Psychophysiological Differences
Between Meditators and Non-meditators
During Anticipatory Stress

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Part A: Literature review
Part B. Empirical Study

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Part A. Literature Review

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Abstract

To further the understanding of the psychophysiology of stress, meditation literature is reviewed to assess the ability of meditation to reduce stress reactivity at rest and during stress. Two psychophysiological measures not previously used in meditation studies were assessed; the startle eyeblink response as a measure of stress reactivity and respiratory sinus arrhythmia (RSA) as a measure of parasympathetic cardiac innervation. Polyvagal theory proposes that negative emotional experience decreases parasympathetic vagal tone, as indexed by RSA. Dominant metamotivational modes as proposed by reversal theory, provide a framework to compare motivations, emotions and personality profiles of meditators and non-meditators.
Traditionally, meditation has been associated with religious and philosophical practices of the East. Drawn from many cultures, meditation generally refers to a group of practices whose aim is to heighten awareness and bring mental processes under greater voluntary control by training awareness. In its more secular and contemporary applications meditation has been added to an array of techniques considered useful as self-control strategies for a range of clinical disorders (Shapiro, 1984). Areas where meditation has been used successfully include stress management, hypertension, addiction, impulse control and pain management (West, 1980). More generally, it has found application in the short-term benefits of relaxation and stress reduction (Walsh, 1983).

As a self-control strategy meditation shares many of the problems that other self-control strategies and treatments share. In particular, motivation and consistency of practice, adherence and compliance are problematic in treatment programs (Bernhard & Krupat, 1994; Dishman, 1982). Another difficulty is in specifying which meditation technique is appropriate for which client, and for which condition (Shapiro, 1982).

Different styles of meditation have been reported in the experimental literature. Davidson and Schwartz (1976) classified meditation into either active or passive types. Passive meditation is the most common type studied, particularly Transcendental Meditation (TM) and to a lesser degree Zen, and Vipassana Meditation (VM). A further distinction has been made between concentration and mindfulness attentional strategies. Concentration restricts attention to a single focal point (TM), whereas
mindfulness expands awareness into sensation, thought, memory, emotion and perception. Some techniques such as VM switch attention between the two (Shapiro, 1982).

Vipassana meditation is a Buddhist technique that is taught internationally in a standardised, non-sectarian manner by S. N. Goenka (Hart, 1991). Vipassana (literally translated as "insight") is a type of mindfulness meditation (Young, 1994, p. 53). At a personal level mindfulness meditation can serve as ..."slow self-paced systematic desensitisation" (Delmonte, 1985, p. 10). At a deeper level it has been proposed (Mikulas, 1981; Young, 1994) that mindfulness lays the ground work for insight into the most basic understandings of the nature of reality, existence and the self.

This study aims to summarise and evaluate laboratory research into the psychophysiology of meditation both at rest and during stress conditions. Two psychophysiological measures not previously used in meditation research will be assessed; the startle blink response as a measure of stress reactivity and respiratory sinus arrhythmia (RSA) as a measure of parasympathetic cardiac innervation. Finally, reversal theory will be used to assess differences in metamotivational dominance between long-term meditators and non-meditating controls.

**Meditation and Physiological Arousal**

*Meditation, Relaxation and Arousal Reduction*

A comparison of meditation and self-control strategies established a common
'relaxation response' (tropotrophic response) underlying these states. The accompanying physiological changes consisted of decreased oxygen and carbon dioxide consumption, lowering of resting HR and respiration, and in reduced concentrations of blood plasma lactate and reduced muscle tension. Increases were noted in skin conductance and EEG slow alpha wave activity and the presence of decreased theta waves (Benson, Beary, & Carol, 1974).

When TM was compared with Benson's relaxation response and a no treatment control, different physiological patterns were not found between the groups for respiration rate, HR, EMG, ECG, and SCL. Neither treatment exhibited a clear superiority in reducing tonic arousal over the other (Puente & Beiman, 1980). A comparison between TM and 'simple resting' established that prior to meditating, meditators had higher HR and BP than non-meditating controls. Meditation was associated with generally reduced arousal. However, while meditating, meditators did not have lower arousal than non-meditating controls did while resting, indicating that baseline comparisons do not demonstrate differences (Holmes, Solomon, Cappo, & Greenberg, 1988). Similar results were found by Delmonte (1984b).

Physical relaxation does not always result from all meditation. Corby, Roth, Zarcone and Kopell (1978) performed a study which challenged the 'relaxation' model of meditation. Using Tantric yoga meditators, three groups of subjects were studied as they progressed from normal consciousness into meditation. Contrary to other meditation studies the autonomic system, as measured by HR and SCL, was activated
during meditation for the experienced meditators, while autonomic relaxation was demonstrated by novices and controls.

Extending Benson's unitary model of relaxation, Davidson and Schwartz (1976) proposed a multi-process model where anxiety was seen as having both a cognitive and a somatic counterpart. It was suggested that meditation would be more effective in reducing cognitive anxiety whereas exercise would reduce somatic anxiety. Little empirical support was found for the proposal (Steptoe & Kearsley, 1990; Woolfolk, Lehrer, McCann, & Rooney, 1982).

Shapiro (1982) reviewed studies comparing meditation with other self-control strategies, and concluded that meditation was not distinguishable from other strategies on metabolic or autonomic measures, nor in terms of EEG patterns. A literature review (Holmes, 1984) on the somatic arousal reducing abilities of meditation found few differences compared to resting.

A meta-analysis of 31 studies compared the physiological responses of TM and rest (Dillbeck & Orme-Johnson, 1987). TM was associated with significantly larger effect sizes than eyes-closed rest across electrodermal, respiratory, HR and plasma-lactate measures. Prior to meditating practitioners demonstrated reduced baseline levels across the same measures compared to controls prior to resting. Overall, meditation has been found to decrease arousal but no more than other self-control strategies when making baseline comparisons.
Meditation and Autonomic Stress Reactivity

Rather than comparing meditation with simple rest or relaxation, a more relevant question is whether meditation demonstrates unique effects under stressful or threatening conditions compared with controls (Morrell, 1986). Holme's (1984) literature review found no evidence from the four somatically based studies he reviewed, that meditators could achieve or maintain lower levels of arousal in threatening situations compared with non-meditating controls. Three of the four studies Holmes reviewed used novice meditators. The studies reviewed include Kirsch & Henry's (1979) study where public speaking was used as a threat. HR for meditators (with three weeks experience) did not decrease, whereas subjects in the desensitisation and muscle training groups did. Similarly, no differences were found between meditators (with two weeks experience) and controls for electrodermal and HR measures, using an IQ test and digit-span backwards as stressors (Boswell & Murray, 1979). Using medical slides as stressors decreases in HR were found for muscle relaxation, cognitive restructuring and self-relaxation but not for meditation (groups had four weeks of training) (Puente & Beiman, 1980). In an experiment using experienced meditators Goleman and Schwartz (1976) found meditators had greater physiological responses (HR and SCR) to a stressor film than non-mEDITatiNG controls. The initial increase in HR reactivity followed by faster SCR habituation and faster recovery time was interpreted as a form of increased adaptive coping. Holme's interpretation of these results was that meditators were not able to reduce somatic arousal under threat, particularly as SCR reduction only brought the meditators down
from a high level of arousal to the level of the non-meditating controls. Holme's noted that the use of different threats or different physiological measures of somatic arousal than those reviewed, may have resulted in differences being found.

