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Bodily feedback: expansive and upward posture facilitates the experience of positive affect

Patty Van Cappellen [a], Kevin L. Ladd[b], Stephanie Cassidy[a], Megan E. Edwards[a] and Barbara L. Fredrickson[c]

[a]Social Science Research Institute, Duke University, Durham, NC, USA; [b]Department of Psychology, Indiana University South Bend, South Bend, IN, USA; [c]Department of Psychology and Neuroscience, University of North Carolina, Chapel Hill, NC, USA

ABSTRACT

Most emotion theories recognise the importance of the body in expressing and constructing emotions. Focusing beyond the face, the present research adds needed empirical data on the effect of static full body postures on positive/negative affect. In Studies 1 ($N = 110$) and 2 ($N = 79$), using a bodily feedback paradigm, we manipulated postures to test causal effects on affective and physiological responses to emotionally ambiguous music. Across both studies among U.S. participants, we find the strongest support for an effect of bodily postures that are expansive and oriented upward on positive affect. In addition, an expansive and upward pose also led to greater cardiac vagal reactivity but these changes in parasympathetic activity were not related to affective changes (Study 2). In line with embodied theories, these results provide additional support for the role of postural input in constructing affect. Discussion highlights the relevance of these findings for the study of religious practices during which the postures studied are often adopted.

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Decades of affective science research have theorised that emotions are both 1) expressed in the body and 2) influenced or constructed by the body (Barrett, 2006; James, 1884; Niedenthal, 2007). Much of this research has focused on the face but a growing corpus of research calls for and has advanced the study of the full body (e.g. neurobiology of "emotional body language" recognition, De Gelder, 2006; full body input to emotion regulation, Koole & Veenstra, 2015). Despite these advances, our knowledge regarding emotion expression beyond the head is still limited.

Research has documented how emotions are communicated through facial expressions, voice, or touch and how this nonverbal expression is critical for emotion and social communication (Sauter, 2017). Yet, existing systematic research on the nonverbal expression of emotion has two main limitations: 1) it focuses primarily on negative emotions but less on positive emotions (with the exception of "happiness" and "pride") and 2) it provides a much richer account of static facial expressions than of static head-to-toe body expressions (but see relevant literature reviewed below). This latter limitation is particularly problematic given that people communicate and recognise the presence of emotions through paying attention to not only the face, but also the full body (Argyle, 1975; Mehrabian, 2017). Therefore, in this research we focused on full-body nonverbal expressions associated with positive and negative affect.

Moreover, the body not only expresses emotions, but also contributes to emotional experiences (Barrett, 2006; MacCormack & Lindquist, 2017; Niedenthal et al., 2005). This embodied approach to emotions has existed for centuries, with, for example, Indian philosophy suggesting yoga as a

CONTACT Patty Van Cappellen patty.vancappellen@duke.edu Social Science Research Institute, Duke University, Box 90420, Durham, NC 27708-0420, USA

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way to prepare the mind for meditation (Kumar, 2009). In affective science, which dates back to Darwin (1872), this approach to emotion was foreshadowed in the James-Lange theory of emotions, and is present in modern constructionist theories, which argue that interoception provides information that constructs basic affect (Barrett & Lindquist, 2008). Embodied theories agree that knowledge, cognition, and emotion do not result only from abstract and amodal/symbolic representations nor that they are disconnected from perceptual inputs from the environment and the body. Modern embodiment theories go a step further and argue that even high-level conceptual processes rely on modality-specific systems and bodily states (Wilson, 2002).

At least two possible pathways can explain how bodily input builds emotions. One pathway works through situated conceptualizations of emotional experiences (Barrett et al., 2014; Barsalou, 2003; Niedenthal et al., 2005): adopting postures that have been previously associated with the experience of positive or negative affect should trigger a whole network of representations and associated feelings. In other words, through repetitive experiences of pairing a specific postural response and related psychological states, people acquire situated conceptualizations of emotions. Cueing one modality of this conceptualisation (like posture) thus activates the other associated modalities.

Another pathway, which we test here, works directly through physiological changes in the autonomic nervous system. The somatic nervous system, which is responsible for voluntary movements including postures, is in constant interplay with the autonomic nervous system (ANS). Some have theorised that changes in facial and bodily expressions lead to innate, parallel changes in measures of the ANS (Ekman et al., 1983). In turn, these changes can influence self-reported affect and motivational inclinations (Craig, 2002; Price et al., 2012). Therefore, adopting certain postures may trigger meaningful psychophysiological changes, which in turn may create a subjective affective experience (Lange, 1885; Price & Harmon-Jones, 2015). The correspondence between peripheral physiology and emotions is not clear cut (a review by Kreibig, 2010 found evidence for both emotion-specific autonomic responses and similarity in responses across different emotions). Still, some argue that changes in sympathetic activity, humans' fight or flight system, could be associated with changes in negative affect (Maslach, 1979). Changes in parasympathetic activity, humans' rest, digest, and connect system (Porges, 2007), could be associated with changes in certain low arousal positive affect, for example positive emotions of love or gratitude (Kreibig, 2014).

A significant body of empirical evidence supports the so-called postural feedback hypothesis, the idea that postures influence thoughts, emotions, and decision-making (e.g. Duclos et al., 1989; Riskind & Gotay, 1982). However, readers may be appropriately wary of its conclusion because some of the empirical support has been called into question. Indeed, for example, the effects of expansive postures (also known as "power poses") on behavioural changes, biological changes, or other non-emotion variables have not passed the test of replication (Carney et al., 2010; Ranehill et al., 2015). Nevertheless, these same poses, when compared to constrictive postures, have had reliable effects on self-reported feelings of power including in the replication study that sparked caution against the biological effects of power poses ($N = 200$, Cohen's $d = .344$; Ranehill et al., 2015) and have been found in a Bayesian meta-analysis of six conceptual replication studies (Gronau et al., 2017), P-curving analysis done on 55 conceptual replication studies (Cuddy et al., 2018; see Körner & Schütz, 2020 for a review), and another recent meta-analysis (Elkjær et al., 2022). Other research reviewed below support the postural feedback hypothesis, especially for outcomes related to emotions. Therefore, in this research we tested experimentally whether adopting postures that varied on key dimensions signalling positive and negative affect would change people's affective reaction to an emotionally ambiguous stimulus. In addition, this research explored whether changes in peripheral physiology would explain changes in affect following posture manipulation.

