Chapter 2

Inner Design Technology: Improved Affect by Quadrato Motor Training

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Additional information is available at the end of the chapter

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Abstract

The relation between positive affect and negative affect is a predictor of emotional well-being. In addition, healthy neuronal synchronization is associated with higher emotional well-being and positive affect. Related to this, recent studies have consistently reported that Quadrato Motor Training (QMT), a sensorimotor-cognitive training, increases alpha synchronization and emotional well-being in healthy participants. QMT was further found to improve creativity, reflectivity, and mindfulness-related experiences in healthy participants. In the current research, we have examined the effect of QMT on emotional well-being using the Affect Balance Scale (ABS), comparing two 1-week training programs: (1) breathing meditation retreat with QMT training (QMT, $n = 42$) and (2) breathing meditation retreat without QMT (BM, $n = 42$). While both groups reported improved affect and self-efficacy following the training, the QMT group reported significantly higher ABS scores following the retreat. QMT can thus improve well-being and emotional regulation as measured by the ABS. The current results strengthen previous claims that different practices, such as BM and QMT, may improve emotional well-being. These results are discussed in the context of the possible mechanisms mediating training-induced improved affect, focusing on the amygdala and neuronal synchronization. In conclusion, incorporating specifically structured motor and mindful practices may serve as important tools to facilitate greater emotional well-being.

Keywords: affect, self-efficacy, Quadrato Motor Training, synchronization

1. Introduction

Accumulating behavioral and physiological evidence suggests that emotions are grounded in *core affect*, namely, the fluctuating level of pleasant or unpleasant arousal. Neuroimaging

studies reveal that participants' subjective ratings of valence (i.e., pleasure/displeasure) evoked by positive and negative experiences are correlated with neural activity in specific brain regions (orbitofrontal cortex and amygdala, respectively) [1]. Initial processing of emotional content occurs in various structures of the limbic system, such as the amygdala [2]. The amygdala has been especially linked to fear processing, ranging from fear conditioning, the modulation of attention and memory for fear-related stimuli, the induction of fear-related behaviors [3–5], stress response, and memory consolidation of newly acquired information through its projections to other brain structures [6].

The problem is that as we age, brain structures mediating the experience of negative affect become more easily activated [7, 8]. Such heightened sensitivity leads to a vicious cycle of increased manifestation of negative affect under stress, which in turn is related to additional aversive emotional and physical health outcomes [9]. Luckily, this mostly automatic process of enhanced emotional sensitivity [10, 11] can be influenced through training, such as meditation. For example, expert meditators showed less activation in the amygdala during focused attention meditation compared to novice meditators [12]. Decreased activation in the amygdala during a computerized emotion visualization task was also reported following an eight-week (2 h of class time per week) mindful attention training [13].

Along with decreased activation of the amygdala, meditation is known to enhance alpha synchronization, which has been suggested to support emotional regulation [14–18]. In fact, different practices, such as breathing meditation (BM), improve emotional and physical well-being as well as cognitive functions (e.g., information processing and attention) [17–22]. For example, intensive meditation/emotion regulation interventions have been found to reduce negative affect, rumination, depression, and anxiety and to increase positive affect and *Mindfulness* [23].

Mindfulness, as an attribute of consciousness, can be defined as the clear minded awareness of the present moment [20]. Mindfulness can be achieved by many ways, and is important for disengaging from automatic thoughts (such as "no one likes me," "I can't stand feeling this way"), habits and unhealthy behavioral patterns. It plays a key role in fostering and orienting attention, thus adding clarity to the experience, which in turn can significantly contribute to well-being and happiness [20, 24, 25]. Mindfulness-based training is associated with reduced anxiety [26]; adaptive response to stress [27]; decreased ego-defensive responsivity under threat [24]; decreased difficulties regulating emotions [28]; and reduced emotional interference resulting from unpleasant stimuli and less prolonged physiological reactivity to negative emotional stimuli [29].