During anticipation of the auditory startle response, autonomic response differences were found between meditators and non-meditating controls (Orme-Johnson, 1973). Meditators electrodermal responses habituated to an auditory startle stimuli (100 db) faster than non-meditating controls, also meditators made fewer multiple electrodermal responses during habituation. In two follow-up experiments, fewer spontaneous electrodermal responses were made both during and out of meditation. The interpretation of results was that meditators may have greater autonomic stability in responding to stress. Lehrer, Schoickett, Carrington and Woolfolk (1980) found that meditators demonstrated increased HR and Frontalis EMG activity, more frontal alpha, and fewer cognitive symptoms of cognitive anxiety than either a relaxation or resting control group, in response to an auditory startle stimuli (100 dB). Physiological results were interpreted as supporting Goleman and Schwartz's (1976) proposal that heightened arousal under threat prepares meditators for stress coping.

Studies that have used lower dB levels to stimulate auditory startle response have found HR responses less likely to increase. English and Baker (1983) found that both meditation and progressive muscle relaxation reduced BP whereas HR did not alter when responding to an auditory startle across baseline, stress periods and stress recovery compared with controls. While this finding supports meditators increased arousal under
anticipatory conditions, the fact that HR did not increase as it has in other studies, may suggest the auditory startle (73 dB) was not loud enough to influence HR. Heide (1986) found that HR did not habituate across trials and controls displayed more defensiveness to the auditory startle response than meditators. Most studies use 95-105 dB for acoustic startle response, whereas Heide used 80 dB because mixed reactions of either acceleration or deceleration of HR had been found in this range.

An area that has not received much attention is that of autonomic dominance. Bono (1984) found meditators to be slightly more effective in decreasing arousal than increasing it, while non-meditating controls were slightly better at increasing electrodermal activity above baseline. It was proposed that a relationship may exist between meditation and parasympathetic dominance. It was envisaged that systematic repetition of the relaxation response may reinforce the acquisition of this response which may lead to greater autonomic stability.

Methodological Issues

Many researchers have commented on methodological problems in meditation research. Design inadequacies and methodological problems have flawed much early research into meditation (Holmes, 1984; Rogers & Livingstone, 1977; Shapiro, 1982). Definitions of meditation and relaxation have differed between studies (Suler, 1985; West, 1985). Experimenter bias is possible when meditation practitioners were the researchers (Williams, Francis, & Durham, 1976) and many studies have focused on TM (Suler, 1985; Shapiro, 1985) moreover, meditation is not a generic independent
variable and types of meditation should be specified in reports (Eppley, Shear, & Abrams, 1989). The fact that meditators may have lower initial values has not been taken into account in many studies (Suler, 1985; West, 1985; Dillbeck & Orme-Johnson, 1987). Self-selection by experienced meditators and the impracticality of randomisation poses problems when longitudinal studies are called for (Holmes, 1984). Conclusions have often been generalised from novice meditators (Jevning & Halloran, 1982, cited in Shapiro, 1982). A learning period of 9-12 months was found to be necessary for successful Zen meditation practice (Compton & Becker, 1983).

Supporting this learning view, Puente (1981) found that five days TM training was inadequate to produce the physiological state accompanying TM, while similarities in psychophysiological responses were found for practitioners with between 1.5 years and 5 years TM experience.

In summary, meditation has been found to reduce arousal, however, few physiological differences have been found between meditation, other self-control strategies and eyes-closed rest. Evidence suggests that under stress conditions meditators demonstrate adaptive coping in their autonomic responses.

**Startle Eyeblink Response**

The startle response is an involuntary wave of skeleto-muscular contraction in response to a sudden, unanticipated stimulus (Reber, 1985). A number of meditation studies have used the startle response to potentiate stress reactivity using auditory stimuli (English & Baker, 1983; Heide, 1986; Orme-Johnson, 1973). More recently the
eyeblink response of the orbicularis oculi muscle has been measured (Fridlund & Cacioppo, 1986). The startle eyeblink response has the advantage of being faster and more stable, and can be evoked at lower levels than a whole body response (Lang, Bradley, & Cuthbert, 1990).

The startle eyeblink response has been successfully modified by a range of cognitive and affective variables; unpleasant pictures (Vrana, Spence, & Lang, 1988); film fragments (Jansen & Frijda, 1994); bad odours (Ehrlichman, Kuhl, Zhu, & Warrenberg, 1997); fear conditioned stimuli (Davis, 1986); fear of the dark (Grillon, Pellowski, Merilangas, & Davis, 1997); and imagined affective situations (Witvliet & Vrana, 1995).

Attention. Startle eyeblink research has found that instructions to attend to the stimulus itself results in increased response amplitude and reduced onset latency (Anthony & Graham, 1985; Hackley & Graham, 1984). Humans show eyeblink responses that are slower and smaller when there is a mismatch between probe modality and foreground stimulation (Silverstein, Graham, & Bohlin, 1981). The startle eyeblink response increases or decreases according to modality directed attention and with the interest value of the foreground task (Simons and Zelson, 1985).

Fear Conditioning. A different pattern of startle modulation was found in studies with animals (Brown, Kalish, & Faber, 1951) and humans (Anthony & Graham, 1985) using fear conditioning which exaggerated responses. More recent research provides evidence
that startle response is potentiated in aversive states. Startle eyeblink magnitudes increased and latency reduced during aversive slides for high-fear but not for low-fear individuals. Short latency HR acceleration was also sensitive to slide content and participant fearfulness (Cook, Davis, Hawk, Spence, & Gautier, 1992).

*Emotion and Arousal.* The modulation of startle eyeblink response by emotional state was initially explained by the response matching hypothesis which suggests that startle eyeblink responses increase with unpleasant material and decrease with pleasant material (Simons & Zelson, 1985). In testing the attentional and affective match hypotheses for the human startle eyeblink response, Vrana et al., (1988) used pleasant and unpleasant slides. Startle eyeblink responses were largest for unpleasant material (in foreground) and smallest for positive material. Startle eyeblink responses were inhibited during visually interesting material. These results suggested that attention was unable to be investigated unless foreground emotional valence was accounted for.

The findings from attention and fear conditioning research allowed opposing predictions to be made. Lang et al., (1990) noted that if the conditioned fear findings were introduced into the cross-modality-attention paradigm (Anthony & Graham, 1985; Simons & Zelson, 1985) the prediction that the conditioned stimulus would be more engaging than the startle stimulus was not upheld. To examine this relationship Lang et al., (1990) proposed an emotional model where appetitive and aversive cues modulate the startle eyeblink response differentially.
While support has been found for this model where startle eyeblink magnitudes were found to be related to affective valence but not arousal (Bradley, Cuthbert, & Lang, 1990; Cook, Hawk, Davis, & Stevenson, 1991; Vrana et al., 1988), it has also been shown that startle eyeblink magnitude was related to affective arousal (Cuthbert, Bradley, & Lang, 1990). Modulation of the startle eyeblink with affective materials that were not confounded on arousal and valence have also been studied (Cook et al., 1991). Results indicate that startle eyeblink magnitudes increased during negatively affective imagery while arousal had mixed effects on magnitude. Latencies were shorter during high rather than low-arousal emotions but were not affected by valence. The conclusion reached was that magnitude indexes valence while latency indexes arousal.

Multiple levels of arousal and affective slides were studied when Cuthbert et al., (1990) examined the effect of valence on startle eyeblink magnitudes. High-arousal negatively valent slides produced the greatest startle eyeblink magnitudes while high-arousal positive slides produced the smallest magnitudes. Low levels of arousal during positive and negative valence slides produced no differences between startle eyeblink magnitudes.

