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## Associations between attention, affect and cardiac activity in a single yoga session for female cancer survivors: An enactive neurophenomenology-based approach



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### ABSTRACT

Yoga practice is reported to lead to improvements in quality of life, psychological functioning, and symptom indices in cancer survivors. Importantly, meditative states experienced within yoga practice are correlated to neurophysiological systems that moderate both focus of attention and affective valence. The current study used a mixed methods approach based in neurophenomenology to investigate associations between attention, affect, and cardiac activity during a single yoga session for female cancer survivors. Yoga practice was associated with a linear increase in associative attention and positive affective valence, while shifts in cardiac activity were related to the intensity of each yoga sequence. Changes in attention and affect were predicted by concurrently assessed cardiac activity. Awareness of breathing, physical movement, and increased relaxation were reported by participants as potential mechanisms for yoga's salutary effects. While yoga practice shares commonalities with exercise and relaxation training, yoga may serve primarily as a promising meditative attention-affect regulation training methodology.

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### 1. Introduction

Contemporary yoga practice consists of lifestyle prescriptions, postures, breath regulation, and meditative techniques, all of which can be modified depending on the desired outcomes and health status of the practitioner (Bower, Woolery, Sternlieb, & Garet, 2005). Emerging research suggests yoga not only shares many of the benefits of exercise but also adds yoga-specific psychophysiological regulation of attention, respiration, relaxation, and autonomic nervous system function (Evans, Tsao, Sternlieb, & Zeltzer, 2009; Khalsa, 2004). Studies comparing yoga and exercise indicate that, in healthy individuals and those with various health conditions, yoga can be as effective as more contemporary Western forms of exercise including walking, jogging, cycling, and aerobics at improving a variety of health-related outcome measures, including

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quality of life, mood, stress, and fatigue (Ross & Thomas, 2010). Within cancer treatment settings, yoga practitioners compared to controls show greater improvements in overall health-related quality of life, psychological health, stress-related symptoms, fatigue, and sleep indices (Boehm, Ostermann, Milazzo, & Bussing, 2012; Cramer, Lange, Klose, Paul, & Dobos, 2012a,b; Culos-Reed et al., 2012; Lin, Hu, Chang, Lin, & Tsauo, 2011; Smith & Pukall, 2009), though reported improvements have not been uniform (Zhang, Yang, Tian, & Wang, 2012).

Yoga practices are said to have numerous applications, ranging from spiritual liberation or *Kaivalya*, as per the Yoga Sutras of Patañjali (YS IV.34) (Bryant, 2009), to ordinary physical and mental training (Rao, 2011). However, the root aim of yoga can be summarized in Patañjali's definition of Yoga as a path towards "stilling the changing states of the mind" – *Chitta vritti nirodaha* (YS I.2) (Bryant, 2009). Briefly, the term *chitta* in Indian yogic philosophy is used to denote the mind or consciousness in its entirety and associated functions. *Chitta* can be considered, "the seat of one's cognition, volition, feelings and actions" (Rao, 2005, p. 13). *Vritti* refers to any permutation or activity of this mind or consciousness. According to Patañjali, these mental states are in a constant state of fluctuation or change (Rao, 1998). *Nirodaha* refers to the complete control or stilling of these mental activities so that one experiences the mind or consciousness unrestricted by this constant state of mental vacillation (Rao, 2012). Control of these changing mental states comes from persevering practice aimed at both attaining and maintaining states of mental stability and equanimity over long, uninterrupted periods of time (YS I.12–I.14) (Bryant, 2009). Importantly, meditative states subjectively experienced during yoga practice are related to neurophysiological systems that mediate both focus of attention and affect regulation (Rubia, 2009; Telles & Raghavendra, 2011).

These meditative states can be further divided into two broad categories (Lutz, Slagter, Dunne, & Davidson, 2008): (1) *focused attention meditation*, which entails voluntary sustained attention on a meditation object of choice, whether external or visualized images, words or sounds, or physical sensations, including the breath; and (2) *open monitoring meditation*, which involves monitoring the content of present-moment experience without focus on an explicit object per se. Both meditative states have correlates in the Yoga Sutras of Patañjali, in which they are referred to as *dharana*, which requires focused attention, and *dhyana*, open monitoring in which an expansive mental state is reached (Telles & Raghavendra, 2011). Of importance to both forms of meditation is the maintenance of an optimum level of arousal or activation (Lutz, 2007). One seeks to avoid the two extremes of dullness or tiredness on the one hand, and excitement or tension on the other. The mind is initially calmed and distractions are reduced via focused attention. From this calm and focused state the practitioner develops a foundation to enter into open monitoring, in which the focus shifts from the meditative object to present-moment experience (Lutz et al., 2008; Slagter, Davidson, & Lutz, 2011; Telles & Raghavendra, 2011). It is thought consistent practice of these skills lead to a trait-like change in which the regulative skills of focused attention are applied less and less frequently, open monitoring meditative states become predominant, and mental calmness and focus become progressively more effortless (Slagter et al., 2011).

The purpose of the current project was to utilize a neurophenomenology-based approach to investigate associations between attention, affect, and cardiac activity in a single yoga session in a group of female yoga practitioners who had survived a cancer experience. The present study also used several supplementary psychological theories to frame the posited attentional, affective, and psychophysiological responses to yoga practice. Theories include: the Effort-Related Attention Model, the Circumplex Model of Affect, the Dual-Mode Theory of Affective Responses to Exercise, and the Neurovisceral Integration Model.

### 1.1. Neurophenomenology

Neurophenomenology is a mixed-methods research approach used to investigate conscious experience (Lutz & Thompson, 2003; Thompson, 2006; Varela, 1996). The neurophenomenological approach provides mutually informative insights between subjective first-person experience, second-person dialogical enquiry stemming from interactions between research participants and the investigator, and third-person neuroscientific data. Neurophenomenology has been used previously to examine contemplative practices, particularly among advanced meditation practitioners using primarily electroencephalography (EEG) or functional magnetic resonance imaging (fMRI) to directly measure brain activity (Farb et al., 2007; Lutz, Brefczynski-Lewis, Johnstone, & Davidson, 2008; Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004; Lutz, Lachaux, Martinerie, & Varela, 2002; Lutz et al., 2009). Emerging research has called for an integration of neurophenomenology, cognitive and affective neuroscience, and psychophysiology – an "affective neuro-physio-phenomenology" (Colombetti, 2013) – to investigate the neurophysiological underpinnings of different attentional and affective states and their relationship to consciousness. This "enactive" approach directs neurophenomenology towards understanding the relationship between subjective experience and the entire psychophysiological organism (Colombetti & Thompson, 2008; Thompson, 2005).

### 1.2. Attention

To investigate how yoga practice regulates attention, we explored research in the area of exercise science to further frame our study. Briefly, focus of attention during exercise can influence changes in affective responses (Lind, Welch, & Ekkekakis, 2009). Attention within exercise settings can be defined as associative, or focusing on present-moment physical sensations related to exercise, while dissociative attention can be defined as focusing on non-exercise-related stimuli and diverting attention away from internal sensations and present exercise experience (LaCaille, Masters, & Heath, 2004). In accordance with the Effort-Related Attention Model (Tenenbaum, 2001), associative and dissociative attention strategies during exercise

vary depending on exercise intensity. During exercise at low-to-moderate workloads, attention can be controlled voluntarily and switch between dissociative and associative modes. However, at higher exercise intensities, the intensification of physiological cues forces an involuntary shift in attention to aversive interoceptive stimuli (Tenenbaum & Connolly, 2008).

In relation to focus of attention, yoga practice provides an opportunity for sustained attention to physical sensations, breathing, and the contents of the mind through progressive sequences of varying intensity, including dynamic movements, restful postures, breathing exercises, and periods of meditative awareness. The strong mind–body interaction within contemporary yoga practice adds a unique contemplative dimension to exercise that has been referred to as ‘mindfulness in motion’ (Salmon, Lush, Jablonski, & Sephton, 2009). Mindfulness is defined as the ability to direct attention towards events in the field of consciousness (thoughts, emotions, physical sensations) in the present moment without judgment (Brown & Cordon, 2009). Within exercise settings, mindfulness builds upon associative attention by refining perceptions of exertion on a moment-by-moment basis via increased sensitivity to a host of cognitive and interoceptive cues, and concurrently limits emotional reactivity to these cues (Salmon, Hanneman, & Harwood, 2010).