Similar to sitting meditation techniques, a novel movement meditation, Quadrato Motor Training (QMT), has also been found to improve different cognitive functions, such as creativity and spatial cognition (for review see [18]). QMT was further found to increase alpha synchronization [30, 31], mindfulness, and emotional well-being [17]. In a recent pilot study, we further found improved emotional well-being following a month of daily QMT in contrast to Simple Motor Training (SMT) in university students [32], as assessed using the Affect Balance Scale (ABS) [33].

Bradburn's [33] classic work on the structure of psychological well-being provided the initial distinction between positive and negative affect. Thus, Bradburn's Affect Balance Scale [33] is based on the definition of "happiness" as a preponderance of positive over negative affect (PA and NA, respectively). Affect balance can be defined as the difference between positive affect and negative affect, with a high score meaning that positive feelings outbalance negative feelings [33], which can, in turn, promote resilience and coping with stress [34–36].

High General Self-Efficacy (GSE) is also considered a resource that buffers against stressful experiences, as high self-efficacious individuals perceive demands as challenging, not as threatening [37]. Physical exercise, as well as different meditation practices, such as Tai Chi, has been found to enhance self-efficacy (for reviews, see Refs. [38, 39]). Nevertheless, to the best of our knowledge, no studies have compared the effects of sitting versus movement meditation on self-efficacy.

Consequently, in the current study, we chose to examine the effects of QMT and of breathing meditation (BM) on emotional well-being using the Affect Balance Scale (ABS) and on General Self-Efficacy (GSE) [40]. To this aim, we compared two one-week intense training programs: (1) breathing meditation retreat with QMT training (QMT) and (2) breathing meditation retreat without QMT (BM). Since both physical exercise and meditation have previously been linked to increased synchronization and emotional well-being [15, 16, 18] and based on our previous results demonstrating QMT-induced enhanced local alpha synchronization in the frontal and parietal lobes as well as alpha parietal-limbic and occipito-limbic connectivity and emotional well-being, we hypothesized that the unique combination of mindfulness and specifically structured movement will have a greater effect on emotional well-being, resulting in greater improvement in affect balance and self-efficacy.

2. Methods

2.1. Participants and design

A total of 84 participants volunteered in the study, which took place in the Research Institute for Neuroscience, Education and Didactics of the Patrizio Paoletti Foundation. The participants signed an informed consent, and the study was approved by the ethics committee of Bar-Ilan University. At each time point, participants also reported their emotional and psychological condition using two questionnaires, the Affect Balance Scale (ABS) [33] and General Self-Efficacy (GSE) Scale [40]. The ABS and GSE were completed at the beginning of the week and at the end of the retreat.

Volunteers were recruited from participants who were registered for two different one-week intense retreats organized by the Ideas—Knowledge of Excellence, International School of Self-Awareness: (1) breathing meditation retreat with QMT training (QMT, n = 42) and (2) breathing meditation retreat without QMT (BM, n = 42). As specific brain activation patterns are linked to different kinds of exercise and participants' physical exercise preferences, the volunteers could decide for themselves in which intense training to participate. The retreats

consisted of lectures, discussions, and meditations. Participants arrived on day 1, which included an evening introduction and guided meditation. Days 2–5 consisted of lectures, discussion, and 3–4 h of meditation that was done in a group setting. On the 6th day, participants met for the morning session and the retreat ended at noon. Participants were given explicit instructions both before and during guided meditations at the beginning of the retreat, though the frequency of instruction during the guided meditations decreased as the retreat continued. Across the retreats, the sitting meditation sessions consisted of breathing meditation, emphasizing physical and mental relaxation and maintaining attention on the breath [41].

