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Short-Term Effects of Dynamic Emotional Bodily Movements on Emotion Regulation

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Abstract

The influence of facial expressions on emotional experience is well established through the facial feedback hypothesis, but the role of postures and full-body movements in emotion regulation is less explored. This study examined the immediate and short-term effects of dynamic bodily movements associated with happiness and sadness on mood. Forty-four healthy adults participated in two experiments; the first assessed immediate affect using the Positive and Negative Affect Schedule (PANAS), whereas the second assessed mood before, immediately after and six hours after movement using the Oxford Happiness Questionnaire (OHQ) and Beck Depression Inventory (BDI). In Experiment 1, movements associated with happiness increased positive affect, whereas movements associated with sadness and fear increased negative affect immediately. These immediate findings provide preliminary evidence that specific bodily movements can shift self-reported affective state in healthy adults. Because the study used a healthy sample and self-report outcomes without a motor-matched non-emotional control condition, any clinical application remains speculative; controlled trials with objective outcome measures are needed before therapeutic claims can be made.

Introduction

The ability to effectively regulate one's emotions is a critical aspect of human cognition and behavior. Traditionally, body language has been conceptualised as an external manifestation of internal emotions through posture and movement (Ekman & Friesen, 1969; Mehrabian, 1972). However, research suggests that postures and movements can also influence emotional states (Atkinson et al., 2004; Bushman et al., 1999; Shafir et al., 2013, 2016).

This concept was first introduced in James-Lange theory (James, 1884), which posits that emotions are consequences of autonomic system activation. Contrary to common belief, this theory suggests that emotions emerge from physical sensations rather than the other way around (Davis et al., 2010). Early studies focused on facial proprioception and demonstrated that facial expressions can influence subjective emotional experiences, supporting the facial feedback hypothesis. This hypothesis proposes that producing specific facial expressions can influence corresponding emotional experiences, challenging the traditional unidirectional view of emotion(Adelmann & Zajonc, 1989; Dimberg, 1982). This line of research has expanded our understanding of the bidirectional relationship between physical movements and emotional states, highlighting the importance of both bottom-up and top-down processes in emotion regulation.

McIntosh (1996) proposed multiple plausible mechanisms for facial effects on emotions, suggesting that facial actions might influence the occurrence of specific emotions, not just their valence and intensity. The evidence for bottom-up processing of emotion is strong enough that smiling is now used in therapies such as dialectical behavior therapy (Barrett et al., 2019). Research indicates that proprioception from facial muscles can activate neuronal networks that influence emotional experience (Buck, 1980; Lee et al., 2006). Studies have shown that manipulating facial expressions can modulate the experience of emotion (Söderkvist et al., 2018).

These facial effects are best understood as one instance of a broader claim advanced by embodied accounts of emotion. Theories of emotion simulation propose that configuring the facial and bodily musculature partially re-enacts the sensorimotor state associated with an emotion, activating emotion-congruent schemas that in turn shape perception, cognition and affect (Barsalou, 2008; Gallese, 2006; Niedenthal, 2007). On this account the face holds no privileged status: any peripheral configuration that reinstates part of an emotion's sensorimotor signature should exert a comparable influence. Facial feedback and body feedback thus become two expressions of a single mechanism, which makes whole-body emotional movement a theoretically motivated extension of the facial feedback literature rather than a loose analogy to it.

Recent work has begun to specify the level of processing at which such peripheral signals act. Using electroencephalography (EEG) frequency-tagging, Baker et al. (2025a) found that holding a posed smile reduced neural discrimination between neutral and happy faces over left occipito-temporal cortex, indicating that voluntary facial action can blunt the visual system's sensitivity to emotional cues. Converging evidence comes from facial neuromuscular electrical stimulation, in which weak smiling is induced externally rather than posed voluntarily. Stimulation of the zygomaticus major biases the categorisation of ambiguous facial expressions towards happiness and reduces P1, N170 and late positive potential amplitudes (Efthimiou et al., 2024), and a subsequent study found this happiness bias to be mediated by a reduced N170 during early visual processing, which the authors interpret as a reduction in visual processing load (Baker et al., 2025b). Because the stimulation is delivered externally, these findings separate the afferent consequences of muscle activation from any voluntary intention to express emotion. Together they locate the influence of proprioceptive manipulation early in the processing stream, at the level of perceptual encoding rather than post-perceptual judgement, and thereby support a bottom-up route through which peripheral bodily signals shape affective states.

Paralysing facial muscles with botulinum toxin has been reported to reduce the intensity of negatively valenced emotional experience, particularly in individuals with depression (Alam et al., 2008; Davis et al., 2010). Because botulinum toxin acts at the neuromuscular junction, its immediate consequence is a reduction in the afferent signal that facial muscles send to somatosensory cortex; the manipulation is peripheral in origin and does not act directly on prefrontal cortex or on its interplay with the amygdala. Neuroimaging findings are nonetheless consistent with downstream consequences for emotion-related circuitry, including reduced amygdala responsiveness to emotional expressions following denervation of the corrugator muscles (Hennenlotter et al., 2009; Kim et al., 2014). These findings warrant caution: critical reviews and meta-analyses report inconsistent evidence, unexpectedly large effect sizes and funnel-plot asymmetry across this literature, and advise against strong conclusions, particularly regarding botulinum toxin as a treatment for depression (Coles et al., 2019a; Coles & Larsen, 2021).

The facial feedback hypothesis has been influential, but its empirical status is actively contested. A large-scale multi-laboratory replication of the classic pen-in-mouth paradigm (Strack et al., 1988) failed to reproduce the original effect (Wagenmakers et al., 2016), and meta-analytic work indicates that facial feedback effects on emotional experience are small, heterogeneous and contingent on procedural details such as the presence of emotional stimuli and the manner in which the expression is manipulated (Coles et

al., 2019b). Facial feedback is therefore better characterised as a plausible but conditional influence on emotional experience than as a settled principle. This unresolved status makes the underlying question more rather than less pressing: are the effects of peripheral feedback on emotion specific to the facial musculature, or do the same principles apply more broadly to motor action and emotion regulation (Buck, 1980)? The hypothesis that proprioception and interoception arising from whole-body posture and movement induce or mediate emotional experience has been tested less comprehensively.

Dance has long been used across cultures as a socially sanctioned means of expressing and regulating emotion, and evidence is accumulating that emotional body postures and movements can in turn influence emotional states. Studies have shown that dance and other expressive physical activities can elicit and amplify positive emotions such as joy in social contexts (Elst et al., 2023). These findings suggest that the effects of motor execution on emotion regulation extend beyond only the facial musculature. Some studies have shown that isometric arm flexion (bringing toward the mouth) is associated with a positive attitude toward a neutral object compared with extension (Cacioppo et al., 1993).

Importantly, studies have shown that merely observing others' emotional expressions and movements can also trigger congruent emotional responses in the observer (Adelmann & Zajonc, 1989; Gury et al., 2024; Shafir et al., 2013).

The way we carry ourselves can influence our emotional experiences. For example, an upright posture can elicit feelings of pride, whereas a slumped posture can evoke sadness (Nair et al., 2015). These postural configurations are associated with neuroendocrine changes, such as increased testosterone and reduced cortisol levels (Carney et al., 2010). Restricting specific facial and motor behaviors can also attenuate emotions (S. E. Duclos & Laird, 2001). Emotional changes after bodily postures combined with facial expressions can last for several minutes even after these behaviors stop (Schnall and Laird, 2003).