In order to reconcile the differences in these results Witvliet and Vrana (1995) examined startle eyeblink and autonomic responses during imagined affective situations. Startle eyeblink magnitudes were larger and latencies faster during negatively valent situations than during positively valent situations, and during high rather than low arousal conditions. Acceleration of HR occurred during high-arousal
imagery while SCR's were also fastest and highest during high-arousal imagery indicating sympathetic nervous system involvement. The results did not support the previous conclusion (Cook et al., 1991) that startle eyeblink response amplitude modulates valence while skin conductance modulates arousal. Instead, it was concluded that both affective valence and arousal modulate startle eyeblink response magnitude and latency. Cuthbert, Bradley and Lang (1996) agreed with this overall conclusion. However, their study found contrary autonomic responses, where deceleration of HR was demonstrated for all pictures, but was greatest for unpleasant pictures. Deceleration also occurred as a function of arousal level.

In summary, it is possible that startle eyeblink responses may differentiate stress reactivity differences between meditators and non-meditators. Differences in HR responses indicate the need for RSA measures as a means of differentiating parasympathetic from sympathetic cardiac responses.

**Cardiac Mechanisms in Physiological Arousal**

It is well established that cardiovascular mechanisms are under dual sympathetic and parasympathetic neural control. These two branches of the autonomic nervous system have been found to ..."covary reciprocally, independently and non-reciprocally"... and are sensitive to cognitive and behavioural influences (Berntson, Cacioppo, & Quigley, 1993, p.183). Consequently, an increase in HR may result from an increase in sympathetic control, a decrease in vagal control, or as a result of both autonomic
branches being simultaneously activated. As a result measures have been sought that differentiate autonomic cardiac control. (Berntson, Cacioppo, & Quigley, 1991).

**Autonomic Control of Heart Rate and RSA**

The chronometric control of the heart can be attributed to the vagus nerve of the parasympathetic branch of the autonomic nervous system (Katona & Jih, 1975). RSA is a measure of the rhythmic fluctuations in beat-to-beat HR associated with respiration (Lane, Adcock, & Burnett, 1992). Chosen for its selectivity, as a non-invasive index of parasympathetic control of cardiac function, RSA is increasingly being used in psychophysiological studies (Muller, Schandry, Montoya, & Gsellhofer, 1992).

The association of RSA with the vagus nerve has been confirmed experimentally using beta-adrenergic blockage (Grossman, Karemaker, & Wieling, 1991). The greater the variation in HR within a respiratory cycle the greater is the vagal influence on the heart (Muller et al., 1992). Even when alterations in parasympathetic tone are small, RSA remains sensitive to cardiac vagal tone (Grossman, Stemmler, & Meinhardt, 1990).

**RSA and Stress Reactivity**

Grossman and Svebak (1987) used threat of electric shock to produce stress in participants and found RSA decreased while HR increased. This HR increase was interpreted as being associated with vagal withdrawal when sympathetic influences exceeded the reciprocal vagal effects. Studying the effects of mental arithmetic on
autonomic dominance, lower vagal tone led to increased HR under stress, presumably through vagal withdrawal, while higher at rest RSA demonstrated faster return to resting rate (Lane et al., 1992). Similar results (Muller et al., 1992) were also found using mental arithmetic, where simultaneous activation of the sympathetic system and inhibition of the parasympathetic system was evident as increased HR, decreased RSA and decreased T-wave amplitude (an index of sympathetic cardiac activity).

These results support the meditation research findings of Goleman and Schwartz (1976) where increased HR was followed by faster recovery rates for HR. It has been suggested that meditators as a group may be parasympathetic dominant (Bono, 1984) which would support the findings where meditators are more reactive to stress than non-meditators.

*Polyvagal Theory*

Porges (1995) proposed that of the two primary medullary source nuclei of the vagus nerve pathway, the nucleus ambiguus (NA) is responsible for RSA, whereas the dorsal motor nucleus (DMNX) is responsible for regulating gastro-intestinal processes. The theory explains how the NA and DMNX pathways operate independently and are responsible for divergent shifts in RSA and HR respectively, where an increase in HR will not necessarily be associated with a decrease in RSA. The NA pathway has been linked to facial, vocal, respiration and heart effects with further associations with attention, motor activity, emotion, communication and with the cardio-respiratory rhythm.
Polyvagal theory predicts a relationship between emotion and autonomic responses where vagal tone is highest during unchallenged situations and is withdrawn in response to stress, exercise and negative emotion. It is assumed that negative emotional experience results in withdrawal of vagal tone to aid mobilisation of the 'fight or flight' response.

In summary, RSA is a selective, non-invasive index of parasympathetic activity. Polyvagal theory proposes a relationship between emotions and autonomic responses where negative emotional experiences result in reduced RSA. Meditation stress reactivity research may benefit from the use of RSA to differentiate parasympathetic and sympathetic cardiac responses.

**Meditation and Motivation**

A number of studies have indicated that novice meditators were more anxious and neurotic than population norms (Delmonte, 1985a; Rogers & Livingstone, 1977; Williams, Francis, & Durham, 1976), whereas long-term meditators were signifi cantly less anxious than infrequent meditators. A review of meditation and anxiety reduction literature found that those who benefit the most from meditation practice demonstrate "the capacity to engage in autonomous self-absorbed relaxation" (Delmonte, 1985a, p. 99).
A study into TM found initial low self-esteem increased due to self-discipline and mastery competence, while increased self-control and responsibility were also reported (Bono, 1984). The effect of Zen meditation on personality and social values after 5 months practice found reduced aggressiveness, less ambition, less preoccupation with the future, reduced interest in social life and a decrease in the tendency to dominate (De Grace, 1976).

Motivational characteristics of meditators have received less attention than physiological responses. It is clear however, that because there are large drop-out rates among the initiated, experienced meditators may constitute a self-selected subgroup with specific motivational characteristics (Delmonte, 1984a).

**Reversal Theory**

Reversal theory proposes a structure to explain the phenomenology of subjective experience. This structure utilises the relationship between hedonic tone, where experience is either pleasant or unpleasant, and arousal, which may be experienced at either high or low levels. The resulting states or modes are termed metamotivational because they determine the type of experience people want at any given time, and reflect ways of being in the world. (Frey, 1997). Apter (1988) identified two types of emotions in reversal theory. Somatic emotions are moderated by 'felt physiological arousal' and Transactional emotions reflect 'felt gain' or loss in response to transactions with people, situations or objects.
Somatic Emotions

The first pair of somatic emotions are the arousal-avoiding and arousal-seeking modes, referred to as the Telic and Paratelic modes respectively. The telic mode is serious-minded, goal directed and future oriented and pleasure is found in the achievement of goals. The paratelic mode is not so concerned with goals, but with immediate sensation, hence its association with playfulness where pleasure is derived from the activity itself. The second pair of somatic emotions are the Negativistic/Conformist modes. The conformist mode is experienced as a willingness to conform or please, in relation to an external force. The conformist mode operates in the telic/paratelic pair unless it is converted into the negativistic emotions during reversal.

The telic-conformist modes at low levels of arousal, are experienced as relaxing and pleasant, whereas high arousal is experienced as anxiety and unpleasant. Subsequently, the term arousal-avoiding is applied. The telic/conformist modes are relevant to the practice of VM. A telic serious-minded approach is required to meet the demands of concentration and mindfulness (extraordinary attention to ordinary experience). At the same time the arousal-avoiding characteristic of the telic mode is conducive to the cultivation of a calm and harmonious mental attitude. Conformity is required in bringing mindfulness and equanimity (no interference with the flow of the senses) to ordinary experience and in conforming to regular meditation practice.

In the paratelic-conformist mode low arousal is experienced as boredom and unpleasant, whereas high arousal is experienced as excitement and pleasant, hence the
term arousal-seeking. The negativistic mode is characterised by defiance and non-conformity. In the telic-negativistic mode low arousal is experienced as placidity and pleasant, whereas high arousal is experienced as anger. Conversely, in the paratelic-negativistic mode low arousal is experienced as sullenness and unpleasant and high arousal is experienced as provocative 'anger' or challenge and pleasant.