The QMT group included additional two sessions of daily QMT sessions, which were conducted once in the morning and the afternoon of days 2–5 in group setting. During QMT, each participant stood at one corner of a 0.5 m × 0.5 m square and was asked to make a step in one of three directions in response to verbal instructions given by the instructor. Participants were instructed to keep the eyes focused straight ahead and their hands loose at the side of the body. They were also told to immediately continue with the next instruction and not to stop due to mistakes. At each corner, there are three possible directions to move. The training thus consists of 12 possible movements (3 directions × 4 corners): 2 forward, 2 backward, 2 left, 2 right, and 4 diagonals. For example, if the sequence required is 1, 2, 1, 2, 1, 2, 3, 2, 4, 3, 1…. this means moving to the first corner, then to the second, then back to the first, and so on. See **Figure 1** for a graphical illustration.

2.2. Measures

2.2.1. Affect Balance Scale (ABS)

The purpose of the Affect Balance Scale is to assess positive and negative affect as indicators of life satisfaction or well-being [33]. It comprises a 10-item scale, with five items that measure positive affect and five that measure negative affect, asking the participants to answer if they have felt certain emotions in the past week on a four-point scale ranging from never, rarely, sometimes, and frequently. Final scoring was conducted by subtracting the average of the negative affect (NA) items from the average of the positive affect (PA) items [33–35].

The ABS has been extensively used in empirical research with a broad range of populations since its development. In a study of 2735 adults, Bradburn [33] reported the reliability coefficients for each component (PA, NA) of the ABS score. These were 0.83 for PA and 0.81 for NA, reflecting the consistency of the subscales [33]. Reliabilities reported in other studies in the literature have ranged from 0.55 to 0.73 for PA and from 0.61 to 0.73 for NA [42]. In the current study, we found the reliability coefficients for pre- and posttraining to be 0.66 and 0.68 for PA and 0.55 and 0.65 for NA.

2.2.2. The General Self-Efficacy Scale (GSE)

The General Self-Efficacy Scale has the aim to assess a general sense of perceived self-efficacy, through a 14-item questionnaire that reflects the respondent's beliefs regarding his or her

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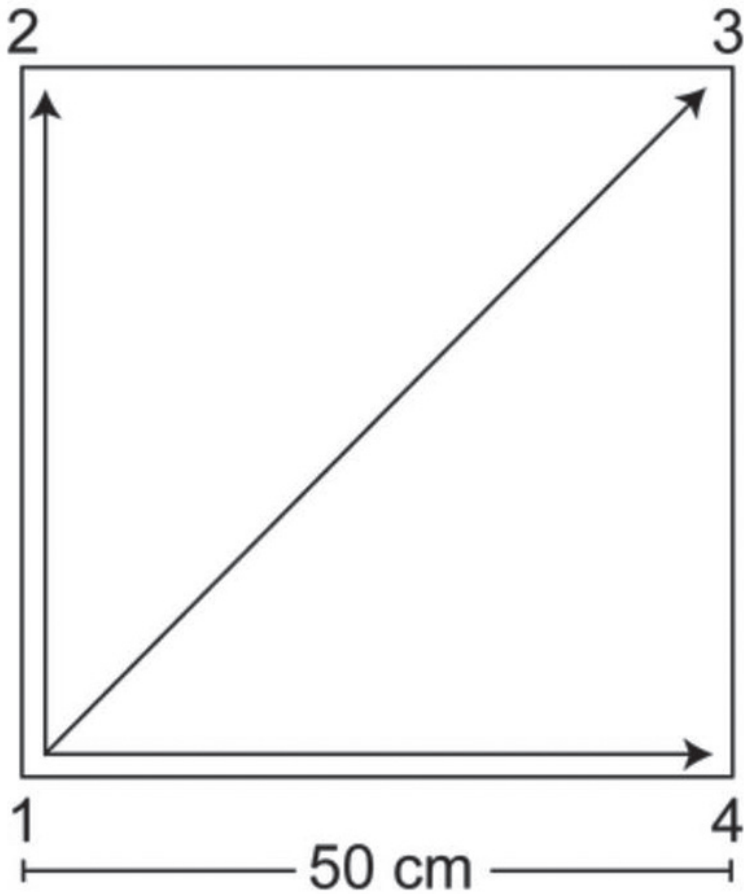