### 1.3. Affect

To explore affective responses to yoga practice we utilized the Circumplex Model of Affect (Posner, Russell, & Peterson, 2005), which suggests affect can be represented by two orthogonal and bipolar dimensions: valence (pleasure versus displeasure), and perceived activation or arousal (high versus low). These two dimensions of valence and activation jointly define the content domain of *core affect*, and are theorized to underlie all affective states. Combinations of these two dimensions are described as: high activation pleasure (e.g., energy), low activation pleasure (e.g., calmness), high activation displeasure (e.g., tension), and low activation displeasure (e.g., tiredness) (Yik, Russell, & Barrett, 1999) (see Fig. 1.1). Unlike approaches based on sampling only a few distinct states (e.g., specific mood states), the Circumplex Model captures the most phenomenologically salient features of the affective response to any given stimulus by tapping its constituent dimensions (Ekkekakis, 2013).

Dual Mode Theory (Ekkekakis, 2003) proposes affective responses related to exercise are regulated via the continuous interplay of both cognitive processes and interoceptive cues. The relative importance of these two factors in the regulation of core affect is hypothesized to shift systematically as a function of exercise intensity. Exercise performed at intensities above lactate or ventilatory thresholds leads to negative affective experiences of exercise when workload increases to a point that exercise cannot be physiologically maintained and interoceptive cues indicate one should stop. Exercising below this threshold leads to positive affective experiences, as individuals are able to maintain this workload, which bolsters positive cognitive factors (Ekkekakis, Parfitt, & Petruzzello, 2011). In relation to yoga practice, participation in a single yoga session has been associated with significant improvements in positive affect and reductions in negative affect comparable to changes seen with moderate intensity aerobic exercise (Netz & Lidor, 2003; West, Otte, Geher, Johnson, & Mohr, 2004).

### 1.4. Cardiac activity

Heart rate variability (HRV) represents the complex beat-to-beat variation in heart rate produced by the interplay of sympathetic and parasympathetic autonomic neural activity as recorded via an electrocardiogram (ECG) (Task Force of the European Society of Cardiology & Electrophysiology, 1996). In general, higher parasympathetic (vagal) mediation of HRV is associated with positive health outcomes (Rajendra Acharya, Paul Joseph, Kannathal, Lim, & Suri, 2006; Thayer & Ruiz-Padial, 2006). The Neurovisceral Integration Model (Thayer & Lane, 2009) implicates a common reciprocal neural network between the heart and brain. This network, which can be indexed with HRV, serves as the structural link between psychological processes like emotion and cognition, and health-related physiological processes. Those with lower resting HRV (indicative of decreased parasympathetic and/or increased sympathetic nervous system activity) are at risk for both

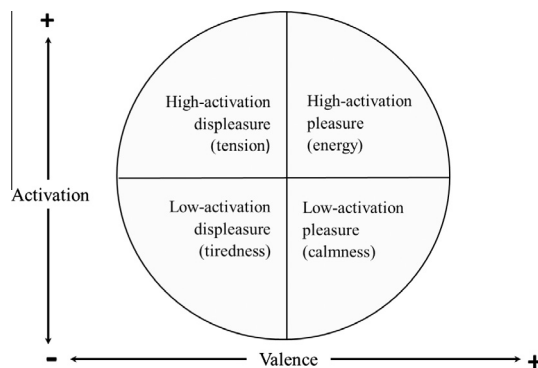


Fig. 1.1. Circumplex Model of Affect.

psychological and physiological dysfunction, whereas both exercise training and a higher level of aerobic fitness are associated with greater parasympathetic modulation of cardiac autonomic function (Routledge, Campbell, McFetridge-Durdle, & Bacon, 2010).

Yoga programs are reported to result in increased parasympathetic nervous system (PNS) activity (Khattab, Khattab, Ortak, Richardt, & Bonnemeier, 2007; Telles et al., 2013). Streeter, Gerbarg, Saper, Ciraulo, and Brown (2012) hypothesize yoga practice corrects PNS under-activity via stimulation of the vagus nerves to ameliorate stress-related illness symptoms. During active yoga poses, heart rate and respiration increases in a manner consistent with exercise (Cowen & Adams, 2007). However, during and following the restful supine and seated meditative postures that conclude most yoga classes, parasympathetic activity is consistent with relaxation and reduced physiological arousal (Sarang & Telles, 2006).

Given these connections between yoga, attention, affect, and cardiac activity, our investigation required the addition of HRV as a novel correlate of psychophysiological function. In addition, both the Effort-Related Attention Model and Dual Mode Theory suggest attentional and affective experience during exercise is driven by the physiological intensity of exercise itself. While common physiological indices of exercise intensity are ventilatory and/or lactate thresholds (McArdle, Katch, & Katch, 2009), yoga practice is generally considered low-intensity and occurs below these ventilatory or lactate thresholds (Ray, Pathak, & Tomer, 2011). Given these associations, measurement of cardiac activity throughout each yoga session provided appropriate neurophysiological indices sensitive to lower-intensity yoga practice-related changes.

### 1.5. Objectives

Taking Patañjali's definition that yoga is the "*stilling of the changing states of the mind*" (YS I.2) (Bryant, 2009) as a guide, the purpose of the present study was to investigate participants' experience of a single yoga session in an effort to understand how yoga practice influences immediate attentional and affective experience. The aims of the current study were threefold: to investigate (1) whether yoga practice elicits (a) increased attention and positive affective valence, and (b) activation, perceived exertion, and cardiac activity consistent with the intensity of each yoga sequence during a single yoga session; (2) associations between these variables across measurement occasions; and (3) whether participants' subjective first-person descriptions of their experience of the yoga session corroborated quantitative findings.

## 2. Methods

### 2.1. Procedures

Ethical approval was obtained from the Conjoint Health Research Ethics Board (CHREB) of the University of Calgary/Alberta Health Services and all participants completed a CHREB-approved informed consent prior to study enrollment. The study sample was drawn from participants who had previously completed Yoga Thrive, a research-based 7-week therapeutic yoga program for cancer survivors and their support persons, as described previously (Mackenzie, Carlson, Ekkekakis, Paskevich, & Culos-Reed, 2013). Upon arrival in the lab, participants ( $N = 18$ ) completed a questionnaire package assessing demographics, medical history, weekly physical activity, and previous yoga experience and had their height and weight measured. Participants then completed a single private and individually-taught standardized 80-min yoga session. Single-item, self-reported psychological scale measures assessing attention, affective valence, activation, and perceived exertion were completed eight times at 10-min intervals at the end of each of the following sequences: (1) supine resting pre-yoga practice, in which baseline resting cardiac activity was measured; (2) supine yoga, which included gentle breathing and movement while participants laid supine with their legs flexed at the hip and supported by a wall; (3) seated yoga, which included a series shoulder rolls, gentle forward/backward bends and twists with attention to the breath in a cross-legged position; (4) kneeling yoga, including flexion and extension of the spine in an "all fours" position, a series of kneeling lunges, and a sustained resting posture in which participants sat back on their heels, bent forward, and rested their foreheads on the ground or their folded arms; (5) standing yoga, including more challenging symmetrical and asymmetrical postures, balance work, and forward bends; (6) a second supine yoga sequence, including bridging through the hips, bringing the knees to the abdomen with the assistance of the arms, a gentle supine twist, and returning to a resting posture with the knees brought to the abdomen; (7) a guided supine meditation, with attention placed on both breathing and bodily sensations; and (8) supine resting post-yoga condition, in which resting cardiac activity was again assessed. All participants had prior training in filling out all self-report measures (Mackenzie et al., 2013).