Only one metamotivational mode of any pair can be in operation at any given time. Reversals between modes may be either to the opposite level of arousal or to the opposite dimension at the same level of arousal. For example, if a person is anxious they can reverse into relaxation on the same dimension of emotional experience. Or they can invert dimensions and reverse into excitement which is at the same level of arousal, but is opposite in the interpretation of felt arousal. Reversals occur in response to contingencies relating to biological needs and environmental cues; frustration with the present state; or satiation, where all states eventually reverse (Apter, 1988).

**Transactional Emotions**

These emotions involve the experience of felt transactional outcome in response to people, situations or objects. The first pair of transactional modes are the Mastery/Sympathy pair. In the mastery mode a person experiences relationship outcomes from the perspective of strength or weakness or as controlling or being controlled. Life is experienced as struggle. In the sympathy mode the relationship outcome is experienced from the perspective of giving and receiving and life is experienced as an opportunity to express affection, or liking.
The second pair of transactional modes are the Autic/Alloic modes. The autic mode orients the person to their own outcomes, so they are self-concerned. Conversely, the alloic mode is concerned with the outcomes of the 'other' in the relationship. The mastery and sympathy modes and the autic and alloic modes also combine on the dimensions of hedonic tone and felt transactional gain or loss.

The autic-mastery orientation accounts for the experience of strength and control that may accompany self-made achievement. Loss or failure would be felt as humiliation and would be unpleasant, whereas its opposite, success, would be felt as pride or triumph and as pleasant. In the autic-sympathy orientation one is wanting someone to do something for us, or to comfort us. Loss or lack of sympathy would be felt as resentment, whereas to gain comfort or support results in feeling gratitude.

If an inversion of the two dimensions occurs and the autic (self-concerned) mode reverses into the alloic mode ('other' concerned) then the same outcome has opposing consequences in terms of hedonic tone. In the alloic-mastery orientation a person may lose a game in order to encourage a younger player; the loss is felt as modesty whereas a win would result in shame. In the alloic-sympathy orientation where one's aim is to nurture or support the 'other,' being able to nurture feels virtuous, whereas not nurturing results in feelings of guilt (Apter, 1988).
Two pairs of somatic emotions and two pairs of transactional emotions have been proposed. Each mode pair gives rise to two opposing emotions, resulting in an account of eight pairs of opposing emotions. Each pair of modes also represents two opposing ways of experiencing arousal, where only one member can operate at any given time.

**Dominance**

Reversal theory proposes that people prefer being in some metamotivational modes more than others. Mode dominance reflects preference, for example, a telic dominant person spends more time in that mode than in the paratelic mode. A person in a dominant mode is no more in that mode than anyone else, as the reference is to frequency rather than content. Behind the healthy inconsistencies that people demonstrate in their mode reversals, mode dominance suggests there are also consistencies (Apter, 1989).

**Salient Emotions of Meditators**

Salient emotions represent what is important to a person and underlie desire, behaviour and thinking. Subsequently, they determine personality and emotional experience. At any given time a person will be in four of the eight modes, of which one or two will be more salient (Frey, 1997).

Predictions about meditators can be made based on reversal theory constructs explicit in; The Tension and Effort Stress Inventory (Svebak, 1993); the Metamotivational Style Profile (Apter, Mallows, & Williams, 1998); and from VM literature sources
The practice of VM involves concentration, attention and awareness, strength, discipline and determination in the practice of meditation and in the development of mindfulness and equanimity. VM is goal-directed in that it aims to free the individual from suffering generated through "craving and aversion" (Hart, 1991, p. 56). Practitioners also cultivate kindness and compassion in the service of others. Committed meditators integrate their practice into all activities, as a result it is predicted that long-term meditation practice may influence the dominance of metamotivational modes. On this basis it is predicted that VM's will be telic (serious-minded, goal oriented, prefer low arousal), conformist (conforms to discipline and regular meditation practice), autocentric (self-concern expressed as mindfulness) and mastery dominant (maintains internal locus of control). When combined the transactional modes of autocentric-mastery (self-concern expressed as mindfulness; locus of control) and allocentric-sympathy (serve others; express kindness and compassion) will also be dominant (Apter, Mallows, & Williams, 1998).

In summary, reversal theory proposes that felt physiological arousal and felt transactional outcomes are experienced in different ways depending on the interpretation of arousal and metamotivational mode dominance. The long-term practice of meditation may influence the dominance and salience of metamotivational modes.

**Conclusion**

Meditation literature has been reviewed to assess the ability of meditation to reduce physiological arousal at rest and during stress conditions. The results have been mixed
on both counts partly due to methodological issues. There is evidence to suggest that meditation does reduce arousal but no more than other self-control strategies, and that under stress conditions meditators demonstrate adaptive coping in their autonomic responses. Startle eyeblink research indicates that aversive responses evoked by auditory stimuli result in increased blink magnitudes and faster blink latencies. It is proposed that comparing startle eyeblink responses of meditators with non-meditators may reveal differences in stress reactivity. Physiological studies into meditation have neglected the role of parasympathetic cardiac responses. Polyvagal theory predicts that negative emotions are associated with decreases in parasympathetic cardiac vagal tone, as indicated by a reduction in RSA. Consequently, RSA is an appropriate measure for future meditation studies. When used in conjunction with other physiological measures, a more coherent picture of stress reactivity between meditators and non-meditators may be built up using startle eyeblink responses and RSA measures. Reversal theory proposes that people have dominant metamotivational modes. Mode dominance provides a useful framework to explain and compare the underlying motivations, emotions and personality profiles of long-term meditators with non-meditators.
References


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Part B. Empirical Report

Psychophysiological Differences Between Meditators and Non-meditators

During Anticipatory Stress

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Abstract

To further understand the psychophysiology of stress, the autonomic responses of experienced meditators (N=14) and non-meditators (N=14) were compared during Auditory Startle Response and Mental Arithmetic conditions. Meditators and controls motivational preferences were assessed using a Reversal Theory (Apter, 1988) questionnaire. Significant group differences were found where reduced eyeblink amplitudes for meditators, but not reduced eyeblink onset latency, provided partial support for the prediction that meditators would be less anxious than non-meditators. The prediction that meditators would demonstrate overall greater autonomic recovery than non-meditators was not supported, although vagal tone activation showed predicted differences. Questionnaire data supported the prediction that meditators would prefer lower arousal and be more Compliance dominant than non-meditators. Clinical implications of the present study and future directions for research are discussed.
Literature reviews have assessed research that compared physiological differences between meditation and relaxation (Dillbeck & Orme-Johnson, 1987), meditation with other self-control strategies (Shapiro, 1982), and the ability of meditation to reduce anxiety (Delmonte, 1985a). Results are equivocal for the efficacy of relaxation and for self-control strategies, and in general meditation is associated with reduced anxiety. A more relevant research question is whether meditation demonstrates unique effects under stressful or threatening conditions compared with controls (Morrell, 1986).

Meditation and Autonomic Arousal Reduction

Holme's (1984) literature review of meditation and its proposed ability to reduce physiological arousal found no evidence from the four studies he reviewed that meditators could achieve or maintain lower levels of arousal in threatening situations, compared with non-meditating controls. Three of the four studies Holmes reviewed used novice meditators. Shapiro (1982) made the point that conclusions generalised from novices contributed to flawed results in meditation research. The fourth study Holmes reviewed (Goleman & Schwartz, 1976) found experienced Transcendental meditators demonstrated increased physiological responses, heart rate (HR) and skin conductance response (SCR) to a stressor film, compared to non-meditating controls. The significant initial increase in HR reactivity followed by faster SCR habituation and faster recovery time was interpreted as a form of increased adaptive coping. In contrast, Holmes' interpretation was that meditators were not able to reduce somatic arousal under threat, particularly as SCR reduction only brought the meditators down from a high level of arousal to that of non-meditating controls. Morrell (1986) commented that
Holmes' dismissal of Goleman and Schwartz's (1976) results ran the risk of overlooking important clinical implications. Other studies have found meditators to have increased arousal under stress conditions (Lehrer, Schoickett, Carrington, & Woolfolk, 1980).