Figure 1. Graphical illustration of the Quadrato Motor Training.

capacities [40]. The participant was asked to state the degree to which he or she agrees with each of the statements in the questionnaire on a scale ranging from "1" (strongly disagree) to "5" (strongly agree). The total scores on the questionnaire range from 14 to 70, with the highest score reflecting higher self-efficacy. The reliability of the GSE is generally high (α = 0.90). The scale's reliability coefficient obtained in this study was 0.90 and 0.89, pre- and posttraining, respectively.

2.3. Statistical analysis

To answer the question regarding the effects of QMT on well-being, we ran a Group (QMT, BM) × Training (pre-, post-) analysis of variance (ANOVA) on the ABS score, and on the GSE

score, separately, adopting the Greenhouse-Geisser criterion. Whenever needed, we added *post hoc paired sampled t* tests.

3. Results

There were no baseline (pre-) difference between groups for the ABS [$t(82)$=1.16, ns]. Mean and STD for QMT and BM were 0.8 (±0.9) and 1.1 (±0.7). A significant Group × Training interaction was found for ABS [$F(1,82) = 4.83$, $p < 0.05$] with significantly higher increase in ABS score for QMT compared to the BM intense training [$t(82) = -2.2$, $p < 0.05$]. See **Figure 2**, presenting the data for the change in ABS.

No base line differences nor a Group × Training interaction were found for GSE [$F(1,82) = 0.99$, ns]. The main effect for training was significant for both ABS and GSE [$F(1,82) = 60.16$ and 38.65, respectively, $p < 0.01$], indicating an increase in score for both measures following training. For the GSE, the increase was from 50.39 to 54.64 posttraining.

In addition, while there was no correlation between ABS and GSE before training ($r = 0.14$, ns), we found a significant correlation between these measures following the retreat ($r = 0.23$, $p < 0.05$, $n = 84$), as can be seen in **Figure 3**.

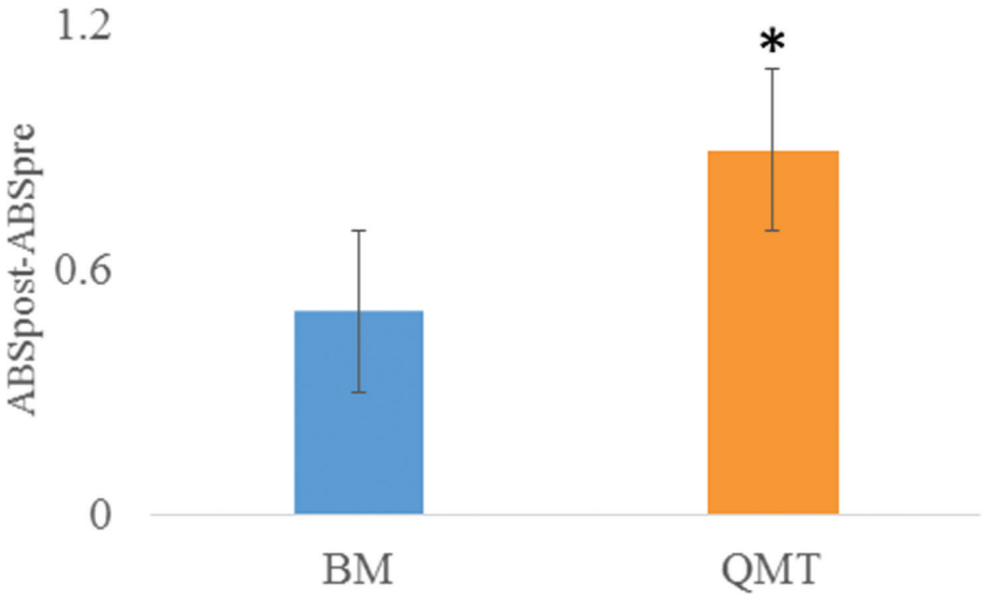

Figure 2. Change in Affect Balance Scale score as a function of Group and Training. Change in Affect Balance Scale score was calculated by subtracting ABS score before the training (ABSpre) from the ABS score following the training (ABSpost).