Given the ambulatory nature of the yoga practice measured in the present study, both fMRI and EEG were precluded from use in gathering neuroscientific data related directly to brain activity. As such, in accordance with the Neurovisceral Integration Model (Thayer, Hansen, Saus-Rose, & Johnsen, 2009), cardiac activity was used as an autonomic neurophysiological correlate of attention and affect regulation. Cardiac activity, including heart rate and HRV, were assessed continuously throughout the session via a wireless chest-band heart rate monitor (RS800CX, Polar Electro, Kempele, Finland). Because cardiac activity exhibits diurnal variation, all participants were assessed in the morning to ensure consistency (Wu & Lo, 2008). In addition, participants were asked to not exercise or consume caffeine or alcoholic beverages 12 h prior to the experiment and to refrain from eating and drinking 3 h prior to the experiment, as these agents have been shown to influence cardiac

activity (Poher, Braun, & Freedson, 2004; Task Force of the European Society of Cardiology & the North American Society of Pacing & Electrophysiology, 1996). Both resting and ambulatory measures of cardiac activity were included in the study.

Following completion of all self-report scales, each participant completed a single 15-min interview after the post-yoga supine resting sequence. Participants were asked to describe their experience of each component of the session via a series of open-ended questions (Rose & Parfitt, 2007). The following four questions were asked to each participant: *Tell me about your experience in the yoga session. Can you describe how you felt while you were practicing yoga? What helped you decide you felt that way? What additional information would you like to add?* In addition, all self-report scale and questionnaire data were reviewed with participants, as well as heart rate range at the beginning and end of each sequence (HRV data required additional processing and analysis and could not be reviewed with participants at that time). Participants were invited to reflect and comment on all available data. Main points were summarized by the researcher at the end of each interview for the purpose of member-checking and credibility (Duncan, Leis, & Taylor-Brown, 2008). All interviews were audiotaped with consent.

## 2.2. Instruments – baseline

### 2.2.1. Demographics

Demographic information included self-reported age, education, marital status and current employment status. Medical history included self-reported cancer diagnosis, date of diagnosis, treatment modalities, and completion of cancer treatment. Participant height and weight were also measured to calculate Body Mass Index (BMI) (mass (kg)/height (m)<sup>2</sup>).

### 2.2.2. Yoga experience

Participants were asked to report frequency of ongoing yoga practice via the yoga for cancer survivors program, community-based yoga programs, home yoga practice or combinations thereof.

### 2.2.3. Godin Leisure Time Exercise Questionnaire (GLTEQ)

The GLTEQ (Godin & Shephard, 1985) was used to assess baseline physical activity levels. The GLTEQ contains three questions that assess frequency of mild, moderate, and strenuous physical activity performed for at least 15 min duration in a typical week within the past month. Total weekly minutes of moderate-vigorous physical activity was also computed from this scale.

## 2.3. Instruments – yoga session

### 2.3.1. Association/Dissociation Scale (A/DS)

The A/DS (Tammen, 1996) is a single-item 10-point scale designed to measure to what extent attention is primarily associative or dissociative. Instructions were to, “estimate your present state of attention right now” (associative = focused in present moment, dissociative = unfocused in past or future). The scale ranges from 1 (very associative) to 10 (very dissociative) (Baden, Warwick-Evans, & Lakomy, 2004) (ICC = .74).

### 2.3.2. Feeling Scale (FS)

The FS (Hardy & Rejeski, 1989) is an 11-point, single-item measure of affective valence (pleasure–displeasure). Instructions were to “estimate how good or bad you feel *right now*.” Anchors are provided at zero (‘Neutral’) and all odd integers, ranging from –5 (very bad) to +5 (very good). The FS is commonly used for assessing affective responses during exercise (Ekkekakis & Petruzzello, 1999) (ICC = .90).

### 2.3.3. Felt Arousal Scale (FAS)

The FAS (Svebak & Murgatroyd, 1985) is a 6-point, single-item measure of perceived activation. Instructions were to, “estimate how aroused you feel *right now*” (low arousal = *calm* or *fatigued*, high arousal = *anxious* or *energized*). Anchors are provided at 1 (low arousal) and 6 (high arousal) (ICC = .89).

### 2.3.4. Rating of Perceived Exertion (RPE)

The RPE (Borg, 1998) is a single-item measure used to assess perceptions of effort. Instructions, in part, were, “while exercising we want you to rate your perception of exertion.” The RPE is a 15-point scale ranging from 6 (no exertion at all) to 20 (maximal exertion) (ICC = .83).

### 2.3.5. Cardiac activity

Given the high potential for multicollinearity ( $r > .80$ ) between various estimates of HRV (Task Force of the European Society of Cardiology & the North American Society of Pacing & Electrophysiology, 1996), a stepwise multivariable approach (Kop et al., 2010) was used to select appropriate indices of cardiac activity. Measures included in the current analysis were heart rate beats per minute (bpm, ICC = .97), high-frequency HRV in normalized units (HF HRV nu; ICC = .83), root mean square of successive normal-to-normal interval differences (RMSSD; ICC = .90), and sample entropy (ICC = .82). RMSSD and HF HRV nu are thought to reflect parasympathetic activation of the cardiac autonomic nervous system, while sample



entropy is a measure of heart rate complexity, a lack of which can be indicative of diminished capacity to adapt to physiological stress (Hautala et al., 2010; Rajendra Acharya et al., 2006; Soares-Miranda et al., 2011).

#### 2.4. Data analysis

A preliminary power calculation using GPower 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) and an *a priori* clinically meaningful effect size (Cohen's *f*) of .25 on the Association Dissociation Scale (Tammen, 1996) as the primary outcome, with an  $\alpha$  of .05 and power of .80 over eight measurement intervals, indicated a minimum of 16 participants were required. All data analyses were conducted on the entire sample ( $N = 18, 144$  observations) using IBM SPSS version 20 (IBM, 2011). Demographics and medical history were described using frequency and descriptive statistics to characterize study participants. HRV indices were analyzed via 5-min epochs derived from the mid-point of each yoga sequence (Sarang & Telles, 2006). For the primary and secondary analyses two sets of multilevel models were employed.

##### 2.4.1. Multilevel models

Multilevel modeling provides a powerful flexible framework for analyzing nested data structures and how change over time in one variable is related to other predictor variables (Hayes, 2006). In the current analyses two sets of multilevel models were employed. To investigate whether yoga practice elicits changes in attention, affect, activation, perceived exertion, and cardiac activity during a single yoga session, estimated marginal means models were created in our primary analyses to sequentially examine changes from baseline in these variables and all subsequent yoga sequences (time points) during the yoga session. Estimated marginal means models utilize all available data for a given subject, accommodate unbalanced datasets, and offer alternative covariance structures versus repeated measures analysis of variance (West, 2009). Model effects were further decomposed using pairwise comparisons. In the estimated marginal means models, Cohen's *d*, a distribution-based effect size measure, was calculated for each outcome variable between baseline and each yoga sequence  $(T_x - T_1)/(T_1 - SE * \sqrt{N})$ . These effect sizes can be interpreted using Cohen's (Cohen, 1988) conventions of .20 as a small effect, .50 as a medium effect, and .80 as a large effect.

A series of multilevel growth curve analyses were conducted in our secondary analyses to assess concurrent associations over time between attention, affective valence, activation, perceived exertion, and HRV during the yoga session. Age, BMI, time since diagnosis, physical activity, and previous yoga experience were also modeled as baseline time-invariant covariates. By fitting each individual growth trajectory to a specific parametric model, the overall trajectory of the study sample was obtained and allowed for further investigation of whether differences in growth parameters were related to other predictor variables (Shek & Ma, 2011).

In each multilevel growth curve model, time was measured continuously and included linear and quadratic terms as appropriate. The time variable was centered at initial status; therefore, the intercept of the regression model was interpreted as participant reports of the outcome variable at baseline. To enhance interpretability of model intercept parameters, all predictor variables were grand-mean centered to allow for inference of average predictor effects (West, 2009). Relationships between outcome and predictor variables were assumed to be constant throughout the study if interaction terms were not significant. Significant 2-way interactions were further decomposed via simple intercepts and slopes analyses (Preacher, Curran, & Bauer, 2006).

All models were tested step-by-step (Hox, 2010; Nezlek, 2012). Initial unconditional models were developed for each outcome variable, followed by unconditional growth models. Using these unconditional growth models as a foundation, predictor variables were tested individually for main effects and interaction effects with each time term. Final trimmed conditional growth models were developed by entering all significant predictors and their interactions to test overall prediction of outcome variables over time (exclusion  $p > .1$ ). This forward-stepping method of model development has proven robust with smaller sample sizes and ensures these models do not tax the number of parameters a data set can estimate, or the "carrying-capacity" of the dataset (Nezlek, 2008). Pseudo  $R^2$  statistics were calculated for each final trimmed multilevel growth model as  $(\text{unconditional model residual variance} - \text{trimmed model residual variance})/\text{unconditional model residual variance}$ . This Pseudo  $R^2$  statistic indicates the proportional reduction in residual variance (error) between the unconditional and trimmed model and provide an estimate of effect size similar to traditional ordinary least squares regression (Hox, 2010). These effect sizes can be interpreted using Cohen's criteria of .02 as a small effect, .13 as a medium effect, and .26 as a large effect (Cohen, 1988).