The auditory startle response (ASR) has been used to induce anticipatory stress in meditation research. Orme-Johnson (1973) found meditators electrodermal responses habituated to an auditory startle stimuli (100 dB) faster than non-meditating controls, also meditators made fewer multiple electrodermal responses during habituation. The interpretation of results was that meditators may have greater autonomic stability in responding to stress. Lehrer, et al., (1980) found that meditators demonstrated increased HR and Frontalis electromyograph (EMG) activity, more frontal electroencephalograph (EEG) alpha, and fewer cognitive symptoms of cognitive anxiety than either a relaxation or resting control group, during ASR's (100 dB). Results were interpreted as supporting Goleman and Schwartz's (1976) proposal that heightened arousal under threat prepares meditators for stress coping.

Anxiety and Startle Response Research
Research indicates that anxiety and fear increase the magnitude of the startle response in animals (Brown, Kalish, & Faber, 1951) and humans (Anthony & Graham, 1985). Anticipatory anxiety has been measured objectively using a fear potentiated startle response in a paradigm not requiring any shock (Grillon, Ameli, Woods, Merikangas, & Davis, 1991). Clinical studies indicate that exaggerated ARSs have been associated
with current posttraumatic stress disorder, supporting the link between eyeblink amplitude and anxiety (Butler, Braff, Rausch, & Jenkins, 1990; Morgan, Grillon, Southwick, Davis, & Charney, 1996). The eyeblink component of the startle response has the advantage of being faster, more stable, and can be evoked at lower levels than a whole body response (Lang, Bradley, & Cuthbert, 1990).

*Cardiac Responses and Respiratory Sinus Arrhythmia (RSA)*

While it is well established that cardiac mechanisms are under dual sympathetic and parasympathetic neural control (Berntson, Cacioppo, & Quigley, 1993), meditation studies investigating stress reactivity have not differentiated these autonomic HR influences (English & Baker, 1983; Goleman & Schwartz, 1976; Heide, 1986; Lehrer et al., 1980). Polyvagal theory proposes that the two pathways of the vagus nerve operate independently and are responsible for divergent shifts in RSA and HR respectively, where an increase in HR will not necessarily be associated with a decrease in RSA (Porges, 1995). RSA measures the rhythmic fluctuations in beat-to-beat HR associated with respiration (Lane, Adcock, & Burnett, 1992), and even when alterations in parasympathetic tone are small, RSA remains sensitive to cardiac vagal tone (Grossman, Stemmler, & Meinhardt, 1990). Mental arithmetic as a laboratory stressor, has been found to simultaneously activate both autonomic branches (Muller, Schandry, Montoya, & Gsellhofer, 1992).
Motivation and Reversal Theory

For meditation to be of therapeutic use, clinicians need to know when a technique is useful and for which patients (Shapiro, 1982). The motivational characteristics of meditators have received less attention than physiological responses. Since there are large drop-out rates among novices, experienced meditators may constitute a self-selected subgroup with specific motivational characteristics (Delmonte, 1984a).

Reversal theory is increasingly being used to explain behaviour, including stress related and health promoting behaviours (Svebak & Apter, 1997). The theory proposes a relationship between metamotivational modes where arousal-seeking/arousal-avoiding behaviour is moderated by 'felt arousal' (high/low). In the arousal-seeking mode a person experiences increases in arousal as increasingly pleasant, or as increasingly unpleasant if in the arousal-avoiding mode, as it increases. Apter (1988) identified somatic emotions that are moderated by 'felt physiological arousal' and transactional emotions that reflect 'felt gain or loss' in response to transactions with people, situations or objects. The first pair of somatic modes are the Telic (goal-oriented, arousal-avoiding) and Paratelic (playful/arousal-seeking) modes. Each pair member can be experienced at high or low arousal levels. Any emotion involving high arousal in the telic mode will be unpleasant, whereas in the paratelic mode high arousal will always be experienced as pleasurable. The second pair are the Compliance (agreeable) and Negativistic (rebellious) modes. Metamotivational modes blend to form mode combinations such as telic-compliance where goal-directed behaviour conforms to some external expectation, and is experienced at either high (anxiety) or low arousal levels (relaxation). The first pair of transactional emotions are the Mastery/Sympathy
The mastery mode is oriented towards control and winning/losing, whereas the sympathy mode is care-oriented and involves sensitivity. The other transactional pair are the Autic (self-concerned) and Alloic (other-concerned) modes. Transactional modes combine at high/low levels of gain. For example, a low gain autic-mastery transaction (loss) is experienced as humiliation, whereas a high gain transaction (win) is experienced as pride. Each mode pair gives rise to two opposing emotions, resulting in an account of eight pairs of opposing emotions. According to Frey (1997) the majority of people have a dominant state involving preference for combinations of modes to which they are predisposed. Similarly, some emotions are more salient than others and underlie desire, behaviour and thinking. Mode dominance and emotional salience determine motivation, personality and emotional experience.

Conclusion

Meditation research suggests that meditators heightened physiological arousal under threat better prepares them for stress coping. Polyvagal theory suggests that negative experience such as stress, reduces RSA. Respiratory sinus arrhythmia is a sensitive index of parasympathetic cardiac control that has not previously been used in meditation research. Startle response research suggests eyeblink magnitude and onset latency vary with anticipatory anxiety levels. Based on evidence drawn from meditation research and startle response research it is proposed that meditators will demonstrate lower amplitude and greater latency in response to auditory startle stimuli than non-meditators. Meditators will demonstrate overall greater ANS recovery from cognitive stress than non-meditators.
The motivational characteristics of experienced meditators has received less attention than physiological responses. Reversal theory proposes that people have dominant metamotivational modes. Mode dominance and emotional salience provide a useful framework to explain motivation, emotion and personality. Using reversal theory psychometric materials (Apter, Mallows, & Williams, 1998; Svebak, 1983) it is further predicted that meditators will prefer lower arousal than non-meditators. Meditators somatic dominance will be Telic, Compliant, Autic and Mastery. Meditators transactional dominance will be Autic-Mastery and Alloic-Sympathy.

Method

Participants

Experienced meditators (N =14) were recruited from members of a Vipassana Meditation Centre (M = 9.6 years experience). Vipasssa meditation is a Buddhist technique that is taught internationally in a standardised, non-sectarian manner by S. N. Goenka (Hart, 1991). An equal number of non-meditators were recruited from the wider community and were matched with meditators for age (meditators M = 42.2; non-meditators M = 40.4); gender (7 female; 7 males in each group); and fitness (Oxygen uptake - meditators M = 39.5 VOl, ml/kg*min; non-meditators M = 36.7, VOl, ml/kg*min). Selection criteria required that non-meditators did not practice meditation. All participants were non-smokers.

Apparatus and Materials
**Physiological measures** - A respiratory transducer belt was fitted to the upper chest to measure respiration utilising a Vitalog Respiration and Body Position amplifier. Miniature Ag/AgCl electrodes (9mm) were fitted for Electrocardiogram (ECG) measurements using standard left and right rib placements, with mastoid earth. Skin Conductance Level (SCL) was measured using Ag/AgCl electrodes (9mm) fixed to the second phalanx of the first and second fingers. Finger Pulse amplitude (FPA) was measured using a photoelectric finger plethysmograph placed around the first phalanx of the second finger. The Electromyograph (EMG) eyeblink used miniature Ag/AgCl electrodes and combined the electrode placements of M. orbicularis oculi (1 cm inferior to to the exocanthion) and M. lateral frontalis (1 cm lateral to the vertical that traverses the pupil, inferior position) (Fridlund & Cacioppo, 1986).