Dynamic emotional movements may influence affective states more effectively than static postures because movement generates continuously varying proprioceptive input, whereas a sustained posture delivers a comparatively constant signal to which the nervous system adapts. Sensory adaptation to unchanging stimulation is a general property of the nervous system, and it provides a straightforward reason to expect stronger and more sustained effects from movement than from posture. Consistent with a difference between the two, dynamic whole-body expressions of emotion are recognised more accurately than static body postures conveying the same emotion (Atkinson et al., 2004).

While these studies highlight the impact of motor actions on emotion regulation, they do not conclusively rule out a covariate contribution from facial expression, since participants are rarely prevented from expressing emotion facially while moving. An integrated model may be needed to characterise the interplay between bodily movement, facial cues and emotion regulation. Emotional experience appears to be strongest when facial expression and whole-body gesture are congruent and combined (Flack et al., 1999). Where whole-body emotional movement has been studied on its own, motor execution has typically been embedded within a protocol that also included observation of a model, imagery, or both, and that compared these modes against one another (Koch et al., 2007; Shafir et al., 2013, 2016). The specific contribution of

execution performed independently, from memory and without any concurrent observational or imagery component, therefore remains difficult to isolate from the existing evidence.

The first aim of our study was to investigate the direct impact of motor execution of emotional body movements on changes in subjective emotional experience. We emphasise execution performed independently, that is, reproduced from memory without concurrent observation of a model and without an accompanying imagery condition, because earlier protocols have combined execution, observation and imagery within a single session (Shafir et al., 2013), which leaves their separate contributions confounded. Specifically, we were interested in whether engaging in bodily movements associated with happiness could enhance positive feelings or alleviate negative emotions. Were this confirmed, it would carry clinical implications, suggesting that targeted physical interventions involving specific body postures and movements might be developed as straightforward, low-cost adjuncts to emotion regulation.

Progressive muscle relaxation (PMR) has been found to reduce state anxiety, stress, and fatigue (Griffith et al., 2017). By systematically tensing and releasing muscle groups, a person can experience deep relaxation and reduced muscle contraction (McCallie et al., 2006). These findings suggest that the effects of motor activity on emotion regulation may extend to the whole body.

Proprioceptive and interoceptive signals have also been linked to affective experience more directly. Neurophysiological accounts propose a close relationship between emotion and the ongoing bodily state of the organism (Craig, 2009; Damasio, 1999; Damasio et al., 2000). On the basis of positron emission tomography data, Damasio (1999) argued that continuous neural mapping of the current state of the body is what makes feelings available to awareness at all, so that a change in bodily state should be accompanied by a change in what is felt. Critchley (2005) similarly identified interactions among the anterior cingulate, insular and orbitofrontal cortices as the substrate through which interoceptive information is translated into emotional feeling. Movement practices that heighten proprioceptive acuity, such as dance and yoga, are well established in physical rehabilitation and balance training (Bartlett et al., 2013; Joung & Lee, 2019; Kuo et al., 2020; Lephart et al., 1997; Waddington et al., 2017); the framework above provides a reason to expect that the altered proprioceptive and interoceptive input they generate may also carry affective consequences. That proposition has yet to be tested directly, and it motivates the present study.

The relationship between facial expressions and emotional experience is well established, yet the influence of full-body motor actions on emotion regulation remains underexplored. Recent studies have begun to investigate this area, examining the role of facial expressions alongside the execution, observation, and imagination of bodily movements in regulating emotions (Shafir et al., 2013). Some of these studies have employed Laban Movement Analysis (LMA) to characterize movements that elicit emotional responses in participants(Shafir et al., 2016). Dance and movement (DMT) therapies have been a focal point of this research, highlighting their potential for fostering hedonism, aesthetic experience, self-awareness, body awareness, nonverbal meaning-making, social interaction, enactive transitional spaces, and creativity (Koch, 2017; Ritter & Low, 1996). In psychiatric and neurological populations, DMT has been utilized to

improve motor coordination (e.g., in Parkinson's disease), reduce anxiety, and enhance cognitive function (Koch, 2017).

To our knowledge, only two studies have specifically used dance- and movement-based therapies to examine these effects. One study explored the impact of DMT on reducing aggression in prison inmates, although it revealed no significant changes in objective measures (Koch et al., 2015). Another study demonstrated a significant decrease in depression following a single session of jumping-like movements in patients with depression (Koch et al., 2007). However, the effects of such movement-based therapies over time remain unexplored.

This study aims to investigate the immediate and short-term effects of performing independent dynamic emotional bodily movements, with a particular focus on movements associated with happiness and with sadness, via validated mood state measures. We hypothesized that these whole-body emotional movements would enhance the corresponding affective states, thereby suggesting potential therapeutic applications.

Materials and methods

Participants

Fifty-one adults were recruited for the study. Recruitment initially involved obtaining written informed consent from the participants, after which the participants were screened with the Movement Imagery Questionnaire-Revised Scale (MIQ-RS) (Gregg et al., 2010) and the Expression Manipulation Procedure (S. E. Duclos & Laird, 2001). The MIQ-RS assesses the ability and ease of performing motor imagery, and participants scoring above 70 were retained. Although the present study involved no imagery condition, the MIQ-RS was the only validated instrument available to us for establishing that participants could form and hold a reliable internal representation of a movement sequence, which is a prerequisite for reproducing that sequence from memory in the independent replication session. This choice is supported by evidence that motor imagery and overt execution recruit substantially overlapping neural substrates during real-world dynamic behaviour (Mustile et al., 2024). We note the trade-off it creates: participants with high motor imagery ability may be more responsive to movement-based manipulations, so the resulting sample may not be representative of the general population, and we return to this point in the limitations. The expression manipulation procedure checks who is attending to and showing emotional reactions to one's own body and activity (personal cues) versus social expectations (situational cues). Only participants scoring above 10, indicating adequate sensitivity to their own bodily cues of emotion, were included. This criterion was intended to ensure that participants could perceive and report their emotional state reliably, but it necessarily selects for heightened interoceptive and proprioceptive awareness and is therefore a source of self-selection bias, which we address in the limitations. This procedure identified five ineligible participants; the MIQ-RS found just one. One additional participant withdrew from the study because of the inability to learn movements. A total of 44 healthy adults (26 males, 18 females; mean age = 21 years, SD = 1.68) completed the study protocol. All had no history of neurological or psychiatric disease and were not taking any medications. The study was reviewed and approved by the institutional human ethics committee

of the authors' university. The name of the committee, the approval number and the approval date have been withheld to preserve anonymity during review and will be supplied to the editor on request.

Stimuli

Each participant was taught bodily movement sequences representing four emotions, happiness, anger, sadness and fear, together with an emotionally neutral sequence. The sequences were adapted from the full-light dynamic body expression stimuli of Atkinson et al. (2004), in which ten actors portrayed each emotion. From that set we selected two representative sequences per emotion, chosen for the clarity with which the target emotion had been recognised in the original validation study, giving eight emotional sequences plus the neutral sequence, and nine sequences in total per participant. We deliberately did not attempt to teach the complete set of forty portrayals: pilot work indicated that participants could not acquire and retain that number reliably, and Shafir et al. (2013) required approximately 1.5 hours to teach five sequences. Restricting the set to nine sequences allowed each to be learned to criterion and retained across the two-day intervals between sessions. Each sequence was demonstrated by an experienced dance instructor. The emotional sequences were dynamic, whole-body expressions of the target emotion; the neutral sequence consisted of bending forward with relaxed hands towards the toes while breathing out. This neutral movement is a cool-down of the kind commonly used in athletic practice. It is dynamic and whole-body in character but conveys no specific emotion, and it was included to help participants return towards a baseline affective state rather than as a motor-matched non-emotional control condition. Concrete descriptions of the sequences used in each condition, in terms of the direction, effort quality and body parts involved, are provided in Supplementary Table S1, and still frames illustrating one sequence per emotion are provided in Supplementary Figure S1.