##### 2.4.2. Qualitative & mixed methods analyses

All interviews were conducted by a single researcher (MM), and coded independently by a research assistant (AW) and the interviewer (MM). Interviews were transcribed verbatim and analyzed using the NVivo 9 computer program (QSR International Pty Ltd., 2010). Using a process of inductive thematic analysis (Braun & Clarke, 2006), raw data quotes were identified, labeled and organized into key themes. Common themes were then combined into higher-order categories. Themes and categories were compared and contrasted to assure consistency of coding and that all data was accounted for by core categories. Direct quotes were provided from participants to ensure transferability of categorical assertions made by the researchers and so that readers could experience participant perspectives in their own words (Duncan et al., 2008; Rose & Parfitt, 2007, 2010).

Finally, a sequential mixed-methods neurophenomenology-based approach was used to analyze and integrate self-reported scale, neurophysiological, and interview datasets (Lutz, 2002; Thompson, 2006; Varela, 1996). In coding with triangulation in mind, the emphasis was placed on seeking corroboration between all data sources (Bryman, 2006). Specifically, after initial quantitative and qualitative analysis, the quantitative data was used to further guide analysis and interpretation of the qualitative data: specifically, the relations between the attentional and affective elements of yoga practice; the intensity of each yoga sequence as evidenced by patient-reported activation, perceived exertion, and cardiac activity measures; and participants' subjective experience of their yoga practice. In addition, the qualitative data was used to enrich the description and interpretation of the quantitative data. This integration of quantitative and qualitative methods (Moran-Ellis et al., 2006) permitted a more parsimonious understanding of measured constructs (Creswell, Klassen, Plano Clark, & Smith, 2011).

### 3. Results

#### 3.1. Demographics

The mean participant age was 54.0 years. All participants were Caucasian and female, and 61.1% of participants had received a breast cancer diagnosis, stage II-III, approximately 36.0 months prior to study enrollment. Participants were commonly married (55.6%), highly educated (61.1%), affluent (44.4%) and many participants had returned to work full-time (61.1%). Participants had completed a 7-week yoga for cancer survivors program a mean of 4.9 times previously. The average participant BMI was 24.8 kg/m<sup>2</sup>, considered to be in the high-normal range. Participants reported an average of 144.9 min of moderate-to-vigorous physical activity per week, just short of American College of Sports Medicine (ACSM) recommendation of 150 min per week (Schmitz et al., 2010). The average interview time post yoga session was approximately 16 min (see Table 1.1).

#### 3.2. Estimated marginal means models

##### 3.2.1. Attention, affective valence, activation, and perceived exertion

Attentional focus became significantly more associative as compared to baseline beginning in the kneeling yoga sequence ( $d = -.46$ ) and peaked during the supine meditation sequence ( $d = -1.08$ ). This state of associative attention was maintained during the post-yoga supine resting period ( $d = -.75$ ) [ $F(7,119) = 9.02, p < .001$ ] (see Table 1.2). Positive affect significantly increased from baseline, beginning during the standing sequence ( $d = .64$ ), and peaked during the supine meditation sequence ( $d = 1.83$ ). This state of positive affect was maintained during the post-yoga resting period ( $d = 1.78$ ) [ $F(7,119) = 19.37, p < .001$ ]. Activation peaked during the standing yoga sequence ( $d = .57$ ); this state of high activation was maintained during the second supine yoga sequence ( $d = .61$ ). Activation returned to baseline values during the supine meditation sequence ( $p = .864$ ) [ $F(7, 119) = 2.12, p = .045$ ]. Perceived exertion significantly increased beginning immediately in the initial supine yoga sequence ( $d = .79$ ), peaked during the standing yoga sequence ( $d = 2.25$ ), then returned to baseline values in the supine meditation sequence ( $p = .151$ ) [ $F(7,119) = 21.30, p < .001$ ] (see Table 1.2).

##### 3.2.2. Cardiac activity

Heart rate increased from baseline beginning in the seated yoga sequence ( $d = 0.73$ ). Participants peaked at approximately 52% of their age-predicted maximal heart rate (Tanaka, Monahan, & Seals, 2001) during the standing yoga sequence ( $d = 2.09$ ), then heart rate decreased below baseline levels during supine meditation ( $d = -.60$ ). This decrease in heart rate

**Table 1.1**  
Baseline demographics ( $N = 18$ ).

Age, years (SD)	53.97 (8.49)
Time since diagnosis, months (SD)	35.95 (19.00)
Times previously completed yoga for cancer survivors program (SD)	4.94 (3.00)
Gender – female (%)	18 (100%)
Cancer diagnosis – breast (%)	11 (61.1%)
Cancer stage	
II (%)	6 (33.3%)
III (%)	5 (27.8%)
Marital status – married/common-law (%)	10 (55.6%)
Education level – completed university/college (%)	11 (61.1%)
Annual household income – >\$80,000 (%)	8 (44%)
Employment status – fulltime (%)	11 (61.1%)
Body mass index (SD)	24.80 (4.49)
Leisure score index (SD)	31.17 (17.40)
Minutes moderate – vigorous PA per week (SD)	144.89 (112.51)
Post-yoga session interview time (min)	16:33 (4:53)

SD = standard deviation, % = percentage.

**Table 1.2**  
Estimated marginal means models – attention, affective valence, activation, and perceived exertion.

Yoga sequence	Attention				Affective valence				Activation				Perceived exertion			
	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>
Pre-resting	5.06 (0.51)	–	–	–	2.06 (0.27)	–	–	–	2.78 (0.32)	–	–	–	6.33 (0.47)	–	–	–
Supine 1	4.56 (0.51)	–0.50 [–1.18, 0.18]	.147	–0.23	2.28 (0.27)	0.22 [–0.31, 0.75]	.409	0.20	2.83 (0.32)	0.06 [–0.58, 0.70]	.864	0.04	7.89 (0.47)	1.56 [0.49, 2.62]	.005	0.79
Seated	4.50 (0.51)	–0.56 [–1.23, 0.12]	.107	–0.26	2.22 (0.27)	0.17 [–0.37, 0.70]	.536	0.15	3.28 (0.32)	0.50 [–0.14, 1.14]	.124	0.37	9.28 (0.47)	2.94 [1.88, 4.01]	.000	1.49
Kneeling	4.06 (0.51)	–1.00 [–1.68, –0.32]	.004	–0.46	2.50 (0.27)	0.44 [–0.09, 0.98]	.100	0.39	3.22 (0.32)	0.44 [–0.20, 1.08]	.171	0.32	10.44 (0.47)	4.11 [3.05, 5.18]	.000	2.08
Standing	3.83 (0.51)	–1.22 [–1.90, –0.55]	.001	–0.56	2.78 (0.27)	0.72 [0.19, 1.25]	.008	0.64	3.56 (0.32)	0.78 [0.14, 1.42]	.018	0.57	10.78 (0.47)	4.44 [3.38, 5.51]	.000	2.25
Supine 2	3.78 (0.51)	–1.28 [–1.96, –0.60]	.000	–0.59	3.50 (0.27)	1.44 [0.91, 1.98]	.000	1.28	3.61 (0.32)	0.83 [0.19, 1.47]	.011	0.61	9.28 (0.47)	2.94 [1.88, 4.01]	.000	1.49
Supine meditation	2.72 (0.51)	–2.33 [–3.01, –1.66]	.000	–1.08	4.11 (0.27)	2.06 [1.52, 2.59]	.000	1.83	2.83 (0.32)	0.06 [–0.58, 0.70]	.864	0.04	7.11 (0.47)	0.78 [–0.29, 1.84]	.151	0.39
Post-resting	3.44 (0.51)	–1.61 [–2.29, –0.93]	.000	–0.75	4.06 (0.27)	2.00 [1.47, 2.53]	.000	1.78	2.94 (0.32)	0.17 [–0.47, 0.81]	.607	0.12	6.39 (0.47)	0.06 [–1.01, 1.12]	.918	0.03

SE = standard error, *d* = Cohen's *d* (effect size).