Data was recorded from raw signals for ECG, respiration, FPA, SCL, EMG eyeblink and the auditory stimulus on 6 channels of a MacLab 8 Data Acquisition System and an Apple Macintosh IIci computer using Chart v 3.5.4 (System Version 7.1). Cardiotachometer and Pulse Height were computed from raw data and occupied an additional 2 channels. Auditory stimuli (bursts of white noise) were presented binaurally through Beaver Dymnamic DT109 (400? ) headphones. The white noise was generated by a white noise generator with instantaneous rise time. Startle EMG was sampled at 1000 Hz for three respiratory phases prestimulus and for 30 seconds poststimulus. A 4-channel audio interval generator alternately produced a 1kHz and 1.5kHz tone which was used to pace respiration at 10 breaths per minute. The MA task utilised a 486 IBM compatible computer to run a mental arithmetic program that added
or subtracted 2 x 2 digit numbers, answers were selected from 4 choices using the keypad numbers 1, 2, 3, 4. Reaction time (RT) was measured, and task difficulty level was adjusted by changing time to respond, starting at 6s. Body weight (kg) was measured using Tanitia electronic scales. Submaximal fitness was measured using a Repco bicycle ergonometer and aerobic work capacity was calculated (HR/age/weight) using a Repco nomogram (Anstrad, 1960) dial and expressed as VO\(_2\), ml/kg x min.

**Psychological Measures** - Emotion, mood and motivational inventories assessing reversal theory constructs were selected according to their reliability and validity (refer Svebak, 1993; Apter, Mallows, & Williams, 1998). Positive and negative somatic and transactional emotions were selected from the Tension and Effort Stress Inventory (TESI) (Svebak, 1993). Visual analogue scales were used to measure stress, arousal and hedonic tone (King, Stanley, & Burrows, 1987). Emotional, personality and motivational preferences and dominance was assessed using the Metamotivational Style Profile (Apter, Mallows, & Williams, 1998).

**Procedure**

The experiment was conducted in a single session. Participants were instructed to not eat or drink one hour prior to the experiment. After the participant arrived at the laboratory, detailed information was provided about the experiment, and Informed Consent was obtained (see Appendix A). A Metamotivational Style Profile questionnaire was filled in prior to arrival. Participant's body weight was measured as part of the fitness calculation. Physiological sensing devices were fitted according to
standard laboratory procedures (see Apparatus). Participants were seated in a comfortable upright position, in front of a monitor during the experiment. ASR trials and Mental Arithmetic (MA) task conditions were counterbalanced. Participants were instructed to keep their eyes open during the experiment. Breathing was paced (10 bpm) to a nearby speaker, and was recorded in conjunction with other physiological responses during all conditions except the MA task.

During the ASR trials the volume of the pacing tone was increased to enable the participant to hear the external pacing tone, while still wearing the headphones. Participants were instructed that they would hear an occasional loud sound through the headphones, which they were to ignore, and to continue to listen to the pacing tone. At the same time they were instructed to relax as much as possible and to restrict their gaze to the center of the monitor (switched off) 500 mm in front of them. The ASR was elicited by five white noise bursts (500ms x 95 dB), presented at 55-65 s intervals.

The MA task involved adding or subtracting two double digit numbers displayed on a monitor, then selecting from four possible answers using the computer keypad to register a response. Practice was given until the participant was competent at the task. Instructions were given to perform with a minimum of errors. The inter-trial interval was adjusted for each participant to ensure performance met an approximate 60% success rate. Following the Baseline, MA and Recovery conditions participants completed a Tension and Effort Stress Inventory (TESI) and Visual Analogue Scales (VAS).
Spontaneous breathing was recorded during a final rest period following the MA conditions. Fitness was evaluated using a sub-maximal bicycle ergonometer test directly after the experiment and prior to the participant being debriefed. Fitness measures were obtained by recording heart rate variability following six minutes of exercise on a Repco bicycle ergonometer. Aerobic work capacity was calculated by maximal oxygen uptake ($VO_{2}$, ml/kg*min) using a Repco nomogram dial.

**Design**

*Control Variables* - Age, sex, fitness level, noise and temperature, not eating for 1 hour prior to experiment.

*Auditory Startle Response* - The between subjects factor was Group (meditator, non-meditator) while the within subjects factor was Trials (x 5). Dependent variables were EMG eyeblink (amplitude and latency). The between subjects factor was Group (meditator, non-meditator) while within subjects factors were Phase (pre-stimulus; stimulus) and Trials (x 5). The dependent measures were HR, RSA, FPA and SCR.

*Mental Arithmetic* - The between subjects factor was Group (meditator, non-meditator) and the within subjects factor was Condition (Baseline, Anticipation, MA, Recovery) The dependent measures were HR, RSA, FPA and SCR.
Metamotivational Style Profile (MSP) - An individual questionnaire with standard instructions used a One Way 2(Group) ANOVA for each of 28 subscales.

An alpha level of .05 was used for all statistical tests. Factorial analyses used the Greenhouse-Geisser correction for repeated measures. Where necessary, t-tests were used for further analysis with Bonferroni correction as appropriate. Statistical power was assessed for factorial analyses (Appendix C).

Data Scoring and Analysis

Postimulus - prestimulus EMG levels of the eyeblink response were measured by taking the RMS (root mean square) of the EMG signal, with a time constant of 20ms in the 30-100-ms poststimulation. Onset latency of the eyeblink response was defined as the mean amplitude of baseline EMG, in the 50-ms prestimulus period (Grillon & Davis, 1995). The following dependent measures were derived off-line using MacLab 8 facilities. Cardiotachometer and RSA were derived from replayed HR and respiratory records. The peak-to-trough method of scoring RSA (Grossman & Svebak, 1987) was then used to produce mean RSA across all conditions. FPA was the percentage of prestimulus-poststimulus change for the startle condition and as percentage change of the Baseline level of FPA for all MA conditions. This produced a positive change score for vasoconstriction responses (and indicates higher sympathetic arousal). SCR was determined as peak-prestimulus level (in ?mhos) across ASR trials. SCL (in ?mhos) was the mean response level across the MA conditions.
Results

Physiological Variables

Means and standard deviations for Auditory Startle Response trials for EMG (RMS) eyeblink magnitude, eyeblink latency, HR, RSA, FPA and SCR measures are shown in Table 1. Data analysis summaries are provided in Appendix C.

Auditory Startle Response

EMG (RMS) Eyeblink Magnitude. A significant between groups main effect was found \( F(1, 20) = 4.723, p = .042 \) during the five auditory startle response trials. A significant within subjects main effect was found for Trial \( F(1.946, 38.919) = 5.888, p = .006 \).

In Figure 1 meditators demonstrate lower magnitude EMG (RMS) eyeblink responses compared with non-meditators.

(Tables not included in email document)
Figure 1. Mean EMG (RMS) eyeblink magnitude to auditory startle stimuli (95dB) during 5 trials for meditators and non-meditators.

Figure 2. Mean EMG (RMS) eyeblink response latency (msec) to auditory startle stimuli (95dB) during 5 trials for meditators and non-meditators.
Eyeblink Latency. No significant main effect was found for eyeblink latency between groups $\text{F}(1, 13) = 1.866, p = .195$. While the difference is not significant, a comparison of means in Figure 2. indicates greater EMG (RMS) eyeblink latency for meditators compared with non-meditators.