Two roles are distinguished here. The actors portraying the emotions in the Atkinson et al. (2004) source clips, which participants never viewed, are referred to as models. The person who taught the sequences in the laboratory is referred to throughout as the teacher. The teacher wore dark grey, tight-fitting clothing and headwear that concealed the face while demonstrating, so that no facial cue accompanied the bodily demonstration and participants could not infer the intended emotion from the teacher's expression.

To maintain consistency, all male participants learned the movements from a male teacher and all female participants from a female teacher. This approach ensured that the instructions were tailored and relatable, facilitating a more accurate and immersive learning experience for the participants.

Design and Procedure

The study comprised two experiments (see Fig. 1), both of which used a within-subjects design. The same participants took part in both experiments, so that each individual served as their own control and between-subject variability was removed from the comparisons of interest. The second experiment was performed at least seven days after the first experiment to ensure that the first experiment did not impact the second experiment.

Experiment 1

In the first experiment, each participant performed all motor executions across three sessions: learning with the teacher, practicing under the teacher's supervision, and independent replication (see Fig. 1). Sessions were separated by two days.

Session 1: Learning with the teacher. In the first session, an experienced dance teacher instructed participants in the nine movement sequences described above, eight emotional and one neutral. The participants watched and performed these movements under the teacher's supervision. Participants were informed that the aim of the study was to investigate the effects of specific muscle activations on brain function. Movements were labelled with letters rather than emotion names, so that no verbal cue to the intended emotion was available, following Shafir et al. (2013). These labels served as cues for replicating movements without revealing their emotional significance. This session lasted 1 to 1.5 hours until both the participant and the teacher were satisfied with the accuracy and ease of the movements. To reinforce memory, the participants were encouraged to practice the sequences using both imagination and actual behavior between sessions.

Session 2: Supervised Practice The second session began with a brief rehearsal of the learned movements, followed by motor executions supervised by the teacher. The participants practiced performing the movements independently, with the session lasting 1 to 1.5 hours until the teacher deemed the movements accurate and smooth.

Session 3: Independent replication In the third and final sessions, after a short rehearsal, the participants performed all dynamic movements independently without teacher interference, even if mistakes occurred. Each sequence was performed at least six consecutive times without rest. To conceal the true purpose of the study, participants were instructed to perform a digit span task, a cognitive measure, both before and after each motor performance assessment, which was followed by the administration of outcome measures. They also rated their physical tiredness and muscle soreness, which were recorded to monitor fatigue across the session and are not analysed further here, and their current affective state using the Positive and Negative Affect Schedule (PANAS) (Crawford & Henry, 2004). Both the PANAS and the rating of physical tiredness were taken before and after the completion of the movement sequence of a particular emotion.

The order of the emotional movement sequences was randomised and balanced across participants, and remained fixed for a given participant. The neutral sequence was always performed last, to help participants return towards a baseline affective state before leaving the laboratory. Because it was always administered in the final position and served this resetting function, the neutral condition is not a counterbalanced, fully equivalent control for the emotional conditions, and we do not treat it as one. Participants were videotaped throughout motor execution, both for later validation of movement accuracy against the source clips and so that spontaneous facial expression could be coded.

Control of facial expression and demand characteristics. Three measures were taken to limit the contribution of facial feedback and of participants' expectations. First, the teacher's face was concealed

during all demonstrations, so participants had no facial model to imitate. Second, the video record of each independent replication session was reviewed and participants were monitored for spontaneous facial expression during execution; participants were not instructed to inhibit facial movement, since doing so would itself have signalled that facial expression was of interest. Third, the movement sequences were identified to participants only by letter, the stated rationale concerned muscle activation and brain function rather than emotion, and a digit span task was interposed before and after each performance block to support that framing.

At the end of Experiment 2, all participants completed a funnelled debriefing in which they were asked, in progressively more specific terms, what they believed the study was about, whether they had noticed anything about the movements themselves, and whether they thought the movements had affected how they felt. Participants were then informed of the true aim of the study and of the cover story that had been used, and consent to retain their data was reconfirmed. No participant identified the emotional categorisation of the movement sequences or the hypothesis under test before being told. We nonetheless regard this as suggestive rather than conclusive, since repeated rehearsal of emotionally expressive movement may convey the study's purpose in ways that a verbal probe does not capture, and we return to this in the limitations.

Experiment 2

In the second experiment, we examined how performing these dynamic bodily movements associated with happiness or sadness affected the emotional states of the participants over a period of time. This was done through pre- and postintervention assessments, with an additional follow-up assessment conducted 6 hours later. The participants, who had already learned to perform these bodily movements in the first experiment, were asked to engage in only one type of movement—either happy or sad—during each session. We then measured the impact on their mood using the Oxford Happiness Questionnaire (OHQ) and the Beck Depression Inventory (BDI) (see Fig. 1).

The Oxford Happiness Questionnaire (OHQ) (Hills & Argyle, 2002) is a validated 29-item self-report instrument designed to measure psychological well-being. The respondents use a six-point Likert scale, where '1' represents "strongly agree" and '6' signifies "strongly disagree." The OHQ has a high reliability coefficient of 0.91. For this study, we utilized the Hindi adaptation of the questionnaire, as developed by Arunachalam (2019).

The Beck Depression Inventory (BDI) (Beck et al., 1961) is a widely used 21-item self-report questionnaire designed to assess the severity of depression symptoms and attitudes. Each item is rated on a scale from 0 to 3 on the basis of severity. The BDI has shown strong internal consistency and reliability (Beck et al., 1988). Although originally intended for administration by trained interviewers, the BDI is now commonly self-administered.

The two sessions of Experiment 2 were separated by two days.

Session of Movements Associated with Sadness

This session began with a brief rehearsal of the learned movements but stopped just after rehearsing movements associated with sadness. This deliberate stoppage was used to control the intervening effect of the other emotional movements. The participants were subsequently asked to perform the movements associated with sadness for 15 minutes. The participants were observed but not interrupted even when they were not performing the motor sequences correctly. Their emotional state was assessed with the Oxford Happiness Questionnaire and Beck Depression Inventory before the session, immediately after the session, and 6 hours after the session to measure any changes. After the follow-up assessment, and only then, the session closed with a short period of movements associated with happiness followed by the neutral cool-down sequence. This was done for ethical reasons rather than experimental ones: having deliberately induced a negative affective shift, we did not consider it acceptable for participants to leave the laboratory in that state. Because these movements were performed after the final assessment, they could not influence any of the reported measures. The movements associated with happiness used for this purpose were the same sequences employed in the happiness condition.