Although more subtle and targeted aspects of body postures may convey specific positive or negative emotions, we focus throughout on two overarching postural dimensions that have been suggested to reflect positive vs. negative affect: expansiveness-constrictiveness and upward-downward orientation of the body. On the one hand, positive affect is associated with cognitive broadening as well as physical broadening (Fredrickson, 2013). In a kinesiology study, experiencing positive emotions of joy and contentment was associated with expansive torso and more upward extension of the neck and thorax (Gross et al., 2012). Another study documented subjective perceptions of bodily sensations associated with emotions. Happiness and love were associated with perceived activation of the upper limbs (Nummenmaa et al., 2014). Positive emotions such as pride and joy have also been generally associated with expansive and upright postures (see Sauter et al., 2014 for a review). Upright postures, chest expanded and arms lifted high are most readily identified as happiness (Coulson, 2004). Stepper and Strack (1993) further found that feelings of pride were greater when the outcome of an achievement task was received in an upright posture rather than a slumped posture.

On the other hand, negative affect is associated with physical constrictiveness and slouching. In the Nummenmaa et al. (2014) study cited above, negative emotions of depression and sadness were associated with sensations of decreased activity in the limbs. Indeed, negative emotions such as sadness, helplessness, or disappointment have been associated with constrictive and/or slumped postures (LaFrance & Mayo, 1978; Oosterwijk et al., 2009; Riskind & Gotay, 1982; see Witkower & Tracy, 2019a for a review). We note that anger, however, may represent a unique exception to other negative affect, as an approach motivated emotion (Harmon-Jones, 2003). Indeed, studies have shown that anger shares expansive postural features with another approach motivated emotion, joy (Van Cappellen & Edwards, 2021b; Wallbott, 1998). While upward, expansive postures may be more advantageous for approach motivations, downward, constrictive postures may reflect avoidant motivations.

Although there are no direct replications of these studies, conceptual replications continue to support postural feedback effects. For example, an upright posture was found to increase high arousal positive affect among people with depressive symptoms (Wilkes et al., 2017), whereas a slumped posture was found to induce negative thoughts (Veenstra et al., 2017) and negative mood (Roberts & Arefi-Afshar, 2007). Similarly, when undergoing stress, participants in upright postures reported higher positive affect, lower negative affect, and used more positive affect words compared to participants in slumped postures (Nair et al., 2015). Movements such as walking more "happily" or performing upward-open movements also led to recalling more positive (vs. negative) affective words compared to downward-closing movements (Michalak et al., 2015; Michalak et al., 2018).

In the present research, we selected standing postures: one neutral and two that vary on our dimensions of interest, i.e., combining upward and expansive postural features or downward and constrictive postural features (see Figure 1). As such, the present research expands on the postural feedback literature by focusing on static *standing* postures which have not been the focus of much research (most work focuses on seating postures and some on laying down or walking postures, Gross et al., 2012; Harmon-Jones & Peterson, 2009; Michalak et al., 2015). These postures also represent common prayer postures (Van Cappellen & Edwards, 2021a) as this research was conducted as part of a larger project on embodied processes in Christian religious practices. Therefore, postures selected here, in addition to testing our core hypotheses, provide ecological validity by being frequently adopted by religious people in their private and collective practices.

The present research

Across two studies, we utilised experimental designs (between-subject in Study 1 and within-subject in Study 2) and manipulated body postures varying on our dimensions of interest (see Figure 1). We tested the causal effect of adopting these postures on the experience of positive and negative affect at the explicit (Studies 1 and 2) and implicit level (Study 2). Following a dual systems model of attitudes (Strack & Deutsch, 2004), implicit affect is defined as the automatic activation of cognitive representations of affective experiences and taps into the associative processing system, while explicit affect taps into conceptual classifications from the reflective processing system (Quirin et al., 2009). While strong implicit affect should eventually lead to explicit reflective processing, by measuring implicit affect, we may be able to assess the associative processing of emotion even if it is not strong enough to result in consciously reported affect. In Study 2, we also examined cardiovascular activity while assuming different postures in order to test whether these peripheral changes represent one pathway through which postures ultimately influence affective processes (Lange, 1885). We tested the following overarching hypotheses:

1) Positive affect: Adopting an expansive and upward-oriented posture will support the experience of positive affect to a greater degree than a

Figure 1. Depiction of full body postures adopted by participants in Studies 1-2. Left: upward and expansive; Middle: downward and constrictive; Right: Neutral.

neutral or a constrictive and downward-oriented posture.

2) Negative affect: Adopting a constrictive and downward-oriented posture will support the experience of negative affect to a greater degree than a neutral or an expansive and upward-oriented posture.

Additionally, we also explored the effect of posture on peripheral physiology and tested whether the assessed cardiovascular changes co-vary with affective changes. Cardiac pre-ejection period was used as an indicator of sympathetic activity (Newlin & Levenson, 1979) and respiratory sinus arrythmia was used as an indicator of parasympathetic activity (Berntson et al., 1993).

Study 1

Using a between-subject design, we compared postures that were expansive and oriented upward, constrictive and oriented downward, and neutral (see Figure 1). All postures were standing positions. The postures selected also represent common prayer poses, which offer ecological validity while varying on our dimensions of interest. Although our hypotheses target everyone independently of their experience with the pose in religious practice, we did test for moderation by Christian religious affiliation.