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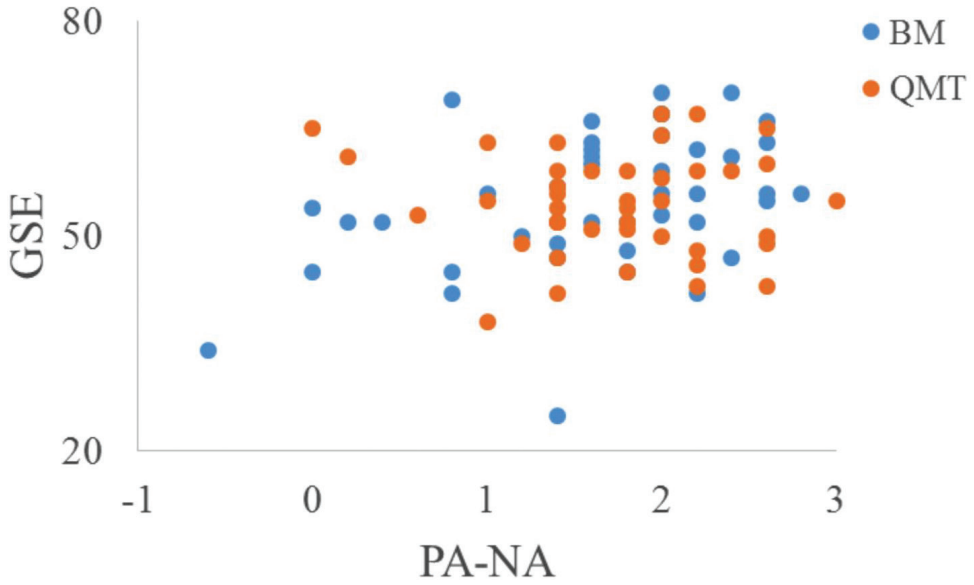

Figure 3. Correlation between Affect Balance Score (PA-NA) and General Self-Efficacy (GSE) following training.

4. Discussion

In the current study, we have found that 1 week of intense training combining breathing meditation and QMT can significantly increase the affect balance. The current results are consistent with previous findings that mindfulness-based interventions were associated with lowered intensity and frequency of negative affect [20, 43]. They are further in line with previous findings regarding QMT-induced affect balance in contrast to simple motor training (SMT) in university students [32], emphasizing the specific effects of QMT, as opposed to simple motor training without the mindfulness aspect. Here we further demonstrate that the combination of BM and QMT has an added value to affect balance compared to intense BM training.

4.1. Possible underlying mechanisms mediating QMT-induced increased affect balance

We build on the previous QMT-induced electrophysiological and cognitive changes and the meditation literature to posit the possible underlying mechanisms of QMT-induced changes in affect. We suggest three interrelated possible underlying mechanisms that might mediate this change: (1) neuronal synchronization and connectivity with limbic areas, especially within the alpha band (8–12 Hz); (2) activity of the default mode network (DMN); and (3) improved allocation of attention following training.

First, based on our previous results and model of an interrelationship between alpha synchronization, improved cognitive, emotional, and bodily function [18, 44–46], we hypothesize that the effects of QMT on affect balance may have resulted from increased alpha activity. Alpha activity has consistently been found to increase following QMT, especially within frontal and parietal areas, as well as between occipito-limbic areas [30, 31, 46, 47]. The occipito-limbic circuit links the occipital cortex and amygdala and is usually activated in response to emotional processing [48–50]. Interestingly, this network is dysfunctional in affective disorders and impulsivity [51].