Session of Movements Associated with Happiness

Similarly, this session began with a brief rehearsal of the learned movements but stopped after rehearsing movements associated with happiness deliberately to stop the intervening effect of the other emotional movements. After that, the participants performed the movements associated with happiness for 15 minutes. Their emotional state was assessed with the same instruments at the same intervals. This session closed with the neutral cool-down sequence alone, since no negative affective shift had been induced.

These sessions in experiment 2 were designed to measure the immediate and short-term effects of singular emotional movement sequences on participants' mood and well-being. This experiment allowed for a controlled examination of how specific bodily movements influence emotional regulation and the duration of these effects.

Data analysis

To confirm that participants executed the movement sequences correctly and that performance was not degraded by fatigue, each sequence recorded during the independent replication session was compared against the corresponding source clip. The participant's video was segmented into the representative motor sequences, and EyesWeb software (Camurri et al., 2003) was used to generate a silhouette motion image for each segment as a visualisation aid. The similarity judgement itself was made on the video recordings rather than on the silhouette images: an independent observer, blind to the emotional category of each sequence, viewed the participant's clip alongside the source clip and rated their correspondence in movement form, timing and amplitude as a percentage from 0 to 100. One sequence was rated for each of the five conditions per participant, that is, one each for happiness, anger, sadness, fear and neutral, giving

five ratings per participant. Sequences were sampled rather than rated exhaustively because the purpose of the procedure was to verify adequate fidelity of execution overall rather than to score every repetition.

The effect of the bodily movement sequences in Experiment 1 was assessed with one-tailed paired t tests calculated separately for each emotional condition, on the difference between post-execution and pre-execution scores. Directional tests were used because the hypotheses specified the direction of change in advance; the implications of this choice are considered in the limitations. Affective state was indexed by the PANAS alone. Both the positive (PANASp) and the negative (PANASn) summary scores were computed and analysed for every emotional condition, so that effects on the non-hypothesised subscale would be visible rather than hidden. The hypothesis-driven contrasts were PANASp for movements associated with happiness, PANASn for movements associated with sadness, anger and fear, and both subscales for the neutral condition; results for the remaining subscale in each condition are reported alongside these. No omnibus family-wise correction was applied across the ten one-tailed tests; these results should therefore be interpreted as exploratory. No visual analogue ratings of discrete emotions were collected, and the study therefore does not include the separate happiness and sadness intensity ratings used by Shafir et al. (2013).

For Experiment 2, emotional state was analysed with one-factor repeated-measures analyses of variance conducted separately within the happiness and the sadness movement conditions, with time as the within-subjects factor at three levels (pre-session, immediately post-session, and 6-hour follow-up). The Oxford Happiness Questionnaire and the Beck Depression Inventory were analysed separately, giving four omnibus tests. With 44 participants and three assessment points the uncorrected within-subjects error term carries 2 and 86 degrees of freedom. Effect sizes are reported as partial η^2.

Sphericity was examined with Mauchly's test, which was significant for the happiness condition on the OHQ, $W = .752$, $\chi^2(2) = 12.10$, $p = .002$, and for the sadness condition on the BDI, $W = .684$, $\chi^2(2) = 16.36$, $p < .001$, and non-significant for the remaining two analyses. Because Mauchly's test is underpowered at this sample size and sensitive to departures from normality, and because a conditional test-then-correct procedure has poor operating characteristics, the Greenhouse–Geisser correction was applied unconditionally to all four omnibus tests rather than only to those in which the assumption was rejected. The correction leaves F unchanged and adjusts the degrees of freedom and probability; ε is reported for each analysis. Where the assumption holds, ε approaches unity and the correction has negligible effect, so this choice is conservative rather than costly.

Following each significant omnibus test, the three pairwise contrasts between time points (pre versus post, pre versus follow-up, and post versus follow-up) were examined with paired t tests, with the Bonferroni correction applied across the three comparisons within each condition and measure. Corrected probabilities are reported together with mean differences and Bonferroni-simultaneous 95% confidence intervals. Comparisons were evaluated against the pooled within-subjects error term from the corresponding omnibus analysis, so each contrast carries 86 degrees of freedom.

These condition-specific analyses test the effect of time within each movement type. They do not constitute a test of the difference between movement types, and the comparative statements in the

Discussion are framed accordingly.

Results

Participant Demographics and Experimental Overview

To evaluate the immediate and short-term effects of learned independent dynamic bodily movement sequences, two experiments involving 44 participants were conducted. The demographic characteristics of the participants are summarized in Table 1, with 59.1% males (n = 26) and 40.9% females (n = 18), and analysis of the gender distribution using a chi-square test showed no significant difference ($\chi^2(1) = 1.454$, $p > 0.05$). The participants had an average age of 21 years (SD = 1.68) and 14 years of education (SD = 1.43). Regarding behavioral practices, 47.7% of participants (n = 21) engaged in dance, but the chi-square test indicated that this difference was not statistically significant ($\chi^2(1) = 0.0909$, $p > 0.05$). Additionally, 9.1% of participants (n = 4) practiced yoga, and 18.2% (n = 8) practiced meditation. Across both experiments, participants executed emotional movement sequences that closely adhered to the validated procedures established by (Atkinson et al., 2004). The fidelity of execution was rated by an independent observer who compared each participant's video against the corresponding source clip, as described in the Data analysis section. Mean fidelity was 78.43% for the sequences performed in Experiment 1 and 67.92% for those performed in Experiment 2.

Table 1
Demographic and Behavioral Characteristics of the Study Participants

Characteristic	Frequency	Percentage
N	44	-
Gender (Male)	26	59.1
Age	21.00 (1.68)	-
Education in years	14 (1.43)	-
Practicing Yoga	4	9.1
Practicing Dance	21	47.7
Practicing Meditation	8	18.2

Immediate Impact of Emotional Bodily Movements

Using Experiment 1, we investigated the immediate impact of independent dynamic emotional movement execution on emotional states as measured by the Positive and Negative Affect Schedule (PANAS) (Crawford & Henry, 2004), which includes both positive (PANASp) and negative (PANASn) affect scores. The analyses employed paired t tests (see Table 2) to examine changes from pre- to post-execution across the five movement conditions, namely the four emotional conditions of happiness, anger, sadness and fear,

together with the neutral condition. This corresponds to the four emotions plus neutral described in the Stimuli section.

Positive Affect Changes

Movements associated with happiness produced the largest increase in positive affect, with mean PANASp scores rising from 37.39 (SD = 9.00) to 41.48 (SD = 5.97), $t(43) = -4.617$, $p < .001$, Cohen's $d = -0.70$. Movements associated with sadness produced a significant decrease in positive affect, from 38.14 (SD = 10.00) to 34.95 (SD = 9.13), $t(43) = 2.722$, $p = .004$, $d = 0.41$. Movements associated with anger and with fear each produced a small decrease in positive affect, of 1.82 (SD = 5.33) and 2.18 (SD = 5.29) points respectively. Both decreases reached the conventional threshold under the one-tailed tests specified in advance, $t(43) = 2.264$, $p = .014$, $d = 0.34$ for anger and $t(43) = 2.734$, $p = .004$, $d = 0.41$ for fear, but the effects are small and, given the number of comparisons conducted across conditions and subscales, we do not interpret them as robust evidence that these movements reduce positive affect. The neutral condition produced a slight and non-significant increase in positive affect, from 35.84 (SD = 10.68) to 36.66 (SD = 10.66), $t(43) = -0.939$, $p = .176$, $d = -0.14$. Full results are given in Table 2 and Fig. 2.

