analysis in a one sample t test revealed activation of the left postcentral, prefrontal, parietal, and insular cortex during the first two steps of AT in contrast to resting state in the group of volunteers experienced in AT (A). The group of non-AT-trained subjects did only reveal activation in prefrontal, parietal, and insular cortex during the first two steps of AT in contrast to resting state (B). The statistically corrected threshold is $p < .05$ in both groups. The two-sample t test revealed activation in prefrontal and postcentral on the left side and postcentral on the right side in the group with AT experience compared to the control group (C). The statistically uncorrected threshold is $p < .001$.

AT experience (Figure 1c). During the motor task, additional activation was revealed in the precentral and prefrontal cortex in the group with AT experience compared to the control group (Table 3). Comparing the control group with the AT group, no significant activation could be detected in either task. The activity strength was also greater in the AT-experienced group in contrast to the control group.

**Discussion**

Some studies attempted to evaluate controlled trials of AT as a means of reducing stress and anxiety levels in human subjects, but no firm conclusions could be drawn even from systematic reviews (Ernst & Kanji, 2000). A later study on the effectiveness of AT in
Table 2
Cerebral Activation During First Steps of AT and Motor Imagination

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Group</th>
<th>Talairach Coordinates (mm)</th>
<th>Region (Cortex)</th>
<th>Side</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First parts AT</td>
<td>AT</td>
<td>−8; −62; 60</td>
<td>Postcentral BA 7</td>
<td>L</td>
<td>6.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−26; −44; 60</td>
<td>Postcentral BA 5</td>
<td>L</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−38; 24; 50</td>
<td>Sup. frontal BA 8</td>
<td>L</td>
<td>6.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−2; −18; 58</td>
<td>Med. frontal BA 6</td>
<td>L</td>
<td>4.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48; 8; 10</td>
<td>Insular</td>
<td>R</td>
<td>5.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−34; −10; 2</td>
<td>Insular</td>
<td>L</td>
<td>5.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−50; −62; 20</td>
<td>Med. temporal (BA 39)</td>
<td>L</td>
<td>5.11</td>
</tr>
<tr>
<td></td>
<td>Non-AT</td>
<td>−12; −8; 62</td>
<td>Med. frontal (BA 6)</td>
<td>L</td>
<td>3.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−6; −14; 58</td>
<td>Med. frontal (BA 6)</td>
<td>L</td>
<td>3.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−56; −26; 28</td>
<td>Inf. parietal (BA 40)</td>
<td>L</td>
<td>5.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−32; −14; 6</td>
<td>Insular</td>
<td>L</td>
<td>3.86</td>
</tr>
<tr>
<td>Motor imagination</td>
<td>AT</td>
<td>−8; −58; 62</td>
<td>Postcentral BA 7</td>
<td>L</td>
<td>5.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−22; −44; 58</td>
<td>Postcentral BA 5</td>
<td>L</td>
<td>9.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−24; −8; 66</td>
<td>Sup. frontal BA 6</td>
<td>L</td>
<td>11.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−60; −32; 26</td>
<td>Inf. parietal (BA 40)</td>
<td>L</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>Non-AT</td>
<td>−36; −44; 70</td>
<td>Postcentral BA 5</td>
<td>L</td>
<td>4.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−14; −4; 64</td>
<td>Sup. frontal BA 6</td>
<td>L</td>
<td>6.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−50; −44; 58</td>
<td>Inf. parietal (BA 40)</td>
<td>L</td>
<td>8.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>−54; −32; 34</td>
<td>Inf. parietal (BA 40)</td>
<td>L</td>
<td>8.23</td>
</tr>
</tbody>
</table>

Note. Activated areas in a one-sample t test for the group of AT practitioners (AT) and for the control group (non-AT) are given. Only p < .001 (corrected) is reported in Talairach coordinates and cortex regions. To report the strength of activation the t value is added for each region.

Reducing anxiety in nursing students revealed a short-term effect in alleviating stress (Kanji, White, & Ernst, 2006a). Especially for AT, there are only rare studies analyzing its effects on pain reduction (Kwekkeboom & Gretarsdottir, 2006). Due to these apparently contradictory results, fMRI studies were needed to shed further light on the potential effectiveness and the mechanisms of AT.