Method

Participants

A total of 110 participants were recruited to detect a moderate to large effect ($f = .30$) of posture manipulation on affect, 80% power, and alpha set at .05. Participants were psychology students from a Southeastern public university in the United States (69.9% women, 27.4% men; $M_{age} = 19.0$, $SD_{age} = 1.9$). We used pre-registered and meta-analytic evidence on embodied effects of adopting power poses on self-reported emotions as the proxy for estimating the effect size of the present research (Gronau et al., 2017), however, sample size was also determined by available financial and personnel resources. The study was approved by the IRB and there were no other exclusion/inclusion criteria. In exchange for course credit, they participated in a study investigating the effect of posture on physiology. The majority of participants self-identified as White/Caucasian (66.4%), and the remaining participants as Asian (22.1%) or Black/African American (7.1%); 2.7% identified as Hispanic. Participants were Christian[4] (67.3%), Agnostic (11.5%), Spiritual but not religious (5.3%), Atheist (1.8%), Muslim (1.8%), Buddhist (1.8%), Jewish (.9%) or other (7.1%).

Procedure

Participants came into the lab and stood for the duration of the study in a cubicle while completing a survey on a computer installed on a standing desk. Participants were told the study was about the effect of posture on physiology. To bolster this cover story, the experimenter attached a sensor on the middle finger of participants' non-dominant hand (yet physiology data were not recorded). The wire was long enough that participants could easily adopt their assigned posture. Participants were randomly assigned to one of three posture conditions (see Figure 1). All three postures were standing positions but varied in the placement of the head and gaze (i.e., up, down, straight ahead) and the expansion-constriction of the upper body (i.e., hands outstretched, hands intertwined, arms along the side). In the upward and expansive posture condition, ($n = 41$) participants were looking up with their hands outstretched, in the down and constrictive posture condition ($n = 36$), participants were looking down with their hands intertwined in front of them, and in the neutral condition ($n = 33$), participants were looking straight ahead with their arms by their sides. Random assignment was done through Qualtrics and the experimenter learned about the posture condition only right before having to demonstrate it. The experimenter gave the instructions verbally piece by piece (see below for exact instructions for each condition) and did not demonstrate the entire posture in order to reduce both priming effects of the posture image and potential experimenter effects due to having assumed the posture him/herself. In addition, the instructions did not include the words up, down, expansive, or constrictive to prevent conceptual priming. Then, the experimenter exited the cubicle to only return after the study (and all dependent measures) were completed.

While holding the posture, all participants listened to the same 4-minute long inspirational song from Enya through noise-cancelling headphones (the song was not religious and included non-English lyrics). We reasoned that some emotional stimulus was needed in order for postures to modulate emotions and we therefore needed a song that was both generative of emotions (inspiring), and emotionally ambiguous (can be experienced as positive or negative). After adopting the posture, participants completed a series of questionnaires on the computer including measures of emotions and demographics (additional measures unrelated to emotions, such as prosociality and religious variables, will support ongoing research). All conditions and data exclusions are reported here.

Conditions

Participants were randomly assigned to one of three posture conditions.

Up and expansive condition. The experimenter demonstrated the posture piece by piece while instructing the participants: "Hold your arms at a 45-degree angle, with your elbows touching your sides and your palms up. Do not look at your hands for the duration of the music but instead, look towards the ceiling."

Down and constrictive condition. The experimenter demonstrated the posture piece by piece while instructing the participants: "Touch your elbows to your sides and delicately intertwine your fingers in front of you, at the level of your chest. Look at your hands for the duration of the music."

Neutral condition. The experimenter demonstrated the posture piece by piece while instructing the participants: "Hold your arms along your body and look straight in front of you for the duration of the music."

Explicit emotions. To measure participants' emotions as a result of posture condition, we used the Differential Emotions Scale-Modified (Fredrickson, 2013). Participants were asked "how did you feel while listening to the music?" and then self-reported how much they felt each emotion on a 5-point scale (1 = *not at all*, 5 = *extremely*). Mean scores were computed for the positive affect subscale (10 items; amused, awe, serene, glad, grateful, hopeful, inspired, interested, love, proud; $\alpha = .91$) and the negative affect subscale (10 items; angry, ashamed, scared, disgust, embarrassed, hate, guilty, sad, contemptuous, stressed; $\alpha = .83$).[1]

Results and discussion

To test for the effect of conditions (i.e., upward and expansive, downward and constrictive, and neutral postures) on positive and negative affect, we ran one-way analyses of variance (ANOVA) followed by Tukey post-hoc tests. In preliminary analyses, we tested for moderation by Christian affiliation (dummy coded Christian = 1, non-Christian = 0). Since no tests of moderation were significant (all *ps* >.150), we dropped this variable in the analyses reported below. For each test, we provide effect sizes, which can be interpreted cautiously using the following rule of thumb: 0.01 small, 0.06 medium, 0.14 large (Cohen, 1988).

There was a significant difference between conditions on positive affect, F (2, 107) = 6.076, p = .003, η^2_p = .102, such that participants in the upward and expansive posture (M = 3.14, SD = 0.71) reported greater positive affect than participants in the downward and constrictive posture (M = 2.50, SD = 0.72; mean difference: 0.64, 95% CI [0.20, 1.08], p = .002), see Figure 2. Group differences between the neutral posture (M = 2.88, SD = 1.00) and the upward posture (mean difference: 0.26, 95% CI [−0.19, 0.71], p = .360) or the downward posture (mean difference: 0.38, 95% CI [−0.08, 0.85], p = .130) were not statistically significant. No significant difference between conditions emerged on negative affect (up, expansive M = 1.11, SD = 0.18; down, constrictive M = 1.15, SD = 0.39; neutral M = 1.12, SD = 0.19), F (2, 107) = 0.24, p = .787, η^2_p = .004.