Negative affect changes

Movements associated with fear produced the most reliable increase in negative affect, with mean scores increasing from 14.30 (SD = 6.35) to 16.80 (SD = 5.86), $t(43) = -5.39$, $p < 0.001$, accompanied by a moderate negative effect size ($d = -0.81$). The largest absolute increase was produced by movements associated with sadness, where negative affect rose from 14.00 (SD = 5.07) to 17.27 (SD = 7.25), $t(43) = -3.569$, $p = 0.0005$, with a moderate negative effect size ($d = -0.54$). Movements associated with anger produced a smaller but still significant increase in negative affect, from 18.93 (SD = 3.05) to 20.11 (SD = 3.61), $t(43) = -1.918$, $p = 0.031$, and a small negative effect size ($d = -0.29$) (see Table 2).

The findings from experiment 1 indicated that the execution of movements associated with happiness resulted in the most pronounced positive shift following the execution. Conversely, movements associated with fear and with sadness induced the greatest increases in negative affect, suggesting heightened emotional responses in these domains post-execution (see Fig. 2).

Table 2
Impact of Emotional Movements on Positive and Negative Affect Scores

Emotional Movement	Measure	Pre Mean (SD)	Post Mean (SD)	Difference Mean (SD)	t-statistic	p	Confidence Interval	Effect Size
Happiness	PANASp	37.39 (9.00)	41.48 (5.97)	-4.09 (5.88)	-4.617***	0.000	(-5.88, -2.30)	-0.7
	PANASn	14.09 (6.37)	12.14 (2.16)	1.95 (6.13)	2.116*	0.020	(0.09, 3.82)	0.32
Anger	PANASp	38.41 (6.41)	36.59 (2.28)	1.82 (5.33)	2.264*	0.014	(0.20, 3.44)	0.34
	PANASn	18.93 (3.05)	20.11 (3.61)	-1.18 (4.09)	-1.918*	0.031	(-2.42, 0.06)	-0.29
Sadness	PANASp	38.14 (10.00)	34.95 (9.13)	3.18 (7.75)	2.722**	0.004	(0.82, 5.54)	0.41
	PANASn	14.00 (5.07)	17.27 (7.25)	-3.27 (6.08)	-3.569***	0.000	(-5.12, -1.42)	-0.54
Fear	PANASp	38.91 (7.74)	36.73 (7.10)	2.18 (5.29)	2.734**	0.004	(0.57, 3.79)	0.41
	PANASn	14.30 (6.35)	16.80 (5.86)	-2.50 (3.08)	-5.39***	0.000	(-3.44, -1.56)	-0.81
Neutral	PANASp	35.84 (10.68)	36.66 (10.66)	-0.82 (5.78)	-0.939	0.176	(-2.58, 0.94)	-0.14
	PANASn	14.20 (5.04)	14.05 (6.29)	0.16 (2.21)	0.478	0.318	(-0.51, 0.83)	0.07

Note: PANASp = PANAS positive affect; PANASn = PANAS negative affect; SD = standard deviation; effect size = Cohen's d; p = p value (one tailed); ***p < .001, **p < .01, *p < .05.

Short-Term Effects of Dynamic Bodily Movements

We examined the immediate and short-term effects of independent dynamic bodily movements—associated with happiness and with sadness—on participants' emotional states in experiment 2. Assessments were conducted before the intervention, immediately after the intervention, and at the 6-hour follow-up, and the Oxford Happiness Questionnaire (OHQ) and Beck Depression Inventory (BDI) were used to measure mood changes.

Movements Associated with Happiness:

When participants performed movements associated with happiness, self-reported happiness on the Oxford Happiness Questionnaire changed significantly across the three assessments, $F(1.60, 68.89) = 20.10$, $p < .001$, partial $\eta^2 = .32$ ($\varepsilon = .801$). Scores on the Beck Depression Inventory also changed

significantly, $F(1.85, 79.72) = 14.12$, $p < .001$, partial $\eta^2 = .25$ ($\varepsilon = .927$). Descriptive statistics for all three time points are given in Table 3 and the trajectories are plotted in Fig. 3.

Bonferroni-corrected pairwise comparisons showed that OHQ scores rose from pre-session to post-session (mean difference = − 0.25, 95% CI [− 0.35, − 0.15], $t(86) = -6.33$, $p < .001$) and remained above baseline at the 6-hour follow-up (mean difference = − 0.14, 95% CI [− 0.24, − 0.04], $t(86) = -3.54$, $p = .002$), with a partial decline between the post-session and follow-up assessments (mean difference = 0.11, 95% CI [0.01, 0.21], $t(86) = 2.79$, $p = .020$). BDI scores fell from pre-session to post-session (mean difference = 1.00, 95% CI [0.52, 1.48], $t(86) = 5.08$, $p < .001$) and returned towards baseline by the follow-up (mean difference = − 0.77, 95% CI [− 1.25, − 0.29], $t(86) = -3.91$, $p = .001$); the pre-session and follow-up assessments did not differ significantly (mean difference = 0.23, 95% CI [− 0.25, 0.71], $t(86) = 1.17$, $p = .739$).

Movements associated with happiness therefore produced an immediate increase in self-reported happiness that was still detectable six hours later, alongside a reduction in depressive symptom scores that was no longer statistically distinguishable from baseline at follow-up. The two measures thus followed different trajectories over the same interval.

Movements Associated with Sadness:

When participants performed movements associated with sadness, Oxford Happiness Questionnaire scores did not change significantly across the three assessments, $F(1.79, 77.14) = 1.58$, $p = .214$, partial $\eta^2 = .04$ ($\varepsilon = .897$). Beck Depression Inventory scores changed significantly, $F(1.52, 65.27) = 39.82$, $p < .001$, partial $\eta^2 = .48$ ($\varepsilon = .759$). Descriptive statistics are given in Table 3 and the trajectories are plotted in Fig. 3.

Bonferroni-corrected pairwise comparisons for the BDI showed an increase from pre-session to post-session (mean difference = − 1.34, 95% CI [− 1.74, − 0.94], $t(86) = -8.17$, $p < .001$) and a decrease from post-session to the 6-hour follow-up (mean difference = 1.18, 95% CI [0.78, 1.58], $t(86) = 7.20$, $p < .001$). The pre-session and follow-up assessments did not differ significantly (mean difference = − 0.16, 95% CI [− 0.56, 0.24], $t(86) = -0.98$, $p = 1.000$). No pairwise comparison reached significance for the OHQ, consistent with the non-significant omnibus test.

Movements associated with sadness therefore produced an immediate rise in depressive symptom scores that was no longer statistically distinguishable from baseline six hours later, and did not measurably alter self-reported happiness. Because a non-significant difference does not establish equivalence, this pattern is better described as the absence of a detectable residual effect than as complete resolution.