Our results indicate significant effects are wrought by AT concerning the hypnotic auto-suggestive imagination of a heavy and warm right arm on the cerebral activation patterns. In this study, we demonstrated that sensory imagination in hypnosis can be used to activate cerebral areas known to be involved in sensory processing (Del Gratta et al., 2000). Subjects with AT experience revealed a greater activation in sensory and prefrontal areas compared to the control group with no experience in AT. Interestingly, both groups did not differ significantly
Table 3

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Group</th>
<th>Talairach Coordinates (mm)</th>
<th>Region (Cortex)</th>
<th>Side</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First parts AT</td>
<td>AT versus Non-AT</td>
<td>−14; −58; 66</td>
<td>Postcentral BA 7</td>
<td>L</td>
<td>3.65</td>
</tr>
<tr>
<td></td>
<td>Non-AT</td>
<td>−50; −24; 52</td>
<td>Postcentral BA 1</td>
<td>L</td>
<td>4.06</td>
</tr>
<tr>
<td></td>
<td>Non-AT</td>
<td>−26; −14; 68</td>
<td>Postcentral BA 3</td>
<td>L</td>
<td>4.64</td>
</tr>
<tr>
<td></td>
<td>Non-AT</td>
<td>32; −62; 62</td>
<td>Postcentral BA 7</td>
<td>R</td>
<td>4.00</td>
</tr>
<tr>
<td>Motor</td>
<td>non-AT</td>
<td>−10; −66; 66</td>
<td>Postcentral BA 7</td>
<td>L</td>
<td>4.64</td>
</tr>
<tr>
<td>imagination</td>
<td>AT versus Non-AT</td>
<td>−18; 2; 70</td>
<td>Sup. frontal BA 6</td>
<td>L</td>
<td>3.56</td>
</tr>
<tr>
<td>Non-AT</td>
<td>versus AT</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Note.** Activated areas in a two-sample t test for the group of AT practitioners (AT) compared to the control group (non-AT) during the first parts of AT and the motor task each compared to resting condition are given. Only p < .001 (uncorrected) is shown.

in reported subjective relaxation during the AT task, but the difference between the neutral task and AT was significantly higher in the AT group than in the control group. This might be related to the significant activation revealed by the two-sample t test comparing the AT group with the control group. The cerebral increase in activation in the AT group could be interpreted as an up-regulation of cerebral activity due to altered sensory information during the imagination process. In some respects, this finding could be interpreted as a plasticity of the cerebral cortex as it was described in other tasks such as piano playing (Krings et al., 2000). But, contradictory to the reduced activation in professional piano players, the AT trained subjects revealed a stronger activation in sensory areas compared to the control group. In contrast to such studies, the training in AT is not a “peripheral” training but more a “mental” training. Therefore, the training effect of AT might be more comparable to differences in brain activity between musicians and nonmusicians. Despite behaviorally matched performance, the two groups showed significant differences in functional brain activity during improvisation. In this study, musicians even deactivated the right temporoparietal junction (rTPJ), while nonmusicians showed no change in activity in this region. This suggests that the musicians’ deactivation of the rTPJ during melodic improvisation may represent a training-induced shift toward inhibition of stimulus-driven attention, allowing for a more goal-directed performance state that aids in
creative thought (Berkowitz & Ansari, 2010). A further study addressing imagination of skills and training was published in 2009 by Wei and Luo. Sport experts in this study showed significant activation in the parahippocampus while imagining skills that they performed professionally, as opposed to the novices, which might reflect the representation adapted to experience-related motor tasks. No significant difference was found between experts and novices when they imagined simple motor skills. A further study might be of importance to a study by Lutz, Greischar, Perlman, and Davidson (2009), who showed an expertise-related increase of activation of post- and precentral regions during meditation.

Brodmann area (BA) 7 was activated only in the group trained in AT. Interestingly, this occurred bilaterally. In addition to BA 6, the BA 7 was shown to modulate the extraction of sensory-relevant information (Meehan & Staines, 2007). Therefore, our results indicate an altered processing, possibly due to the directed attention in the AT-trained subjects.