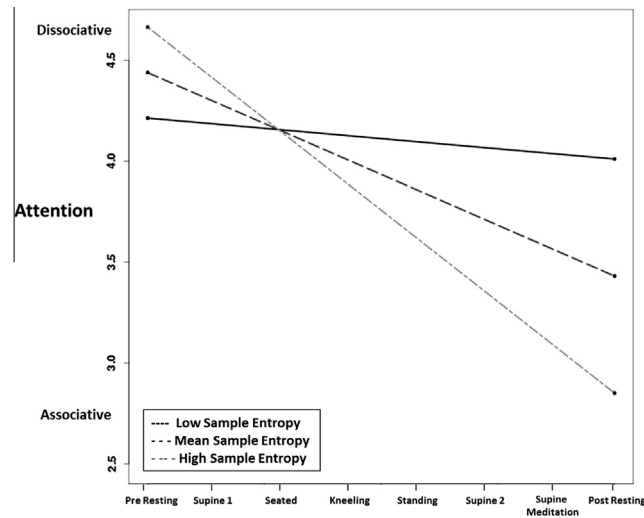
**Table 1.3**

Estimated marginal means models – heart rate, HRV nu, RMSSD and sample entropy.

Yoga sequence	Heart rate				HF HRV nu				RMSSD				Sample entropy			
	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>	Mean (SE)	Mean difference [95% CI] (pre-resting referent)	Sig.	<i>d</i>
Pre-resting	67.94 (2.29)	–	–	–	41.41 (4.28)	–	–	–	35.87 (6.57)	–	–	–	1.43 (0.08)	–	–	–
Supine 1	69.48 (2.29)	1.54 [–1.40, 4.48]	.302	0.16	22.90 (4.28)	–18.51 [–27.13, –9.88]	.000	–1.02	38.08 (6.57)	2.21 [–7.67, 12.09]	.658	0.08	1.20 (0.08)	–0.23 [–0.41, –0.06]	.010	–0.68
Seated	75.07 (2.29)	7.14 [4.20, 10.08]	.000	0.73	18.77 (4.28)	–22.63 [–31.26, –14.01]	.000	–1.25	34.59 (6.57)	–1.28 [–11.16, 8.60]	.798	–0.05	1.04 (0.08)	–0.39 [–0.57, –0.22]	.000	–1.15
Kneeling	81.52 (2.29)	13.59 [10.65, 16.52]	.000	1.40	21.72 (4.28)	–19.69 [–28.31, –11.07]	.000	–1.09	32.34 (6.57)	–3.53 [–13.41, 6.35]	.481	–0.13	0.66 (0.08)	–0.78 [–0.95, –0.60]	.000	–2.29
Standing	88.19 (2.29)	20.26 [17.32, 23.19]	.000	2.09	22.51 (4.28)	–18.89 [–27.52, –10.27]	.000	–1.04	22.34 (6.57)	–13.53 [–23.41, –3.65]	.008	–0.49	0.88 (0.08)	–0.55 [–0.73, –0.38]	.000	–1.62
Supine 2	70.04 (2.29)	2.10 [–0.84, 5.04]	.159	0.22	27.84 (4.28)	–13.57 [–22.19, –4.94]	.002	–0.75	35.57 (6.57)	–0.30 [–10.18, 9.58]	.952	–0.01	1.13 (0.08)	–0.30 [–0.48, –0.13]	.001	–0.89
Supine Meditation	62.08 (2.29)	–5.85 [–8.79, –2.91]	.000	–0.60	35.59 (4.28)	–5.81 [–14.43, 2.81]	.185	–0.32	47.26 (6.57)	11.38 [1.51, 21.26]	.024	0.41	1.36 (0.08)	–0.07 [–0.25, 0.11]	.429	–0.21
Post-resting	62.53 (2.29)	–5.41 [–8.34, –2.47]	.000	–0.56	41.76 (4.28)	0.36 [–8.27, 8.98]	.935	0.02	40.15 (6.57)	4.28 [–5.60, 14.16]	.393	0.15	1.30 (0.08)	–0.14 [–0.31, 0.04]	.127	–0.40

SE = standard error, *d* = Cohen's *d* (effect size).

HF HRV nu = high frequency heart rate variability (normalized units); SDNN = standard deviation of all normal-normal r–r intervals; RMSSD = square root of the mean of squares of successive r–r interval differences.



**Fig. 1.2.** Simple slopes of the regression for Association/Dissociation Scale (A/DS) at low, mean, and high levels of sample entropy. Note: low, medium, and high values of sample entropy are defined as plus and minus 1 SD above the mean (−0.40, 0, 0.40). Slopes of the simple regression for high sample entropy significantly differ from zero ( $B = -0.23$ ,  $SE = 0.07$ ,  $p = 0.002$ ), but the simple slopes at mean ( $B = -0.13$ ,  $SE = 0.07$ ,  $p = 0.07$ ) and low sample entropy ( $B = -0.03$ ,  $SE = 0.09$ ,  $p = 0.78$ ) do not.

relative to baseline was maintained during the post-yoga session supine resting sequence ( $d = -.56$ ) [ $F(7,119) = 74.84$ ,  $p < .001$ ]. HF HRV nu significantly decreased beginning immediately in the initial supine yoga sequence ( $d = -1.02$ ), reached it is lowest point during the standing yoga sequence ( $d = -1.04$ ), then returned to baseline values during the supine meditation sequence ( $p = .185$ ) [ $F(7,119) = 9.02$ ,  $p < .001$ ]. RMSSD remained stable from baseline throughout the first supine, seated and kneeling sequences ( $p$  values  $\sim .481$  to  $.798$ ), decreased during standing yoga sequence ( $d = -.49$ ), then increased above baseline values during the supine meditation sequence ( $d = .41$ ). RMSSD returned to baseline values during post-yoga supine resting sequence ( $p = .393$ ) [ $F(7,119) = 4.02$ ,  $p = .001$ ]. Finally, sample entropy showed a pattern of lessening complexity beginning immediately in the initial supine yoga sequence ( $d = -.68$ ), reached it is lowest point during the kneeling sequence ( $d = -2.29$ ), then returned to approximate baseline values in the supine meditation sequence ( $p = .429$ ) [ $F(7,119) = 17.27$ ,  $p < .001$ ] (see Table 1.3).

**Table 1.4**  
Multilevel regression analyses – attention, affective valence, activation, perceived exertion and sample entropy.

Predictor	Attention		Affective valence		Activation		Perceived exertion	
	B [95% CI]	Sig.	B [95% CI]	Sig.	B [95% CI]	Sig.	B [95% CI]	Sig.
Intercept	4.44 [3.39, 5.49]	.000	2.02 [1.54, 2.49]	.000	2.66 [2.12, 3.20]	.000	6.18 [5.10, 7.25]	.000
Linear time	−0.13 [−0.27, 0.02]	.082	0.26 [0.19, 0.33]	.000	0.39 [0.06, 0.72]	.021	1.85 [1.34, 2.37]	.000
Time <sup>2</sup>	–	–	–	–	−0.05 [−0.09, −0.01]	.019	−0.24 [−0.31, −0.17]	.000
<i>Level-2 predictors</i>								
Body mass index	–	–	–	–	−0.09 [−0.16, −0.01]	.025	–	–
Physical activity	–	–	0.03 [0.01, 0.05]	.015	–	–	0.05 [0.01, 0.09]	.009
Yoga classes	−1.83 [−3.31, −0.34]	.019	–	–	–	–	–	–
<i>Level-1 predictors</i>								
Attention	–	–	−0.14 [−0.25, −0.03]	.012	0.21 [0.09, 0.33]	.001	–	–
Affective valence	−0.35 [−0.54, −0.15]	.001	–	–	0.17 [0.003, 0.34]	.046	−0.50 [−0.81, −0.19]	.002
Activation	0.33 [0.15, 0.50]	.000	–	–	–	–	0.30 [0.05, 0.54]	.017
RPE	−0.09 [−0.17, −0.01]	.048	–	–	0.10 [0.01, 0.19]	.024	–	–
Heart rate	–	–	−0.02 [−0.04, −0.01]	.000	–	–	0.05 [0.01, 0.08]	.005
Sample entropy	0.56 [−0.42, 1.55]	.259	–	–	0.52 [0.05, 1.00]	.030	–	–
Sample entropy * time	−0.25 [−0.47, −0.04]	.021	–	–	–	–	–	–
Pseudo R <sup>2</sup>	0.65		0.56		0.42		0.60	

B = estimate.  
Note: Dashes in cells indicate excluded variables not entered into the model.  
Excluded ( $p > .1$ ): age, time since diagnosis, HF HRV nu, SDNN, RMSSD.