Table 3
Summary of Statistical Outcomes for the Happiness and Sadness Conditions on OHQ and BDI using Repeated Measures ANOVA

Measures	Measurement			F	p	partial η^2
	Pre	Post	Follow-up			
Movements associated with happiness						
OHQ	3.35(0.40)	3.60(0.30)	3.49(0.25)	20.10	< .001	0.32
BDI	6.12(1.30)	5.12(1.30)	5.89(1.36)	14.12	< .001	0.25
Movements associated with sadness						
OHQ	3.42(0.25)	3.36(0.22)	3.38(0.19)	1.58	.214	0.04
BDI	6.05(1.20)	7.39(0.99)	6.21(1.20)	39.82	< .001	0.48

Note: Values for pre-intervention, post-intervention, and follow-up assessments are presented as mean (standard deviation). F values represent the omnibus effect of time obtained from the repeated-measures ANOVA. OHQ = Oxford Happiness Questionnaire; BDI = Beck Depression Inventory; partial η^2 = partial eta squared (effect size). Statistical significance was set at $p < .05$. Because Mauchly's test is underpowered at this sample size and sensitive to departures from normality, the Greenhouse–Geisser correction was applied unconditionally to all four omnibus tests; the F statistic is unaffected by the correction, while the degrees of freedom and probability are. Corrected degrees of freedom were (1.60, 68.89) for happiness/OHQ (ε = .801), (1.85, 79.72) for happiness/BDI (ε = .927), (1.79, 77.14) for sadness/OHQ (ε = .897), and (1.52, 65.27) for sadness/BDI (ε = .759). Uncorrected degrees of freedom were (2, 86) throughout.

Discussion

The present study examined the immediate and short-term effects of emotional bodily movements on affective states, contributing to the understanding of how bodily movements can influence emotional regulation. Our findings demonstrate that engaging in specific emotional movements significantly alters emotional states, as measured by the Positive and Negative Affect Schedule (PANAS). Notably, movements associated with happiness led to a significant increase in positive affect, indicating that dynamic, uplifting movements, such as jumping and spreading arms wide, can effectively elevate the mood. These results align with previous research by (Atkinson et al., 2004) and (Shafir et al., 2013, 2016), who observed similar effects using rhythmic movements that are essential components of various cultural dances, which are often performed to enhance mood (Brymer & Gray, 2009). The positive psychological effects of adopting an upright posture, as reported in studies by Inagaki et al. (2018), further support our results, emphasizing the role of physical movement in emotional regulation. Additionally, previous research has suggested that the embodiment of certain postures can evoke specific emotional responses (Atkinson et al., 2004; Winters, 2008).

The design assessed mood again at six hours, but it included no non-emotional dynamic comparison condition running in parallel over the same interval. It therefore cannot separate movement-specific effects from physical activity, repeated assessment, or ordinary diurnal variation in mood. Koch et al. (2007)

reported that rhythmic, dance-like movement combined with music reduced depressive symptoms in psychiatric patients with a co-diagnosis of depression, although the movements in that study differed from ours. Establishing whether any effect is durable and attributable to the emotional content of movement will require a matched non-emotional movement condition followed over the same interval.

Conversely, movements associated with sadness and fear were found to significantly increase negative affect, reinforcing the notion that such movements can amplify the corresponding negative emotions. This finding is consistent with the literature, which indicates that slumping or sinking postures, often linked with sadness and fear, can intensify negative emotional states (Riskind & Gotay, 1982). The pronounced increase in negative affect following movements associated with fear highlights the potent impact of fear-inducing postures, likely due to the evolutionary basis of fear, which elicits more immediate and intense emotional and physiological responses than other emotions do (Flack et al., 1999). Similarly, (Harmon-Jones & Peterson, 2009) reported that specific postures and movements, such as those associated with anger, enhance emotional experiences through the activation of brain regions such as the left prefrontal cortex. Their research, which used EEG, rTMS, and fMRI, revealed that the supine position could activate the left prefrontal cortex, which is associated with anger. Similarly, (Bushman et al., 1999) demonstrated that aggressive movements, such as hitting a punching bag, increase subsequent aggression.

The moderate effect size observed for movements associated with anger in our study suggests that while these movements enhance negative affect, their impact is less intense than that of fear or sadness. This may be due to anger's nature as an approach emotion, which can sometimes be associated with feelings of control and dominance, potentially mitigating its negative impact (Winters, 2008). The findings also align with those of Duclos et al. (1989), who reported that certain postures can lead to increased fear and sadness ratings. The present design, with a six-hour follow-up and no matched control, cannot establish a sustained feedback cycle between movement and low mood. Hillman et al. (2004) reported that emotional responses could alter posture, and Flack (2006) suggested that facial expressions, bodily movements, and vocal sounds all contribute to emotional experiences. Understanding this possible cycle could provide insight into mechanisms that maintain low mood and depression.

These findings bear on emotion regulation in ways that may eventually prove useful in therapeutic settings, though the present study cannot establish that. Participants were healthy young adults and the outcomes were self-reported; extrapolation to the treatment of depression, anxiety or personality disorders is therefore premature. What the present evidence supports is the narrower claim that executing bodily movements associated with a given emotion can shift immediate self-reported affect in the congruent direction in a healthy sample. If that effect proves robust, movement-based exercises might complement cognitive and verbal therapies (Duclos & Laird, 2001), potentially within dance movement therapy and potentially enhanced by pairing movement with congruent music (Murrock & Higgins, 2009). The observation that movements associated with sadness and fear amplified immediate negative affect argues for corresponding caution about their unsupervised use with vulnerable populations. Previous work has stressed the value of establishing duration and dosage for movement interventions (Shafir et al., 2013); fifteen minutes of execution is a unit worth testing, not a prescription.

One feature of the present results warrants explicit comment. Several of the effect sizes we obtained are larger than meta-analytic estimates for comparable embodiment paradigms, where effects on emotional experience are typically small and variable (Coles et al., 2019b). We do not think this should be read as evidence that bodily movement is a markedly more potent manipulation than facial posing, although that remains possible. The more conservative reading is that some combination of a modest sample, directional testing, multiple pre-post comparisons and residual demand characteristics has inflated the estimates. Effect sizes reported here should therefore be treated as upper bounds pending replication in a larger, preregistered sample with two-tailed tests and a matched control condition.

Several limitations should be acknowledged. First, all outcomes were self-reported. The PANAS, OHQ and BDI are susceptible to social desirability and to inaccurate introspection, and none provides an objective index of affective change. Physiological measures such as salivary cortisol or heart rate variability would have strengthened the inference, though they carry their own difficulty here, since physical activity influences them directly and no established method separates the contribution of movement quantity from that of movement quality. Second, the sample was small. No a priori power analysis was conducted, so we cannot state that the study was adequately powered to detect effects of the size observed, and the precision of our effect size estimates is correspondingly limited. Larger and more diverse samples, including clinical groups, are needed, as is attention to individual differences such as baseline affectivity and personality that may moderate responsiveness to emotional movement.

Third, the neutral condition does not function as a full control. It was always performed last and served to return participants towards baseline, so it was neither counterbalanced against the emotional conditions nor matched to them in motor demand. As a consequence we cannot firmly separate emotion-specific effects from non-specific effects of movement, arousal or expectancy. Future work should include a dynamic but affectively neutral comparison condition, such as functional gestures, neutral locomotion or simple rhythmic sequences, matched to the emotional sequences in duration, intensity and complexity but carrying no affective meaning.

Fourth, demand characteristics remain a live concern. Participants rehearsed each sequence repeatedly across three sessions, and although the sequences were identified only by letter, the cover story concerned muscle activation and brain function, and no participant identified the hypothesis at funnelled debriefing, extended practice with emotionally expressive movement may still communicate the study's purpose in ways a verbal probe does not detect. Self-report measures are precisely the outcomes most vulnerable to this. Designs that mask the affective dimension more completely, or that use outcomes less amenable to strategic responding, would provide a stronger test.