Heart Rate. No significant main effect was found between groups. Significant within subjects main effects were found for Trial $[\text{F}(2.480, 64.474) = 3.271, p = .035]$ and for Phase $[\text{F}(1, 26) = 9.797, p = .004]$. T-test comparisons indicate non-meditators HR decelerated significantly from trial 1 to trial 2 $[t(13) = 2.441, p = .03]$. 

RSA. No significant group main effect was found. Significant within subjects main effects were found for Trial $\text{F}(2.990, 77.749) = 3.336, p = .024]$, for Phase $\text{F}(1, 26) = 8.422, p = .007$ and a significant interaction was found for Trial x Phase $\text{F}(3.064, 79.651) = 5.407$. Figure 4 demonstrates habituation to the auditory startle response during the first three trials, followed by RSA recovery for both groups.

SCR Change. No significant main effect was found between groups $\text{F}(1, 26) = .170, p = .683$. A highly significant within subjects main effect was found for Trial $\text{F}(1.935, 50.303) = 10.671, p < .001$, where both groups habituated to the ARS, during trials 3-5 (see Figure 5).
**Figure 3.** Mean heart rate responses during Auditory Startle Response trials for meditators and non-meditators.

**Figure 4.** Mean RSA response to auditory startle stimuli during 5 trials for meditator and non-meditators.
Figure 5. Mean SCR post-pre stimulus change (?mhos) elicited by auditory startle response during 5 trials for meditators and non-meditators.

Figure 6. Mean SCR onset latency to auditory startle stimuli during 5 trials for meditators and non-meditators.
**SCR Latency.** No significant main effect was found between groups \(F(1, 22) = 2.516, p = .127\), whereas a significant within groups main effect was found for Trial \(F(2.199, 48.373) = 3.395, p = .038\). Figure 6 demonstrates lower SCR latencies by meditators compared with non-meditators.

**FPA.** No significant main effect was found between groups \(F(1, 24) = 1.321, p = .262\). Figure 7 demonstrates habituation to the auditory startle for both groups. Non-meditators demonstrate increasing vasodilation during successive trials, whereas meditators vasoconstriction increased during trials four and five.

![Figure 7](image)

**Figure 7.** Mean percentage change in FPA response to auditory startle stimuli during 5 trials for meditators and non-meditators.

**Mental Arithmetic**
Means and standard deviations for the Mental Arithmetic task for HR, RSA, FPA and SCR measures are shown in Table 2.

Heart Rate. No significant group main effect was found. A highly significant within subjects main effect was found for Condition $F(2.241, 58.262) = 14.575, \ p < .001$. T-test comparisons indicate HR was significantly higher during the MA condition compared with Anticipation for both groups; meditators $t(13) = -3.417, \ p = .005$; non-meditators $t(13) = 4.667, \ p = .001$. HR during the Recovery condition was also significantly lower than during the Mental Arithmetic condition; meditators $t(13) = 2.562, \ p = .02$; non-meditators $t(13) = 4.611, \ p = .001$. All comparisons were significant following Bonferroni adjustment ($p = .05/4, = .0125$) except for meditators in the MA condition, which should be replicated.

RSA. No significant main effect or interaction was found. Figure 9 demonstrates increased RSA for meditators during the Anticipation and Recovery conditions which is in the predicted direction. T-test comparisons indicate significant differences for meditators RSA responses between Baseline and Anticipation conditions $t(27) = -2.019, \ p = .05$ and between Anticipation and Mental Arithmetic conditions $t(27) = 2.126, \ p = .004$. The comparison between Baseline and Anticipation conditions was not significant following Bonferroni adjustment ($p = .05/2, = .025$), indicating the difference should be replicated.

(Table 3 not included)
Figure 8. Mean HR during Mental Arithmetic conditions for meditators and non-meditators.

Figure 9. Mean RSA responses during Mental Arithmetic conditions for meditators and non-meditators.
Figure 10. Mean percentage change in FPA response from Baseline during Anticipation, Mental Arithmetic and Recovery conditions for meditator and non-meditators.

Figure 11. Mean SCL during Mental Arithmetic conditions for meditators and non-meditators.
FPA. A non-significant trend was found between groups $F(1, 24) = 3.731, \ p = .065$ where meditators demonstrated greater vasoconstriction during the Anticipation condition, whereas non-meditators demonstrated greater vasodilation during the Recovery condition (Figure 10).

SCL. No significant main effect was found between groups $F(1, 26) = 1.903, \ p = .179$ while a main effect was found for Condition $F(2.605, 67.729) = 7.487, \ p < .001$. Figure 11 demonstrates a similar pattern of SCL responses between groups, where meditators responses were higher than non-meditators during the Mental Arithmetic conditions. T-test comparisons indicate meditators SCL was significantly higher during the MA task than during the Recovery condition [$t(13) = 3.028, \ p = .01$]. Non-meditators SCL was significantly higher during the Anticipation condition than during Baseline [$t(13) = -3.585, \ p = .003$] and the Anticipation condition was lower than the Mental Arithmetic condition [$t(13) = 2.582, \ p = .02$]. (Bonferroni adjustment $p = .05/3, = .016$). Comparisons were significant following Bonferroni adjustment ($p = .05/2, = .025$) except where the non-meditators Anticipation condition was lower than the Mental Arithmetic condition, indicating the difference should be replicated.

Psychological Variables

Tension and Effort Stress Inventory. Means and standard deviations are shown in Table 3. No significant main effects or interactions were found between groups for Positive Emotions or for Negative Emotions for Baseline, MA or Recovery conditions.
Visual Analogue Scales. No main effects were found between groups for the Calm-Worried scale, the Active-Sleepy scale or the Pleasant-Unpleasant scale for Baseline, MA or Recovery conditions (Table 4).

Paced Respiration and Effect of Order

Spontaneous Respiration. No significant differences were found when t-test comparisons were made between Baseline paced respiration (10 bpm) and Spontaneous Respiration (following the MA conditions) for RSA \( t(27) = -.623, p = .538 \); FPA \( t(27) = 1.756, p = .092 \); SCL \( t(27) = -1.366, p = .183 \) and HR \( t(27) = 1.168, p = .253 \) where non-significance indicated there was no differences in physiological arousal in the Baseline condition.

Counterbalance Order. No significant main effects of interactions were found for Order.

Metamotivational Style Profile

Means and standard deviations for MSP subscales are shown in Table 5. As predicted, a significant main effect was found for Arousal-Avoidance Dominance \( F(1, 26) = 4.880, p = .036 \), where meditators were more arousal-avoiding than non-meditators. A significant main effect was found for Compliance Dominance \( F(1, 26) = 5.812, p = .023 \) where, as predicted, meditators were more compliance-dominant than non-meditators. No significant main effect was found for Telic Dominance.
However, a significant between groups difference was found for the Telic subscale
$[F(1, 26) = 5.534, p = .026]$ where, against the prediction, meditators were less Telic
than non-meditators. A significant main effect was found for Autocentric-Dominance
$[F(1, 26) = 4.872, p = .036]$ where meditators were less autocentric-dominant than
non-meditators, against the prediction. No significant main effect was found for
Mastery Dominance, and the means were in the opposite direction to the prediction. A
significant main effect was found for Autocentric-Mastery $[F(1, 26) = 12.201, p =
.002]$ where meditators were less autocentric-dominant than non-meditators, contrary to
the prediction. No significant main effect was found for Allocentric-Sympathy,
however means indicate that meditators scored less for allocentric-sympathy than non-
meditators, also contrary to the prediction.