### 3.3. Multilevel growth curve analyses

Follow-up multilevel growth curve analyses were conducted to investigate associations between attention, affect, activation, perceived exertion, and cardiac activity including fixed covariates: age, time since diagnosis, physical activity, BMI, and previous yoga experience.

#### 3.3.1. Attention

A complex interaction was observed between sample entropy and time in relation to attention. Follow-up simple slopes analyses (Preacher et al., 2006) illustrated those with low sample entropy experienced non-significant reductions in dissociative attention over time ( $B = -.03, p = .78$ ). For those with average sample entropy there was a trend suggesting these individuals experienced decreases in dissociative attention over time ( $B = -.13, p = .07$ ), while those with high sample entropy experienced the greatest decreases in dissociative attention over time ( $B = -.23, p = .002$ ) (see Fig. 1.2). Those who participated in more weekly yoga classes reported higher associative attention throughout the yoga session ( $B = -1.83, p = .019$ ). Higher reported affect ( $B = -.35, p = .001$ ) and perceived exertion ( $B = -.09, p = .048$ ) were also associated with higher associative attention throughout the yoga session, while higher activation ( $B = .33, p < .001$ ) was associated with higher dissociative attention. The Pseudo  $R^2$  value suggested inclusion of these predictor variables accounted for 65% of the variance in predicting attention (see Table 1.4).

#### 3.3.2. Affective valence

A main effect for linear time was observed ( $B = .26, p < .001$ ). Higher overall physical activity predicted higher positive affect throughout the yoga session ( $B = .03, p = .015$ ). Higher associative attention ( $B = -.14, p = .012$ ) and lower heart rate ( $B = -.02, p < .001$ ) at each measurement occasion also predicted higher reported affect consistently over the course of the yoga session. The Pseudo  $R^2$  value suggested inclusion of these predictor variables accounted for 56% of the variance in predicting affective valence (see Table 1.4).

#### 3.3.3. Activation

A quadratic effect for time in relation to activation was observed ( $B = -.05, p = .019$ ). Higher BMI at baseline predicted lower activation throughout the yoga session ( $B = -.09, p = .025$ ). In addition, higher dissociative attention ( $B = .21, p = .001$ ) and a higher perceived exertion ( $B = .10, p = .024$ ) predicted higher activation across measurement occasions. Those who reported higher sample entropy also reported higher activation throughout the yoga session ( $B = .52, p = .030$ ). The Pseudo  $R^2$  value suggested inclusion of these predictor variables accounted for 42% of the variance in predicting activation (see Table 1.4).

#### 3.3.4. Perceived exertion

A quadratic effect for time in relation to perceived exertion was observed ( $B = -.24, p < .001$ ). Higher reported physical activity ( $B = .05, p = .009$ ), activation ( $B = .29, p = .017$ ) and heart rate ( $B = .05, p = .005$ ) predicted higher reported perceived exertion throughout the yoga session, while higher affective valence predicted lower perceived exertion throughout the yoga session ( $B = -.50, p = .002$ ). The Pseudo  $R^2$  value suggested inclusion of these predictor variables accounted for 60% of the variance in predicting perceived exertion (see Table 1.4).

### 3.4. Qualitative & mixed methods findings

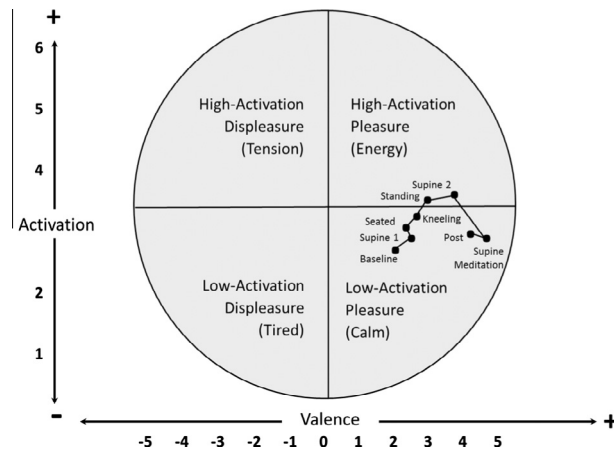
#### 3.4.1. Description of yoga session

The majority of participants drew comparisons between the baseline resting sequence and all subsequent sequences. Many participants characterized baseline as a time where dissociative attention was predominant: “My head was doing all sorts of busy brain stuff.” and, “I was feeling agitated – my thoughts were all over the place.” Several participants reported noticing an immediate shift in attention during the first supine yoga sequence: “The first sequence got my mind focused. Focusing on breathing really clears your mind.” Other participants reported shifts in attention occurred later in the yoga session: “It takes a bit for me to get there then suddenly I am in the moment.”

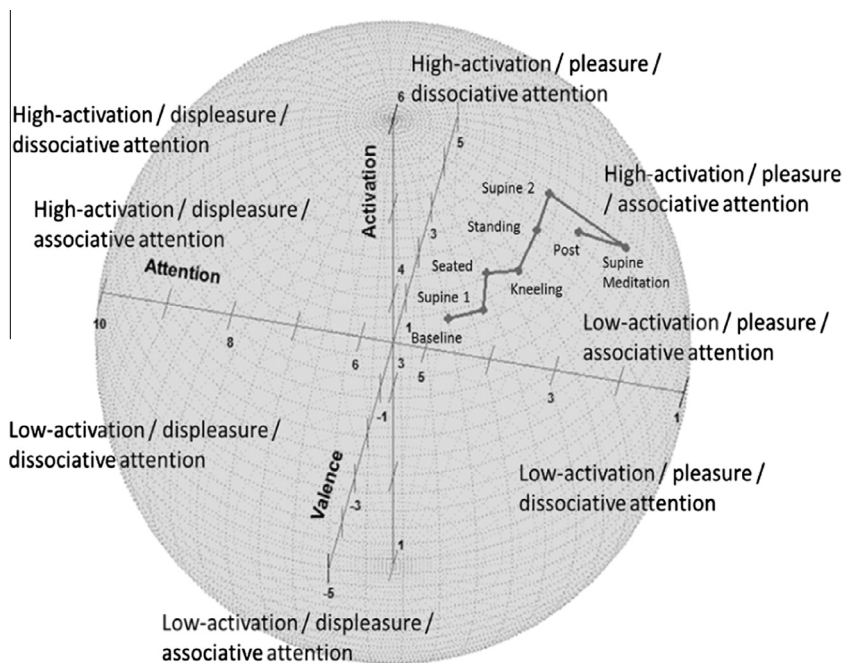
Participants remarked that as the yoga sequences intensity increased focus of attention was heightened: “I was feeling more focused because my body was doing something, so the mind was not able to go grocery shopping.” The standing sequence was described as the most physically demanding yoga sequence, which is corroborated by reported perceived exertion and cardiac activity indices: “I definitely felt like that was the most energetic of the sequences.” Several participants suggested heart rate was a good indicator of their level of exertion during these more active poses: “Your heart tells you what you are doing.”

Participants characterized the second supine sequence as more relaxing, despite scale self-reports of high activation and perceived exertion: “I can feel a deep rest and let go...”

Breath awareness was a strong point of associative attention in the supine meditation sequence: “I was really in the yoga moment... I was experiencing my breath and sensation through my whole body.” Despite self-reports of increased positive affect and associative attention, not all participants had a pleasant experience during the supine meditation sequence. One participant reported: “I completely zoned out.” When probed as to why this was the case, the participant replied: “I have a hard time focusing and am very easily distracted.” For others, supine meditation was associated with sleep states: “It was relaxing. I



**Fig. 1.3.** Affective responses (Mean FS and FAS) to a single yoga session plotted on a two-dimensional circumplex model. Labels indicate time points for affective responses: Baseline, Supine 1, Seated, Kneeling, Standing, Supine 2, Supine Meditation, Post.