In sum, Study 1 provided preliminary evidence that manipulating people's posture modified their affective response to music. Specifically, using a between-subject design, participants who were instructed to listen to music in an expansive and upward posture self-reported greater positive affect than participants who were listening to the same piece of music in a constrictive and downward posture, partially supporting H1. There was, however, no effect on self-reported negative affect (failure to support H2) and the neutral posture was also not different from either of the two other conditions (always in the middle). Study 1 was limited by the fact that experimenters were not blind to conditions. Indeed, the experimenter learned about the posture condition right before demonstrating it to the participant and leaving the room for the participant to complete all follow-up measures. Although experimenter-participant interaction was minimal during the short time when the experimenter knew the participant's condition, we cannot completely rule out concerns about experimenter expectancy effects.

Study 2

Study 2 conceptually replicated Study 1 by using the same three posture conditions and explicit emotions assessment but in a within-, instead of between-, subject design. Within-subject designs are more powerful than between-subject designs because they remove the variance due to differences between individuals from the overall error variance and are therefore particularly helpful when measuring changes in affective responses. Study 2 also importantly extended Study 1. First, to address an important limitation of Study 1, Study 2 used a rigorous double-blind design: the experimenter was blind to the participants' posture condition throughout the experiment. Second, Study 2 extended Study 1 by adding an implicit measure of emotions, which is less susceptible to experimental demand. Study 2 also added recording of physiological activity during the posture both at the parasympathetic (indicator: respiratory sinus arrhythmia [RSA]) and the sympathetic (indicator: cardiac pre-ejection period [PEP]) levels. By recording physiological activity, Study 2 explored whether the postural effects on emotions were mediated by changes in physiology, one pathway through which the postural feedback effect on emotions is theorised to unfold (Critchley & Garfinkel, 2015). RSA was chosen as it is the most common indicator for parasympathetic activity and used in affective research as an index related to general positive affect. PEP was chosen as it is one of the few typical measures solely representing sympathetic activation (Berry Mendes, 2016).

Method

Participants

A total of 79 participants were recruited, which was slightly more than the number of participants needed to detect an effect even half the size of the effect assumed in Study 1 (f = .15) of posture manipulation on affect, 80% power, and assuming all other default parameters in G*Power (Faul et al., 2007). The change in study design from Study 1 to Study 2 and available resources led us to favor a larger number of participants than the minimum required should we have chosen the same effect size as in Study 1. Participants were students and staff recruited through university email from two public universities, one in the Midwest and the other in the Southeast (67.1% women, 32.9% men; M_{age} = 31.0, SD_{age} = 13.4). The study was approved by the IRB and there were no other exclusion/inclusion criteria. In exchange for a $40 gift card, they participated in a study advertised as investigating how postures affect physiology and how music affects emotions and thoughts. The majority of participants self-identified as White/Caucasian (68.4%), and the remaining

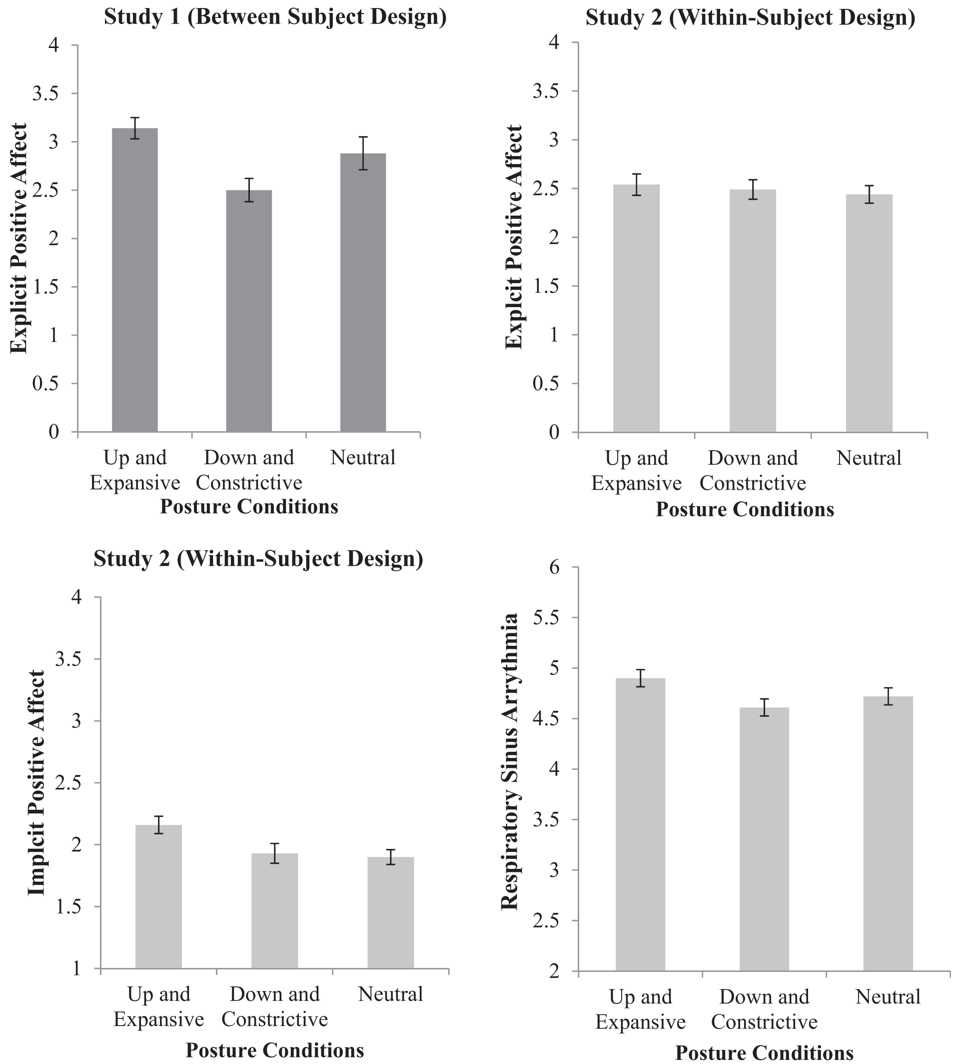

Figure 2. Top: Mean scores of explicit positive affect by posture conditions (Study 1, between-subject design on the left, Study 2, within-subject design on the right). Bottom: Mean scores of implicit positive affect (left) and respiratory sinus arrhythmia (right) by posture conditions (Study 2, within-subject design). Error bars represent standard errors.