Fifth, participant selection may limit generalisability in two respects. The MIQ-RS screen retained participants with high motor imagery ability, who may be unusually responsive to movement-based manipulations, and the Expression Manipulation Procedure retained participants with high sensitivity to their own bodily cues of emotion. Both criteria were adopted to ensure that participants could learn the sequences and report their affective state reliably, but together they produce a sample that likely

overrepresents individuals with heightened interoceptive and proprioceptive awareness, which may amplify the observed effects relative to an unselected population.

Sixth, the analytic approach was less conservative than it might have been. We used one-tailed paired t tests on pre-post difference scores computed separately within each condition, which follows from having specified the direction of each effect in advance but inflates the Type I error rate and does not exploit the factorial structure of the design. A mixed-effects analysis of covariance with two-tailed tests, treating movement condition and time as fixed effects and participant as a random effect, with correction for multiplicity, would provide a more robust and more generalisable analysis. We report the analysis as conducted, and we recommend the mixed-effects approach for future work in this area.

Furthermore, investigating the neural mechanisms underlying these observed effects would be beneficial. Functional imaging studies could provide deeper insights into how bodily movements influence brain regions associated with emotion regulation, such as the prefrontal cortex and amygdala (Harmon-Jones & Peterson, 2009). This could help refine movement-based interventions and tailor them more effectively to individual needs.

Conclusion

This study provides preliminary evidence that dynamic bodily movements can shift immediate emotional state in the direction of the emotion they express. Executing movements associated with happiness increased self-reported positive affect immediately, whereas movements associated with sadness or fear increased immediate negative affect. These results are consistent with embodied accounts of emotion, under which the peripheral configuration of the body contributes to what is felt rather than merely expressing it. They were obtained, however, in a small sample of healthy adults, with self-report outcomes and without a motor-matched non-emotional control condition, and the effect sizes are larger than the broader literature would lead one to expect. Replication in larger, preregistered studies with appropriate control conditions and objective outcomes is needed before movement-based strategies can be recommended for emotion regulation in practice, and functional imaging would help clarify the mechanisms involved.

Declarations

During the preparation of this work the authors used ChatGPT-4 and Curie solely to improve the language and readability of text they had already drafted. These tools were not used to generate scientific content, to identify or summarise source literature, or to produce citations. Every reference cited has been checked against the primary source by the authors. The authors reviewed and edited all text after using these tools and take full responsibility for the content of the publication.

Author Contribution

A.K.S. conceived and designed the study, developed the bodily movement protocol and supervised the project. A.K.S. and C.G. recruited the participants and collected the data for Experiments 1 and 2. C.G. curated the dataset, performed the statistical analyses and prepared the tables and figures. A.K.S. wrote the main manuscript text. M.K. contributed to the clinical framing and interpretation of the PANAS, OHQ and BDI findings and revised the manuscript critically for important content. All authors reviewed and approved the final manuscript.

Data Availability

The de-identified data supporting the findings of this study, together with the analysis scripts used to produce the reported statistics, are available from the authors on reasonable request. Video recordings of participants are not available, as participants did not consent to the sharing of identifiable audiovisual material.

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Figures

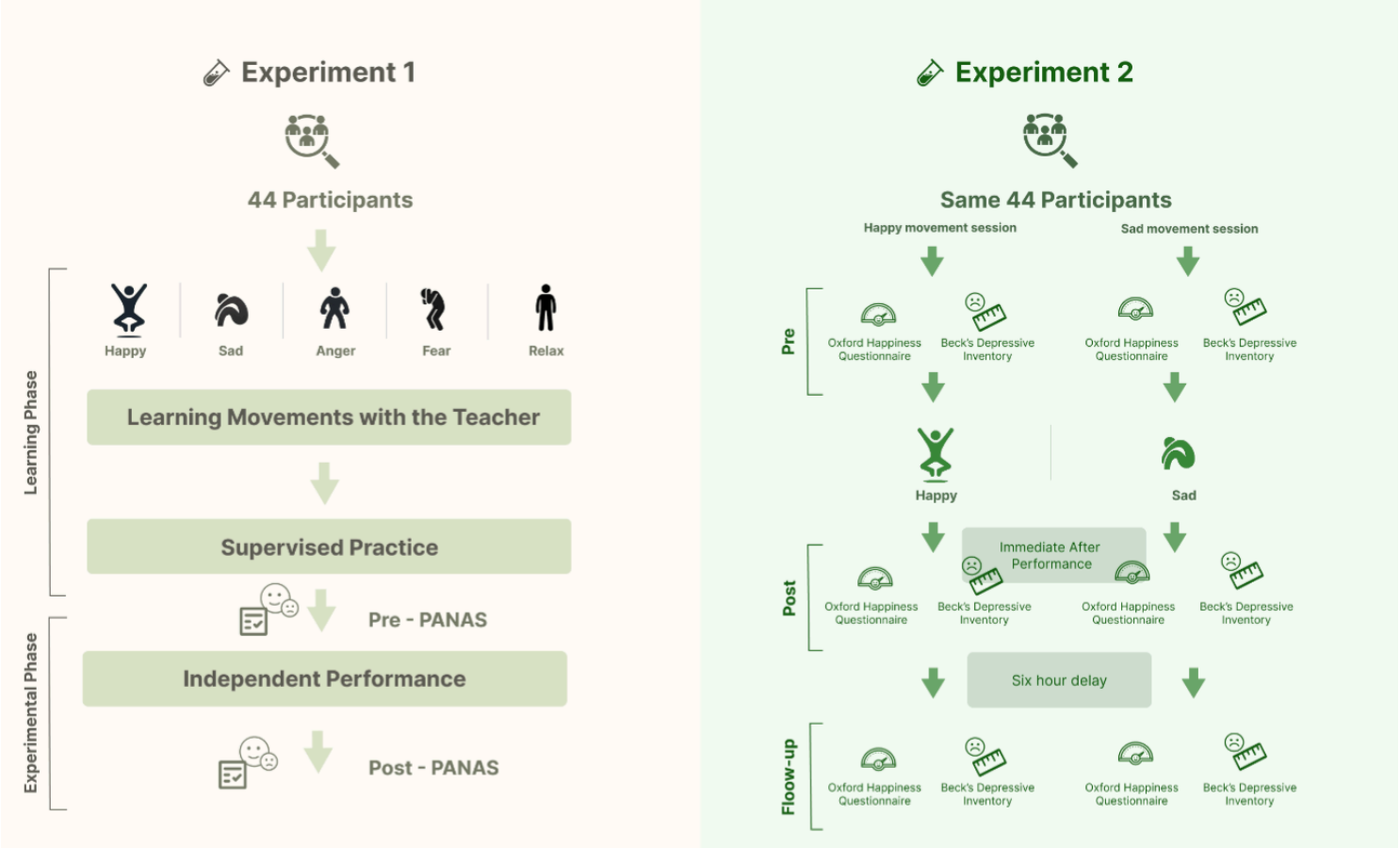


Figure 1

Experimental design. Schematic representation of the study design for two experiments assessing the impact of emotional bodily movements on mood states. In Experiment 1, 44 participants learned, practised and then independently performed bodily movement sequences associated with happiness, sadness, anger and fear, together with an emotionally neutral sequence. The neutral sequence is the cool-down movement described in the Stimuli section; it is referred to as neutral throughout, and the term relaxation is not used. The Positive and Negative Affect Schedule (PANAS) was administered before and after performance to measure the immediate effect on emotion. In Experiment 2, the same participants completed one session of movements associated with happiness and one session of movements associated with sadness. Mood was assessed before, immediately after, and six hours following the intervention using the Oxford Happiness Questionnaire and Beck Depression Inventory. This figure illustrates the flow of participant activities and the assessment tools used in both experiments.