Further, this enhanced activation of the prefrontal areas was also present in the AT group during the motor imagination. This suggests a generalized training effect on cerebral activation of AT training. Those subjects used to performing imagination of sensory processes also seem to perform a similar imagination task (the motor imagination) more successfully than the subjects without AT experience. This may explain the general relaxation process of AT during regular practice. Both groups could activate the areas involved in motor processing (Castelli, Happe, Frith, & Frith, 2000; Wiese, Stude, Nebel, Forsting, & de Greiff, 2005). However, an interesting finding was that there was a stronger and more extended activation of BA 40 in the group of subjects not trained in AT. This area is known to be involved in sensory and motor processing and in associative and integrative processes (Caspers et al., 2006; Naito, Roland, & Ehrsson, 2002). It appears that preparatory attention modulations occur in higher order motion-processing regions like BA 40 (Luks & Simpson, 2004). BA 40 was also activated in this group during the AT task but not in the group of AT practitioners. Therefore, the extended activation in the nontrained group may represent enhanced cerebral network processing to perform both tasks and a generalization of training effect in the AT group even in tasks not directly trained during AT practice. These theories are of special interest as the subjective rating of success in motor imagination that was similar in both groups as assessed by the questionnaire.

A significant finding was the correlation of the insular activation with the number of years of AT training. The insular was also activated in the subjects without experience in AT, which might represent the normally associated positive feeling during AT (O’Doherty, Rolls, Francis,
But the dependence on the years of AT practice might represent the increase in emotional connection to the sensory information. Additionally, the enhanced prefrontal activation in the AT group compared to the volunteers without experience could be a representation of altered emotional processes even when starting the AT commands. However, studies addressing other forms of meditation like mindfulness meditation might also reveal significant insular activation in the trained group (Farb et al., 2007). Furthermore, this group demonstrated an uncoupled connectivity of insular and prefrontal activation in trained subjects and concluded that these results suggest a neural dissociation between distinct forms of self-awareness. The insular cortex is described to be of primary importance for the integration of sensory information with the emotional context. Via connections to the amygdala and brain stem, the anterior cingulate and insular cortex can elicit and coordinate affective and autonomic reactions (Derbyshire, 2003; Neafsey, 1990). The left insular cortex especially was described as representing a strong neurovisceral coupling (Lutz et al., 2009). These theories could explain the insular activation even during the first steps of AT where a complete relaxation should not be present.

A limitation of this study is that only the first three steps of AT were used. This was due to the blocked design paradigm at fMRI studies. Therefore, no clear conclusion can be drawn concerning the influence of the full relaxation during AT. Nonetheless, the study demonstrated an influence on cerebral activation even in the first three steps of AT. Furthermore, the MR scanner with its loud noise and narrow gantry might have influenced our findings dealing with relaxation methods. Nonetheless, at least one study clearly demonstrated that hypnosis can be employed and investigated using fMRI (Oakley, Deeley, & Halligan, 2007).

In conclusion, activation of sensory areas can be affected due to AT, which may be a training effect due to imagination of special sensory qualities. Furthermore, the correlation of insular activation with the years of practice could represent a different emotional processing after years of training.

**References**


Autogenes Training verändert zerebrale Aktivität muster im fMRI

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Jan Mikulica

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L’entraînement autogène modifie les modes de recrutement cérébraux dans l’imagerie par résonance magnétique fonctionnelle (IRMF)

Marc Schlamann, Ryan Naglatzki, Armin de Greiff, Michael Forsting et Elke R. Gizewski

Resumen: Investigamos los patrones de activación cerebral durante las tres primeras fases sugestivas de auto-entrenamiento autógeno (EA) en relación con las experiencias percibidas. Estudiamos con activación de la resonancia magnética funcional (fMRI) a 19 voluntarios entrenados en EA y 19 controles durante las primeras fases del entrenamiento autógeno. El FMRI reveló una activación de las áreas poscentrales izquierdas durante EA en aquellos con experiencia en EA, que también se correlacionó con el nivel de experiencia con EA. La activación de la corteza prefrontal e insular fue significativamente mayor en el grupo con experiencia en EA, mientras que la activación insular se correlacionó con experiencia en ejercicios simples de relajación. La activación específica en los participantes con experiencia en EA puede representar un efecto del entrenamiento. Además, la correlación de la activación insular sugiere que estos participantes difirieron de los principiantes en el procesamiento emocional o conciencia de sí mismos.

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