**Fig. 1.4.** Affective responses (Mean FS, FAS and the addition of A/DS) to a single yoga session plotted on a three-dimensional circumplex model (affective valence, activation & attention). Labels indicate time points for affective responses: Baseline, Supine 1, Seated, Kneeling, Standing, Supine 2, Supine Meditation, Post.

*probably could have fallen asleep.* Several participants indicated the supine meditation left them feeling more wakeful: *“When I came in I was drowsy and sleepy. Savasana (supine meditation) is just like having a power nap... at the end of it I was feeling much more energized.”*

Participants commented on the return of dissociative attentional patterns immediately following supine meditation: *“My mind started to wake up and think again because you do not have anything to focus on”* and *“I still felt very relaxed, but there is a difference between just lying around and savasana (supine meditation).”* Others characterized this time as a continuation of the previous supine meditation sequence: *“I was still pretty relaxed from the carry-over from savasana (supine meditation).”* Differences highlight these experiences are not uniform and give weight to multilevel regression models that help tease apart associations between self-reported outcomes and other predictor variables.

### 3.4.2. Comparisons between pre- and post-yoga session

When participants reflected on what they felt changed before and after the yoga session, several insights were offered in relation to focus of attention: “When I came in my mind was jumping everywhere. At the end I was very focused... whereas at the start there was just no focus.” Participants generally reported feeling they were relaxed with more energy at the end of the yoga session: “I felt really relaxed and actually felt more energized than when I came in. I was ready to go off and conquer the world.” Participants also spoke about tiredness in relationship to energy levels: “I was very tired coming in. I feel a lot more energetic now and rested.” and, “You have that battery charge... You are rested but not tired.”

Discussion of feelings of calmness was a prevalent theme. Participants related this increased calmness post-yoga session to decreased tension: “Over the course of the practice, the calmness level really increased... You can almost feel yourself exhaling, letting the tension go,” and increased energy: “I’m calmer, but more energized, as opposed to being tired and lethargic.” Several participants also described calmness in conjunction with focus of attention: “It really focuses you and calms you. It stops your mind from going crazy all over the place.” and, “Maybe it’s just the experience of yoga that makes me feel calmer. As I feel calmer I tend to be, I guess, in the present. It’s when I’m not calm that I’m in the future.” Participants reported these shifts regardless of baseline affective valence: “At the end you just feel better than when you started, no matter where you started.”

### 3.4.3. Attention in yoga practice

Several participants described yoga as a different state of relaxed consciousness: “It (yoga) focuses you and totally gets rid of all the noise: the stuff going on in your brain.” As participants continued to practice, they noticed a shift in attention concomitant with positive affect: “I was very much focused on what we were doing and really enjoyed how it felt... I didn’t find the busy brain was taking over.” Despite a linear decrease in dissociative attention over the course of the yoga session, many participants reported this state was not uniform: “I was really relaxed but also had some monkey brain moments... I would pay attention for a few breaths then my mind would go off... Before you know it I am busy running errands.”

Many participants suggested a link between the breath and associative attention: “The more you have to focus on your breathing, the more it clears all the other stuff out of your mind... (Yoga) really quiets your mind.” Attention to breathing and the physical postures was reported to help keep participants focused and present: “When I finally start concentrating on my breath I realize I am right here, right now, in this moment.” and, “When you are just concentrating on the breathing and doing the poses, everything else just disappears... It is so nice to just be in the moment.” Taken together, participant statements suggest a strong emphasis is placed on the role of attention in the experience of a single yoga session.

## 4. Discussion

### 4.1. Attention, affective valence, activation, and perceived exertion

The impetus for the present study was to investigate yoga’s ability to “still the changing states of the mind” in a single yoga session. This is the first study to integrate models of attention and affect within an overarching neurophenomenology-based framework, using several supplementary theories to frame the posited attentional, affective, and psychophysiological responses to yoga practice, and accompanying methodologies (patient reported outcomes, cardiac activity indices, and first-person phenomenological reports) in the exploration of the subjective experience of a single yoga session in a group of cancer survivors.

Using the Circumplex Model of Affect, the majority of change in the single yoga session occurred in the low-activation pleasure quadrant (calm) and touched into the high-activation pleasure quadrant (energy) in yoga sequences of higher intensity (see Fig. 1.3). Specifically, participants reported increasingly improved positive affect throughout the yoga session while activation rose and fell largely with the intensity of each yoga sequence. The addition of a dimensional measure of associative attention led to a revised 3-Dimensional (3D) Spherical Circumplex Model of Attention and Affect. Within this 3D model the majority of change in the single yoga session occurred in the low-activation/pleasure/associative attention quadrant (focused calm) and touched into the high-activation/pleasure/associative attention quadrant (focused energy) in more active yoga sequences (see Fig. 1.4). Specifically, both associative attention and positive affect increased over the course of the yoga session and activation rose and fell with the difficulty of each yoga sequence.

Interestingly, only attention was related to previous yoga experience, suggesting those who practiced yoga more reported higher associative attention throughout the yoga session. Research in the field of yoga and meditation would suggest those participants with greater practice and heightened attentional focus experience meditative states differently than those who practice less (Lutz et al., 2008; Wadlinger & Isaacowitz, 2011). Specifically, individuals with greater yoga practice shift more readily from focused attentional states (*dharana*) to open monitoring meditative states (*dhyana*). This trained ability to sustain attention to bodily movement and breath awareness could lead to subsequent gains in affect regulation by enhancing sensory processing of experience (Kerr, Sacchet, Lazar, Moore, & Jones, 2013; Rubia, 2009).

The linear increase in positive affect over the course of the yoga session was in concordance with previous research utilizing Dual-Mode Theory (Ekkekakis et al., 2011), which suggests exercise below lactate/sub-ventilatory thresholds is generally reported as pleasant both during the actual exercise session and upon completion. The overall yoga session could be considered low-intensity exercise given participants in the current study worked at a maximum of 52% of their age-predicted maximal heart rate (Tanaka et al., 2001) during the standing yoga sequence. In addition, participants reported only

moderate activation and “light” exertion throughout more active yoga sequences. The lower-intensity level throughout the yoga session could have led to a continued primacy of positive-valenced attentional cues versus negatively-valenced interoceptive cues seen at higher exercise intensities, as evidenced in the Effort-Based Attention Model (Tenenbaum, 2001). Higher activation among individuals at each time point, however, was associated with higher dissociative attention. This “excitement” has been reported in the meditation literature and can be related to distraction or attention wandering (Lutz, 2007; Slagter et al., 2011).

#### 4.2. Cardiac autonomic concomitants of attention and affect

Heart rate and HRV indices corroborate research findings that suggest yoga’s active poses create physiological stress similar to light-intensity exercise (Cowen & Adams, 2007), while resting poses can heighten autonomic activity (Sarang & Telles, 2006), as exhibited via heart rate and RMSSD indices in the present study. Attention was related to sample entropy, such that higher sample entropy predicted a significant decrease in dissociative attention over the course of the yoga session while lower sample entropy was not associated with a significant shift in focus of attention throughout the yoga session. However, activation was also related to sample entropy, suggesting those with higher sample entropy at each time point also reported higher activation. As expected, higher perceived exertion was linked to increased participant heart rate in each yoga sequence (Katsanos & Moffatt, 2005), however those who reported lower heart rates reported increased affective valence at each measurement occasion. Overall findings support the Neurovisceral Integration Model thesis that both attention and affect are linked via underlying autonomic function and the dynamic interactions between physiological, cognitive and behavioral systems (Hansen, Johnsen, & Thayer, 2003; Thayer & Friedman, 2002).

Telles et al. (2013) report findings relating yoga practice to autonomic regulation are equivocal; some studies show meditation practice is associated with reduced sympathetic activity, whereas other studies report increased sympathetic activity. In the current study, different indices of cardiac activity suggest different modulation of the autonomic nervous system. Specifically, HF HRV nu and sample entropy suggest HRV is modulated based largely on yoga intensity, while heart rate and RMSSD suggest the same effects as well as lower heart rate and increased vagal activity during supine meditation. Decreased heart rate and increased RMSSD during the supine sequence could also be due to the inherent benefits of supine posture in post-exercise parasympathetic reactivation (Buchheit, Al Haddad, Laursen, & Ahmaidi, 2009).