participants as Black/African American (15.2%), Asian (10.1%), or American Indian or Alaska native (1.3%); 4 participants chose not to report race; 12.7% identified as Hispanic. Participants were Christian[2] (57%), Agnostic (19%), Spiritual but not religious (10.1%), Atheist (8.9%), Jewish (2.5%) or other (2.5%).

Procedure

All procedures and questionnaires were exactly the same in both locations of the study. First, participants' height and weight were taken and then sensors for physiological measurement were attached as described below. As in Study 1, participants stood for the duration of the study in a cubicle while following instructions and completing surveys on a computer installed on a standing desk (given that Study 2 was significantly longer than Study 1, participants were allowed to sit on a high chair while filling out questionnaires in between the posture conditions). Using a within-subject design, the study presented the same three conditions from Study 1 in a counterbalanced order (we tested for posture order effects on all dependent variables but all tests were not statistically significant). As part of the cover story, the experimenter explained that in order for participants to not have to do all questionnaires in one block and then all physiological recordings in one block, the study had been broken up into three blocks with questionnaires and physiological recordings happening in each block. Participants were presented with written and visual instructions on how to adopt the posture on the computer (embedded in the survey) in order to keep the experimenter blind to condition. While adopting the posture, participants listened to one of three similar inspirational songs from the singer Enya (approximately 3 min, see codebook on OSF, https://osf.io/69ufk/) through noise-cancelling headphones. The songs were counterbalanced within conditions. The experimenter, who could hear the music through his own headphones but not see the participant or their computer monitor, started and stopped the physiological recording at the beginning and end of the song during which participants were instructed to hold the posture. This procedure was repeated for the three postures. After each posture/song, participants completed an implicit then an explicit measure of emotions. They also completed measures of humility and self-transcendent beliefs not reported here and that were not affected by the manipulation (see codebook on OSF for full measures, https://osf.io/69ufk/). When participants had completed all three conditions and all measures, the experimenter went back into the cubicle, removed the physiological sensors, and debriefed participants. We report all conditions and data exclusions.

Postural conditions

The same three postures as in Study 1 were presented in this study. Since participants were presented with all three conditions, three similar sounding inspirational songs from Enya were selected and pre-tested ($N = 11$): no difference was found between the three songs on explicit positive and negative emotions (all ps are around .20). All three songs were approximately 3 min long, not religious, and included non-English lyrics. The songs were counterbalanced within condition. For each posture, written instructions for how to place different sections of the body (head, hands, and legs) were accompanied by pictures (for all details, see codebook on OSF, https://osf.io/69ufk/). Participants did not see a full body representation of the posture to reduce priming effects of the posture image. In addition, as in Study 1, the instructions did not include the words up, down, expansive, or constrictive to prevent conceptual priming. Participants were instructed to hold the posture for the duration of the song.

Upward and expansive condition. Participants were instructed to "hold your arms out at a 45-degree angle, with your elbows touching your sides and arms turned outward with your palms facing up." Then, participants were instructed to "not look at your hands but lean your head backwards and look towards the ceiling." Lastly, "Please remain in this position for the duration of the song."

Downward and constrictive condition. Participants were instructed to "touch your elbows to your sides and delicately intertwine your fingers in front of you, at the level of your chest." Then, "Look at your hands for the duration of the music."

Neutral condition. Participants were instructed to "hold your arms along your body." Then, Llook straight in front of you for the duration of the music."

Measures

Emotions

Implicit emotions. The Implicit Positive and Negative Affect Test (Quirin et al., 2009) was adapted to measure participants' emotions at an implicit level. After each posture/song, participants were told that they would be presented with two words from an artificial language and asked to rate how well on a 4-point scale (1 = *Doesn't fit at all,* 2 = *Fits somewhat,* 3 = F*its quite well,* and 4 = *Fits very well*) each of seven feelings (*gratitude, sad, helpless, pride, joy, humble, inspired*) fit the words. Participants were instructed to let themselves be guided by their own spontaneous feelings as they were making these judgments. Research has shown that participants' current mood influences how they rate the words (Quirin et al., 2009). The two words to rate were different for each posture, randomly selected from a pool of six words (Safme, Vikes, Talep, Tunba, Belni and Sukov). Two subscales were created: a positive affect subscale composed of gratitude, joy, and inspired ratings (upward and expansive, $\alpha = .72$, downward and constrictive, $\alpha = .77$, neutral $\alpha = .62$), and a negative affect subscale composed of sad and helpless ratings (upward and expansive, Spearman's $\rho = .55$, downward and constrictive, $\rho = .66$, neutral $\rho = .63$). Reliabilities were overall lower for the negative affect subscale. Note that humble and pride were analyzed separately to capture dominance and did not differ as a result of posture, therefore are not further discussed.

Explicit emotions. The same measure as in Study 1 was administered (Differential Emotions Scale-Modified, Fredrickson, 2013). Participants were asked "How did you feel while listening to the music?" and then rated how much they felt each emotion on a 5-point scale (1 = *not at all* and 5 = *extremely*). Likewise, two subscales were created: a positive affect subscale (10 items; upward and expansive, α = .94, downward and constrictive, α = .93, neutral α = .91) and a negative affect subscale (10 items; upward and expansive, α = .88, downward and constrictive, α = .84, neutral α = .78).