Significant main effects that were not hypothesised for were found for the following
MSP subscales: Arousal-seeking $[F(1, 26) = 12.830, p = .001]$ where meditators were
less arousal-seeking than non-meditators; Arousability $[F(1, 26) = 4.944, p = .035]$,
where meditators were less arousable than non-meditators; Pessimism $[F(1, 26) =
9.360, p = .005]$, where meditators were less pessimistic than non-meditators; Arousal-
Avoiding/Seeking Salience $[F(1, 26) = 17.588, p < .001]$, where arousal-avoiding
/seeking was less salient for meditators than for non-meditators; Transactional
dominance $[F(1, 26) = 5.784, p = .024]$ where transactional emotions were less salient
for meditators than non-meditators.
Discussion

The prediction that meditators ASR eyeblink amplitudes would be smaller than non-meditators was supported, whereas the prediction of slower eyeblink latencies for meditators was not. The prediction that meditators would demonstrate overall greater autonomic recovery from anticipatory stress compared with non-meditators, was not upheld. However, within group effects and interactions indicate some support for the prediction.

The Metamotivational Style Profile questionnaire produced mixed results. The prediction that meditators would prefer lower arousal than non-meditators was supported. The somatic dominance prediction that meditators would be Compliance dominant was supported, whereas predictions for Telic, Autic and Mastery dominance were not supported. Transactional dominance predictions that meditators would be Autocentric-Mastery and Allocentric-Sympathy dominant were not supported. Group differences were found for other non-predicted subscales which contribute to establishing a meditator profile.

Physiological Variables

Auditory Startle Response. Significantly lower amplitude eyeblink responses (but not eyeblink latencies) by meditators supported predictions made on the basis of ASR research into anxiety and fear where higher anxiety levels produce greater ASR eyeblink amplitudes and shorter latencies (Grillon & Davis, 1995). These results support other meditation findings which suggest that long-term meditation practice
leads to lower state anxiety (Delmonte, 1985a; Eppley, Shear, & Abrams, 1989; Goleman & Schwartz, 1976). Recording equipment problems during ASR trials reduced the number of useable meditator eyeblink latency records (N = 5) which may account for the non-significant results. Means for the ASR eyeblink latency differences are in the direction of the prediction (Table 1).

Autonomic measures recorded during the ASR trials indicated no significant differences between groups for HR, RSA, FPA and SCR responses. A main effect for HR responses for both Trial and for Phase (Figure 3) indicated non-meditators HR significantly decelerated on the 2nd trial. Deceleration is a characteristic of the orienting response (Lynn, 1966).

A significant interaction for RSA for Trial x Phase supported the prediction of greater parasympathetic nervous system recovery by meditators, following habituation of the ASR on trial 3 (Figure 4).

Group differences for sympathetic recovery were not demonstrated for SCR change, SCR latency or FPA responses during ASRs. However, meditators FPA responses did not habituate to the auditory stimulus, compared with non-meditators, indicating greater sympathetic arousal. Habituation was demonstrated by both groups during trials 4-5 for RSA, SCR change and SCR latency. This stands in contrast with the Orme-Johnson (1973) study where habituation was faster for meditators over 11 trials. Heide (1986) found that SCR did not habituate, whereas HR did in response to ASRs. These
studies are not entirely comparable to the present study because they used Transcendental meditators, during meditation.

In summary, significantly lower ASR eyeblink amplitudes by meditators partially supports the prediction of meditators being less anxious than non-meditators. Differential parasympathetic and sympathetic activation was observed for meditators during ASRs. The prediction of greater autonomic recovery by meditators was supported by increased RSA responses during trials 4-5, but was not supported when FPA responses demonstrated increasing sympathetic arousal during trials 4-5, compared with non-meditators.

*Mental Arithmetic.* The MA condition produced no significant between groups differences for HR, RSA, FPA or SCL. Physiological responses to the MA conditions are listed below in relation to the prediction that meditators would demonstrate greater autonomic recovery than non-meditators during stress.

For the Anticipation condition meditators RSA responses demonstrated significantly increased vagal tone which supports the prediction. In contrast, a non-significant trend for FPA responses suggests increased sympathetic arousal by meditators, which was contrary to the prediction.

For the Mental Arithmetic task both groups demonstrated significantly elevated HR responses. Vagal tone was inhibited for both groups supporting polyvagal theory
predictions that stress decreases RSA (Porges, 1995). Meditators FPA responses
demonstrated increased sympathetic arousal, which was contrary to the prediction. Dual
autonomic activation during MA tasks is consistent with the literature (Muller, et al.,

For the Recovery condition both groups demonstrated a significant decrease in HR.
This is contrary to Goleman & Schwartz's (1976) finding where meditators increased
HR was followed by faster recovery. RSA responses of meditators did not support the
prediction, although the means were in the right direction. Non-meditators FPA
responses suggests greater sympathetic recovery than meditators. Meditators SCL
responses demonstrated significantly higher sympathetic activation during the MA task
compared with the Recovery condition for meditators, indicating support for the
prediction.

In summary, no between group differences were found to support the prediction that
meditators would demonstrate greater autonomic recovery than non-meditators, during
the MA condition. Differential autonomic responses for meditators supported the
prediction for RSA during Anticipation, and for SCL during Recovery, but not for FPA
across Anticipation, MA and Recovery conditions.

*Psychological Variables*

Tension and Effort Stress Inventory results found no group differences for changes in
positive and negative emotions during the Baseline, MA task and Recovery conditions.
Similarly, no group differences were found for the VASs for changes in stress, arousal or hedonic tone during the Baseline, MA task and Recovery conditions. It is possible that the tight sequence of activities during the course of the experiment, in conjunction with the intensity of the laboratory setting kept the participants in a goal-directed Telic mode, which precluded other self-report differences from being found.

*Metamotivational Style Profile*

While some of the predictions made for the MSP were supported, other non-predicted results provide additional information relevant to forming a profile for meditators. Results of predicted motivational dominance and salience subscales indicate the following differences between meditators and non-meditators. Meditators preferred lower arousal and were less concerned with goals and achievement, more compliant, less concerned with winning/losing or giving/receiving in relationship outcomes, and less concerned with self and other. Non-predicted subscale results indicate that compared with non-meditators meditators were significantly less arousal-seeking, less arousable and less pessimistic. Arousal-avoiding/seeking behaviour, as well as 'felt gain or loss' in relation to people, situations or objects also had less salience for meditators than for non-meditators.

Due to the methodological limitations of testing multiple hypotheses the results should be treated cautiously. The lack of significant group differences may be attributed to a lack of statistical power, partly due to the small number of participants in the study. The possibility that meditators may have been under greater stress because they were an
obvious focal point of the study is also a possibility. A consistent pattern of higher mean physiological responses for meditators, while not significant could be interpreted as supporting this view.

**Conclusion**

Lower ASR eyeblink amplitudes support meditators being less anxious than non-meditators. The prediction of meditators demonstrating greater autonomic recovery than non-meditators found mixed results. During anticipatory stress conditions meditators demonstrated more differential parasympathetic and sympathetic activation compared with non-meditators. This finding supports previous studies where increased sympathetic arousal was found for meditators under stress (Goleman & Schwartz, 1976; Lehrer, et al., 1980) The use of RSA in the present study extends the previous findings, to include evidence of increased parasympathetic activation under stress by meditators. Further research to confirm this finding is necessary. The finding that meditators demonstrate less physiological anxiety than non-meditators is congruent with the reversal theory finding that meditators prefer lower arousal (Arousal-avoiding dominant). An important clinical implication of the MSP data, is that meditation is more likely to be suitable as a long-term practice for clients with low arousal preferences and who are compliant. Other MSP results indicate that meditators may be less influenced by hedonic tone and arousal than non-meditators. Future longitudinal research is required to establish meditators physiological and psychological predispositions prior to taking up meditation. This would allow comparison with any changes that develop from meditation practice.
References


US: Francis & Taylor.