Perhaps more importantly, cardiac indices heart rate and sample entropy predict attention, affect, activation, and perceived exertion, suggesting cardiac activity differs based on the individual’s given meditative state. Specifically, lower sympathetic activity and/or increased autonomic regulation are suggested to relate to open monitoring meditation states, or *dhyana* (Telles et al., 2013). Hence, differing results are not solely related to *what* is being done in a given yoga sequence as much as *how* that sequence is experienced by a practitioner *given the meditation state they are in*. Individuals who are better able to focus attention on physical sensations in the body, including the breath, could have more accurate knowledge of their physiological states which should, in turn, be linked to and coherent with their actual physiological responses (Sze, Gyurak, Yuan, & Levenson, 2010).

#### 4.3. Integration

Participants’ first-person phenomenological accounts provide insight into the subjective experience of the yoga session. These subjective reports highlighted elements of the data not observable by strict quantitative analysis alone and provided much needed context for the quantitative research findings (Lutz, 2002). Using a neurophenomenology-based approach allowed further comparison of data at all levels, including participant-reported measures of attention, affective valence, activation, and perceived exertion during the yoga sequences, continuously monitored cardiac activity, and participant’s subjective experiences of these conditions. These detailed descriptions informed both the overarching analysis and its interpretation, highlighting that participants themselves viewed changes in attention both during class and pre-post class as the primary mechanism of engagement in yoga practice and in deriving affective benefits. Participants further suggested awareness of breath was a primary technique to achieve these aims. Regulation of the breath is thought to be a definitive element of yoga practice and descriptions in traditional yoga texts mention the regulation of the breath as a way of achieving spiritual transcendence (Telles & Naveen, 2008).

In sum, these neurophenomenological findings suggest yoga practice facilitates an increasingly associative, positively-valenced affective state both during and after a single yoga session that has autonomic correlates. Attention to the breath and body and concomitant measures thereof provides insight into participants’ subjective living experience of their bodies (Colombetti & Thompson, 2008). This enactive neurophenomenology-based approach suggests the very act of focused attention on the physical experience of the body moving is moderated by concurrently assessed autonomic nervous system function, resulting in increasingly positive affective states throughout a yoga session.

#### 4.4. Strengths, limitations & future directions

Participants’ descriptive emphasis on the attentional aspect of yoga and awareness of breathing specifically are illuminating given the relationship between indices of cardiac activity, respiration, and attention (Telles & Naveen, 2008; Telles, Singh, & Balkrishna, 2011; Telles et al., 2004). One factor that seems common among different types of yoga and meditation is some



degree of respiratory and cardiac synchronization. It is thought that awareness of this synchronization leads to states of increased calm and focused attention (Jerath, Barnes, Dillard-Wright, Jerath, & Hamilton, 2012). Additional research devoted to respiratory influences on attention, affect, and autonomic function are of great interest, and consideration of the use of an ambulatory measure of breaths per minute is warranted. While several exercise studies support the validity of using ambulatory heart rate monitors to assess HRV (Nunan et al., 2008; Porto & Junqueira, 2009), there has been some controversy regarding their use with women over the age of 60 years (Quintana, Heathers, & Kemp, 2012; Wallen, Hasson, Theorell, Canlon, & Osika, 2012).

Post-hoc power analyses based on the large effect sizes for both attention ( $d = -1.08$ ) and affect ( $d = 1.83$ ) in the estimated marginal means models suggest the reported sample size was appropriate. However, despite convergence of all reported multilevel regression models, this comparatively small sample could have limited the potential for observing significant predictions among predictor variables in the multilevel regression models. In regards to the use of multilevel modeling given the small study sample size, while research suggests samples of 50 study participants or more are preferable, numbers of as small as 50 total observations (all time-points) can be sufficient, showing little bias in the regression coefficients (Maas & Hox, 2005). In addition, no corrections were made for multiple comparisons, as it has been suggested these corrections unnecessarily inflate the Type II error rate (Nakagawa, 2004). Instead, effect sizes for the estimated marginal means models (Cohen's  $d$ ) to quantify the magnitude of these changes over time and the pseudo  $R^2$  statistic was calculated for each multilevel growth curve model to account for variance explained. Confidence intervals were included for both the estimated marginal means models and multilevel growth curve models and provide a range of possible values likely to contain the population mean and better reflect the generalizability of these findings to the population as a whole (Kalinowski & Fidler, 2010).  $p$ -Values, effects sizes, and confidence intervals were used concurrently to triangulate on and describe the range of the current findings, their relative magnitude of effect, and generalizability (Culos-Reed et al., 2012; Thompson, 2001).

Finally, the current study does not contain a direct neuroscientific measurement of brain activity (i.e. EEG, fMRI) due to the temporal and physical limitations of these measures in capturing the dynamic nature of yogic practice. Instead cardiac activity was used as a robust autonomic neurophysiological correlate of the neural link between the heart and brain in the regulation of attention and affect (Thayer & Lane, 2009; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). Given the novel use of cardiac activity, it is perhaps best to qualify our approach as “neurophenomenology-based” and inspired by the neurophenomenological approach, versus neurophenomenology per se as we did not directly measure brain activity. However, neurophenomenology is a recent theoretical and methodological development in which definitions, procedures, and standards are still evolving. It is our hope the present study enriches the scientific neurophenomenology literature and provides innovative methods of investigating the relations between attention, affect, and attendant physiology in the exploration of consciousness.

Despite these limitations, multilevel modeling within a neurophenomenology-based mixed-methods framework allowed for the integration of theory to investigate female cancer survivors' experience of yoga during a single yoga session. Identifying potential mechanisms that explain how yoga leads to clinically significant outcomes is an important next step as yoga programs are increasingly integrated into oncology settings. An ongoing neurophenomenology-based integration of yoga philosophy, phenomenology, psychophysiology, and allied cognitive, affective, and behavioral neurosciences will move this endeavor forward. Moreover, embedding this research within an overarching framework derived from traditional contemplative sources adds insight to the purpose of yoga and its effects on attention and affect.

Recent research has coined the term “meditative movement” for forms of exercise, including yoga and qigong, which use movement in conjunction with meditative attention to bodily sensations such as the breath and feelings of relaxation (Payne & Crane-Godreau, 2013). While these practices have often been compared to aerobic, resistance, stretching or relaxation techniques, meditative movement practices uses elements of these practices in novel ways and/or target mechanisms different from conventional exercise modalities (Larkey, Jahnke, Etnier, & Gonzalez, 2009). In exploring contemporary yoga practice and other meditative movement modalities working definitions, purported mechanisms of action and means of evaluation must be developed. As in the current study, researchers can use conventional exercise models as a preliminary framework for assessing those aspects of yoga that parallel conventional exercise modalities, while other aspects of yoga related to attention, affect, and psychophysiological correlates require the development of novel models, methods, and measures.

## 5. Conclusion

The current research was designed to model neurophenomenological processes and outcomes while taking into consideration a traditional definition of yoga as “*stilling of the changing states of the mind* (YS I.2).” The result is an initial detailed exploration of the attentional and affective experience of yoga practice. The intention was to bridge the “explanatory gap” (Lutz & Thompson, 2003) between the phenomenal character of yoga practice with the quantitative measurement of the yoga experience. Taken together, study findings suggest yoga practice is a form of meditative movement that facilitates a confluence of associative attention and positive affect that effectively *stills the changing states of the mind* via heightened attention to the breath and body. These pleasantly-valenced, associative attentional states may be closely aligned with focused attention (*dharana*) and open monitoring (*dhyana*) meditative states, though future research is required. While yoga

practice shares commonalities with both exercise and relaxation training, yoga practice may serve primarily as a promising meditative attention-affect regulation training methodology. Given the identified complexity of the cancer experience, the unique challenges faced in each diagnosis, and the variety of tools yoga practice offers, highly prescriptive interventions can be developed from this research to aid cancer survivors in their personal quests to “*still the changing states of the mind.*”

## Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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