Autonomic response

Physiological data were collected using sensors and amplifying hardware supplied by Mindware, Inc. Electrocardiographic (ECG) recording was performed with disposable electrodes attached in a Modified Lead II configuration (right upper chest, left lower rib). Cardiac impedance (Zo) recording used four additional electrodes: at the base of the throat, right below the sternum, and in the back, one on the neck and one 1.5 in. below the one placed in the front, below the sternum.

Sampling frequency for all variables was 500 Hz. In order to remove error and artifact (e.g., movement, coughing), all data were screened visually by research assistants blind to emotion condition prior to analyses.

Respiratory sinus arrhythmia (RSA). RSA was derived using Mindware, Inc.'s HRV analysis software (version 3.2) and using both the ECG signal and Zo signal (controlling for respiration monitored by impedance cardiography; see Ernst et al., 1999). RSA was derived in accordance with recommendations from the Society for Psychophysiological Research committee on heart rate variability (Berntson et al., 1997). For the editing process, the approximately 3-minute recording was split into 60 s segments in the HRV analysis software. Then, each segment was visually inspected by trained research assistants to see if the ECG was readable and/or the R wave peaks were in the correct place. Eight participants were excluded due to technical errors during data collection and one participant was excluded because they had more than 5% estimated beats (R wave peaks), rendering their data less reliable. The Mindware HRV analysis software calculates RSA by subjecting the IBI series to Fast Fourier Transform, and applying a Hamming window for the .12–.40 Hz frequency range of the resulting spectral distribution. A mean score of the three segments was computed and used in the analyses.

Cardiac pre-ejection period (PEP). Cardiac impedance analysis software (Mindware, Inc., version 3.2) was used to calculate PEP using the ECG signal, the Zo signal and its first derivative, dZ/dt. The percent of dZ/dt time + c algorithm was used to automatically identify the B point on the dZ/dt ensemble average. This algorithm places the B point at a certain percentage of the R-Z interval and adds a constant millisecond value C (set at 4) to the placement time (Lozano et al., 2007). Twenty participants were excluded due to technical errors or research assistant error during data collection, and four participants were excluded for unreliable PEP values due to the inability to identify the B point on the dZ/dt signal.

Results and discussion

To test for the effects of postures on affect, RSA, and PEP, we ran a series of one-way repeated measure ANOVAs followed by Sidak post-hoc tests. In preliminary analyses we tested for moderation by Christian affiliation (dummy coded Christian = 1, non-Christian = 0). Because no tests of moderation were significant (all *ps* >.156), we dropped this variable in the analyses reported below. If the assumption of sphericity was violated, results are reported using Greenhouse-Geisser correction.

Emotions.

Explicit emotions. Explicit positive, $F(1.82, 140.33) = 0.48$, $p = .600$, $\eta_p^2 = .006$, and negative affect, $F(2, 154) = 1.88$, $p = .156$, $\eta_p^2 = .024$, did not differ as a result of posture (positive affect: upward, expansive $M = 2.54$, $SD = 0.99$; downward, constrictive $M = 2.49$, $SD = 0.90$; neutral $M = 2.44$, $SD = 0.81$; negative affect: upward, expansive $M = 1.18$, $SD = 0.35$; downward, constrictive $M = 1.22$, $SD = 0.38$; neutral $M = 1.14$, $SD = 0.26$), see Figure 2.

Implicit emotions. A significant difference between conditions on positive affect emerged, $F(2, 156) = 6.51$, $p = .002$, $\eta_p^2 = .077$, such that participants experienced greater positive affect following the upward and expansive posture ($M = 2.16$, $SD = 0.64$) than following the neutral posture ($M = 1.90$, $SD = 0.53$; mean difference: 0.27, 95% CI [0.06, 0.47], $p = .006$) or the downward and constrictive posture ($M = 1.93$, $SD = 0.67$; mean difference: 0.23, 95% CI [0.03, 0.44], $p = .021$), see Figure 2. Group differences between the neutral posture and the downward and constrictive posture (mean difference: 0.03, 95% CI [−0.17, 0.87], $p = .250$) were not statistically significant. No difference between conditions was evident for negative affect (upward, expansive $M = 1.64$, $SD = 0.58$; downward, constrictive $M = 1.80$, $SD = 0.61$; neutral $M = 1.78$, $SD = 0.63$), F (2, 156) = 1.75, $p = .177$, $\eta_p^2 = .022$).

Autonomic response

RSA. A significant difference between conditions on RSA emerged, $F(2, 138) = 7.04$, $p = .001$, $\eta_p^2 = .093$, such that participants had higher RSA in the upward and expansive posture ($M = 4.90$, $SD = 1.32$) than when in the downward and constrictive posture ($M = 4.61$, $SD = 1.43$; mean difference: 0.30, 95% CI [0.10, 0.50], $p = .002$) or in the neutral posture ($M = 4.72$, $SD = 1.35$; mean difference: 0.19, 95% CI [0.01, 0.37], $p = .041$)[3], see Figure 2. Differences between the neutral posture and the downward and constrictive posture were not statistically significant (mean difference: 0.11, 95% CI [−0.10, 0.32], $p = .480$). There was also no significant interaction between BMI and postures in predicting RSA (see OSM for analyses).

Pre-ejection period. Pre-ejection period did not differ as a result of posture (up, expansive $M = 105.50$, $SD = 10.43$; down, constrictive $M = 105.14$, $SD = 10.50$; neutral $M = 104.90$, $SD = 10.34$), $F(2, 108) = .96$, $p = .385$, $\eta_p^2 = .018$.