In fact, alpha activity has been linked to emotional well-being [52, 53]. Supportive evidence of this hypothesis comes also from the fact that both physical exercise and meditation increase frontal alpha activity [53, 54], and that this effect is thought to be independent of meditation technique and degree of experience [14].

Second, neuronal synchronization in the alpha range is negatively correlated with default mode network (DMN) activity [55]. The DMN, which includes regions such as the amygdala, hippocampus, and ventromedial prefrontal cortex, is thought to mediate negative emotions. While DMN activity is related to negative emotion, meditation is known to decrease DMN activity [56, 57].

Third, the DMN is further related to mind-wandering and autobiographic self-processing (for review see [58]). An antagonistic network to the DMN is the *attentional extrinsic system* related to self-processing, defining the self as the momentary agent of experience [57]. Mental states that explicitly involve the control of attention allocation, such as mindfulness training, require the participant to bring greater awareness to the present moment and to the body [56, 59, 60]. This allocation of attention may permit the modulation of negative emotions (e.g., [61, 62]). QMT, similar to other mindfulness training paradigms, increases attention to the body and to the present moment but perhaps in a greater frequency, as it requires constant attention to the incoming instruction and consequently responding to it [17]. This in turn can be mediated by increased synchronization [18], thus enabling a state of increased affect balance.

4.2. Self-efficacy, the DMN, and the importance of aims

In addition, we found that self-efficacy significantly increased following a week of intense training. The construct of self-efficacy reflects an optimistic self-belief that one can cope with adversity and difficulty in various domains of human functioning [37]. Self-efficacy facilitates goal-setting and can be regarded as a source of resilience and, therefore, is relevant for behavior change. The current result is especially important as reactivity to stress increases as we grow older due to a lifetime of repeated activations of the neural systems that mediate negative affect, including the limbic system and the amygdala [44, 63].

Automatic responses to affective stimuli and stress can disrupt performance during demanding goal-directed behavior as compared to neutral stimuli [10]. Noteworthy in this context is the fact that DMN activity decreases during goal-directed tasks compared to baseline rest conditions; while the sensorimotor and attention-related cortices become activated during goal-directed tasks [64, 65]. These important observations have practical implications for

health and well-being, through the orientation of attention and can be modulated by training mindfulness. For example, neuroimaging studies have shown that even simply verbally labeling affective stimuli activates right ventrolateral prefrontal cortex and attenuates responses in the amygdala through the ventromedial prefrontal cortex [66–68]. DMN activation can be reduced with attention focused on breath-related sensations [69].

This goal-directed behavior occurs both in breathing meditation, in which the participant is instructed to focus on his breath, as well as during the QMT, emphasizing the importance of training. In addition, we found that while there was no correlation between ABS and GSE scores prior to training, there was a significant correlation between them following training. The relationship between affect balance and self-efficacy in the literature is not strong [70] and can perhaps be strengthened by training.

In conclusion, the current results suggest that QMT can be advantageous for improving affect, and that training can improve perceived self-efficacy. The current findings are in line with recent results demonstrating QMT-induced increased connectivity in the limbic system and strengthen previous claims that mindfulness practices and sensorimotor training may improve well-being. The examination of emotional changes resulting from mindful movement trainings should be conducted in parallel to the examination of changes in neuronal synchronization and functional and structural connectivity. Although we have not conducted this in the current study, future studies should be conducted in order to verify whether local alpha oscillations and limbic connectivity as well as the DMN comprise the underlying electrophysiological mechanism mediating the change in affect. We are currently working in this direction.

At this historic moment, which is characterized by exponential external technological development, which increasingly influences our lives, we need tools to help us cope better with induced stress. What may be required in order to keep pace with this rapid development is a work on the *Inner Design Technology*, in which people, through different training paradigms such as mindfulness and QMT, can manage their emotions. Inner Design Technology and neuroplasticity though training may aid in advancing a state of improved affect and cognition.

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