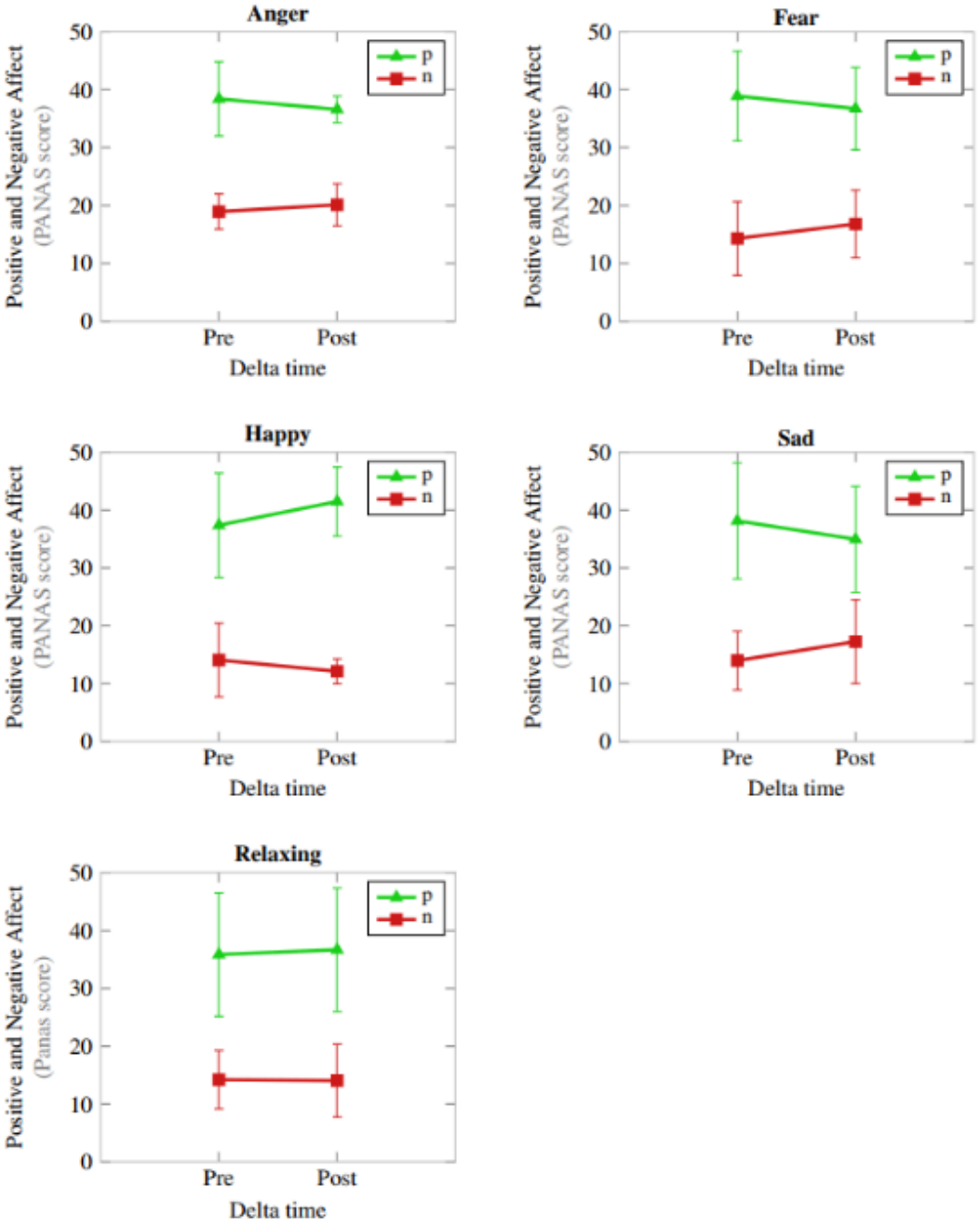


Figure 2

Changes in positive and negative affect across the five movement conditions. Green lines show the PANAS positive affect summary score (PANASp) and red lines the PANAS negative affect summary score (PANASn), plotted before and after execution. Error bars represent the standard error of the mean. Asterisks denote the significance of the pre-to-post paired t test for that condition and subscale: *** p < .001, ** p < .01, * p < .05; ns = not significant. All tests were one-tailed. Exact values are given in Table 2.

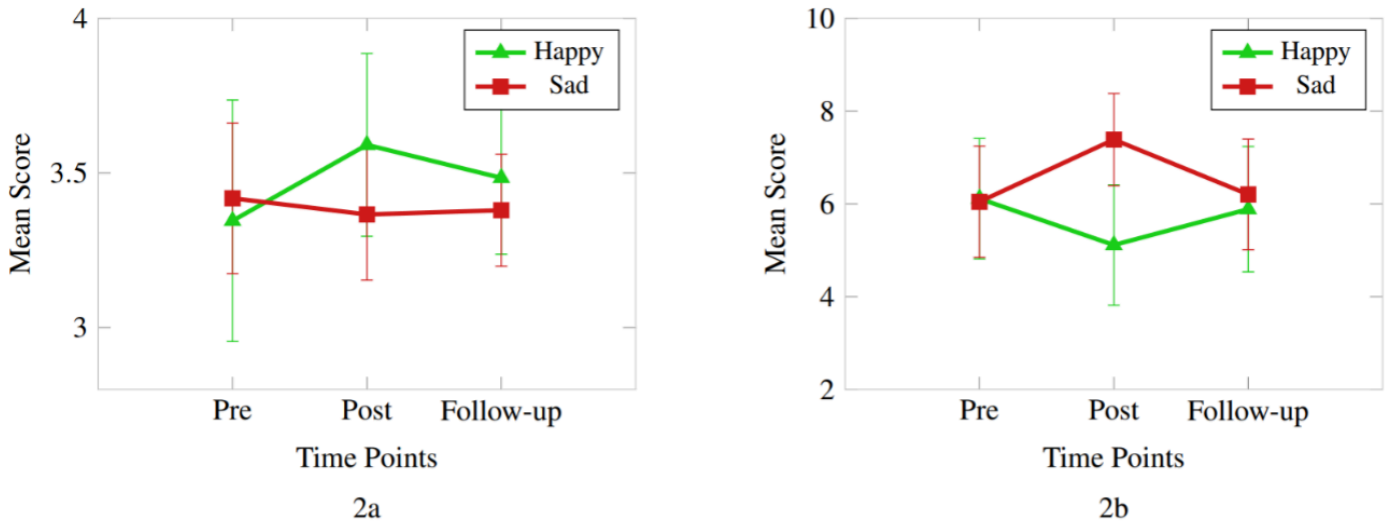


Figure 3

Changes in emotional state measured by the OHQ and BDI following movements associated with happiness and with sadness. Panel (a) shows the Oxford Happiness Questionnaire mean item score and panel (b) the Beck Depression Inventory total score, each across the three time points of pre-session, immediately post-session and six-hour follow-up. Green lines represent the condition using movements associated with happiness and red lines the condition using movements associated with sadness. Error bars represent the standard error of the mean.