Mediation analyses

We tested whether changes in RSA mediated the changes in implicit positive affect following posture condition. We followed recommendations by Montoya and Hayes (2017) and used the MEMORE v. 2.0 macro to test mediation in repeated measures design with 5000 bootstrap samples. First, we contrasted the upward and expansive posture to the downward and constrictive posture. The 95% bootstrap confidence interval for the point estimate of the indirect effect is −0.08 to 0.06, which includes zero and therefore does not show evidence for mediation. Second, we contrasted the upward and expansive posture to the neutral posture. The 95% bootstrap confidence interval for the point estimate of the indirect effect is −0.08 to 0.05, which also does not show evidence for mediation. Results were not different when switching RSA to be the dependent variable and implicit positive affect to be the mediating variable.

In sum, we found further evidence that manipulating people's posture modified their affective response to music. Specifically, using a within-subject design, the study demonstrated that participants instructed to listen to music in an expansive and upward posture showed greater positive affect than when instructed to listen to music in a downward and constrictive posture or in a neutral posture, fully supporting H1. However, these results were limited to the implicit measurement of affect and were not apparent for the explicit measurement of affect. Further, the study results did not support H2, that a downward and constrictive posture amplifies negative affect. As in Study 1, negative affect was generally very low and the implicit measurement was also less reliable as indexed by lower Cronbach's alphas.

We did not find any changes in sympathetic activity (as assessed through PEP) between all three standing postures. However, we did find that parasympathetic activity (as assessed through RSA) was greater when participants were in an upward and expansive standing pose compared to a downward and constrictive, as well as a neutral standing pose. However, there was no evidence of mediation of the effect of posture on positive emotions through physiology. It is not uncommon for studies to fail to find a relationship between peripheral physiology measured during an emotional stimulus and subjective experience assessed after the emotional stimulus (Mauss et al., 2005). More research is needed to better understand the relationship between physiological and affective changes as a result of posture.

General discussion

The present series of studies examine whether adopting an upward and expansive, downward and constrictive, or neutral posture modifies the affective and physiological responses to an emotionally ambiguous stimulus. This work, partially drawing from and building upon theories taking an embodied approach to cognition and emotion, advances our knowledge on the embodiment of emotions. The present results align with the central proposition of embodied approaches that postural signal contributes to the construction of affect (Barrett & Lindquist, 2008;

Barsalou, 2008; Niedenthal et al., 2005). More specifically, the results support the postural feedback hypothesis. Indeed, both in Studies 1 and 2, adopting a posture that is expansive and oriented upward causally promoted the experience of positive affect while listening to music compared to a posture that is constrictive and oriented downward (Studies 1-2) and to a posture that is neutral (Study 2 only).

However, these effects were small and present at the explicit/self-report level in Study 1, but only at the implicit and not the explicit level in Study 2. On one hand, effects at the implicit but not explicit level suggest that demand characteristics are probably not an issue in explaining the findings of Study 1. On the other hand, the lack of replication of the effect of postures on explicit emotions is puzzling. There are several possible explanations for these findings.

First, we a posteriori wonder whether the within-subject design of Study 2 may be partly responsible. Participants adopting each posture right after each other may not have experienced a big enough change in affect to warrant a full point difference on a self-report scale. However, the implicit measure appeared to be capable of capturing preconceptual representations of affect activated by the posture (Quirin et al., 2009). Second, the Study 2 explicit positive affect ratings were lower than in Study 1, which could further account for the lack of differences on explicit affect in Study 2. Third, while the double-blind procedure in Study 2 removed any chances of experimenter expectancy effects, this may also explain the lack of effects on explicit mood. This leaves open the possibility that the significant findings on explicit affect in Study 1 were due to experimenter expectancy effects.

However, neither Studies 1–2 provided support that adopting a posture that is constrictive and oriented downward promotes the experience of negative affect. The music stimuli, though chosen to be emotionally ambiguous, were still rated higher in positive than negative affect. Negative affect, in general, was experienced at very low levels, which could explain why there were no differences found. Further, in Study 2, the measurement of implicit negative affect was limited to two items, which offered less reliable measurement than multi-item scales. Future research could increase the number of items to have a more reliable index of negative affect.

Study 2 also examined biological mechanisms of the postural effects on affect: that changes in cardiovascular activity while assuming a specific posture are associated with affective changes (e.g. Lange, 1885; Price et al., 2012). Although we found that parasympathetic activity (as assessed through RSA) was greater when participants were in an upward and expansive standing pose compared to a downward and constrictive, as well as a neutral standing pose, there was no evidence of mediation of the effect of posture on positive affect through physiology. Therefore, we did not find support for the idea that postural feedback happens through peripheral physiology changes.

While such a mechanism is theorised in some embodiment accounts, research has typically provided support for parallel changes in physiology and affect or approach/avoidance motivation following whole body posture manipulation, but did not directly investigate mediation (see for a review, Price et al., 2012). We note that these results are preliminary, awaiting replication, and limited by a small sample size given some lost data to technical errors.

However, future research may also test whether the present findings could be explained by a more central mechanism: situated conceptualizations of emotional experiences (Barsalou, 2003; Wilson-Mendenhall et al., 2011). This mechanism implies that postures activate other modalities that have been associated over time and through repetitive experiences. The features of expansiveness and upward body orientation of the posture selected in Studies 1 and 2 may have been associated with previous experiences of positive affect.

Indeed, the expansive and upward postures such as the one used in this research is at least adopted by Christians in their worship practices and has been shown to be associated with the experience of positive affect in that context (Van Cappellen & Edwards, 2021b; Van Cappellen et al., in press). Moreover, among people of diverse faiths, upward expansive postures are used in bodily expressions of joy (Van Cappellen et al., in press; Witkower & Tracy, 2019b).

Future research may explore in more depth situated conceptualizations of emotional experiences, especially since this mechanism may also better explain how postures can affect higher-level forms of emotion processing such as emotion regulation (Veenstra et al., 2017). In addition, this mechanism recognises potential cultural differences in the experiences and meanings attached to specific postures. It is in line with findings suggesting that postural effects depend not only on the physical aspect of the posture but also on its symbolic meaning, which can vary by culture (Park et al., 2013) as well as by context (see for a discussion, Van Cappellen & Edwards, 2021b). Each of these topics represent potentially fruitful areas for future research.

Finally, as we were writing the results of this research, a new meta-analysis using the largest sample of studies so far on the effects of high-power and upright postures on self-report, behavioural, and physiological dependent variables was published (Körner et al., 2022). As we showed in the present research, they found that body positions did affect self-report dependent variables (small to medium effect size). They also found stronger effects for within-subject designs than for between-subject designs. However, they did not find an effect of body postures on physiology, but we note that all the studies under this umbrella used measures of hormones and not measures of the ANS as in the present research.

Strengths and limitations

Strengths of this work include that Studies 1 and 2 were designed to conceptually replicate each other using both a between and a within-subject design. Within-subject designs provide greater power to detect our hypothesised effects by removing the error variance due to differences between subjects. Both studies used a cover story to reduce concerns for demand effects. Study 2 also employed a rigorous double-blind design and counterbalanced posture conditions. Finally, the present work is one of the relatively studies in embodiment research to include a "neutral" posture from which to contrast the effects of expansive and constrictive postures (Elkjær et al., 2022; Körner et al., 2022). While no posture is truly neutral and can also create in and of itself some experimental demand, this addition allows to test the separate effects of each postural configuration.

The present work also has limitations. First, we did not pre-register these studies (although see OSF for complete lists of measures and protocols, https://osf.io/69ufk/). In addition, regarding the physiology findings of Study 2, we chose to use a neutral standing posture as our comparison condition instead of a passive resting baseline. This comparison choice has the advantage of engaging similar muscles and attentional activity as the other conditions but prevents us from claiming that expansive and upward postures *increase* RSA since all postures may have *decreased* RSA compared to a resting baseline, with less decrease when in an expansive and upward posture (for similar design and limitation see, Stellar et al., 2015). We therefore consider the present results as preliminary.

Future research may investigate more examples of postures fitting the upward/expansive and downward/constrictive postural configurations beyond the ones studied here. Similarly, future research may investigate more fine-grained postural features associated with the expression of specific positive and negative emotions, beyond the two studied here. For example, arm positions appear to distinguish between various positive emotions (e.g. for joy, arms reaching high up; for awe, hand(s) touching the face as if the person is exceptionally surprised and actively striving to accommodate the new, colloqually "blow my mind," Van Cappellen et al., in press) and head tilt can alter social judgment of otherwise similar faces (Witkower & Tracy, 2019b).

Finally, we only investigated how expansiveness relates to positive affect but not to power or the specific positive emotion of pride (see Chang et al., 2017, which links positive affect to perceived agency) despite a large body of research relating the two (Burgoon & Dunbar, 2006; Tracy & Robins, 2004). We suspect that expansiveness can convey nuanced messages that may also depend on other features of the body or even on the context in which the posture is adopted.

Such contextual and cultural factors on the effects of postures on affective processes were not the focus of the present research. Participants were in a laboratory setting devoid of other contextual features and listened to inspirational music by the artist Enya. Considering such experimental demands, we cannot suggest that these effects are context-independent (see for a discussion, Elkjær et al., 2022). This leaves open the question of whether the effects found here could generalise beyond that particular context, for example in response to other ambiguous stimuli, and beyond the present mostly White and Christian U.S. samples (Park et al., 2013; Van Cappellen & Edwards, 2021b).

Implications and conclusion

More broadly, these findings have implications for our understanding of mind–body connection in religious and spiritual practices. Indeed, the postures in

Studies 1 and 2 correspond to two frequent prayer and worship poses (of note, we tested and did not find that the results from Studies 1–2 were moderated by participants' Christian affiliation). The results add to previous research on the effects and functions of bodily postures within Christians' worship habits (Van Cappellen et al., 2021; Van Cappellen & Edwards, 2021a). We find that studying these questions in the context of religious practices provides good ecological validity. Indeed, in 2010, 83.6% of the world's population was estimated to be affiliated with a religion and 31.4% as Christian (Pew Research Center, 2012). Further, people who are religious spontaneously adopt poses that vary on our dimensions of interest (Van Cappellen et al., 2021). It also holds practical interest: given that people who are religious adopt a specific and limited set of prayer poses up to multiple times a day, embodiment effects could potentially compound over time to explain known psychological correlates of religious practice. Further speaking to the interdisciplinary nature of this research, these findings are relevant to the study of kinesiology and highlight the interconnection between body mechanics and psychology.

In conclusion, the present studies align with embodiment theories and provide additional support for the role of bodily input in psychological processes. Across two experimental studies (one between-subject and one within-subject), we find evidence for an effect of manipulated full-body postures on affect and cardiovascular activity. We highlight two postural features that track positive affect: upward body orientation and expansiveness.

Notes

1. We also created a composite score for self-transcendent positive emotions (i.e., awe, gratitude, inspiration, and love) because these specific emotions have been shown to be at the core of religious experience (Van Cappellen, 2017; Van Cappellen et al., 2013) and were expected to be particularly affected by expansive and upward postures often adopted in a religious context. We report these results in the OSM.
2. Some participants reported Christian denominations in the "other" category, these participants were recoded as Christian.
3. There were two non-extreme outliers in the data (values greater than 1.5 box-lengths from the edge of the box), as assessed by inspection of boxplots separately for each condition. Results were similar when running the analysis without outliers $F(2, 134) = 6.46$, $p = .002$, $\eta_p^2 = .088$, such that participants had higher RSA in the upward and expansive posture than when in the downward and constrictive posture (mean difference: 0.27, 95% CI [0.07, 0.47], $p = .004$ or in the neutral posture (mean difference: 0.21, 95% CI [0.03, 0.39], $p = .021$.

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The datasets and codebooks are freely accessible through the Open Science Framework: https://osf.io/69ufk/

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ORCID

Patty Van Cappellen http://orcid.org/0000-0001-5880-6232

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