# A PILOT EXPLORATION OF HEART RATE VARIABILITY AND SALIVARY CORTISOL RESPONSES TO COMPASSION-FOCUSED IMAGERY

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## Abstract

This study measured heart-rate variability and cortisol to explore whether Compassion-Focused Imagery (CFI) could stimulate a soothing affect system. We also explored individual differences (self-reported self-criticism, attachment style and psychopathology) to CFI. Participants were given a relaxation, compassion-focused and control imagery task. While some individuals showed an increase in heart rate variability during CFI, others had a decrease. There was some indication that this was related to peoples self-reports of self-criticism, and attachment style. Those with an increase in heart rate variability also showed a significant cortisol decrease. Hence, CFI can stimulate a soothing affect system and attenuate hypothalamic-pituitary-adrenal axis activity in some individuals but those who are more self-critical, with an insecure attachment style may require therapeutic interventions to benefit from CFI.

**Key Words**: Compassion – Cortisol – Depression – Imagery – Heart Rate Variability – Self-Criticism

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Self-criticism is a major vulnerability factor to psychopathology (Gilbert & Procter 2006, Whelton & Greenberg 2005, Zuroff et al. 2005). In addition, it can undermine the success of traditional psychotherapies such as Cognitive Behavioural therapy (Rector et al. 2000). Recent research has explored the use of compassion-focused imagery (CFI) as part of a therapeutic process to help people who are highly self-critical (Gilbert 2000; Gilbert & Irons 2004, 2005; Wheatley et al. 2007)

For thousands of years imagination has been used to stimulate various physiological states (Frederick & McNeal 1999, Leighton 2003). Sexual, anxious, excited and calm feelings, along with self-confidence and preparation for tasks, can be stimulated via the imagination (Singer 2006). Mental imagery has also been used as a therapeutic aid to help desensitisation to aversive stimuli, coping with stress, and for the promotion of positive states of mind (Arbuthnott et al. 2001, Hall et al. 2006, Holmes et al. 2007, Singer 2006). Recent research and clinical work has focused on the value of helping patients develop self-compassion via various means including imagery (Gilbert 2007; Gilbert & Irons 2004, Gilbert et al. 2006).

Compassion evolved with the attachment system, such that signals of care, support and kindness, help to calm and sooth distressed individuals (Bowlby 1969). The soothing/calming that results from receiving kindness and support from others has been linked to a specific oxytocin-opiate 'affiliative' type of positive affect regulation system (Carter 1998, Depue & Morrone-Strupinsky 2005, Wang 2005) and reduces sensitivity in the amygdala, especially to socially threatening stimuli (Kirsch et al. 2005). This can be contrasted with an 'agentic' positive affect regulation system associated with drive and excitement (Depue & Morrone-Strupinsky 2005). Imagery and fantasising are believed to access these different systems – much as other forms of imagery stimulate other affect systems (e.g., anxious or sexual).

Porges's Polyvagal theory (2003, 2007) details how the evolution of the myelinated vagus nerve has supported interpersonal approach behaviours that enable social affiliations, caring and sharing. The myelinated vagus nerve evolved with attachment and the ability for infants to be calmed by parental caring behaviours (Depue & Morrone-Strupinsky 2005). This addition to the autonomic nervous system can inhibit sympathetically driven threat-defensive behaviours (e.g. fight/flight) and hypothalamic-pituitary adrenal (HPA) axis activity, and promote a calm physiological state, conducive to interpersonal approach and social

affiliation. In general, the safer people feel, the more open and flexible they can be in response to their environment (Gilbert 1993). This is reflected in the dynamic balancing of the sympathetic and para-sympathetic nervous systems that give rise to the variability in heart rate (Porges 2007). Hence, feeling safe is linked to HRV, and higher HRV is linked to a greater ability to *self*-sooth when stressed (Porges 2007).

In contrast, when individuals feel unsafe, they will tend to rely on more threat focused and stereotyped defensive behaviours (Dickerson & Kemeny 2004, Gilbert 1993) characterised by a less flexible balance of the sympathetic and parasympathetic nervous systems, with lower tone in the myelinated vagus nerve (Porges 2007). This relative inflexibility and unbalance of the autonomic nervous system, associated with lower measures of HRV, has been associated with both mental and physical ill health (Appelhans & Luecken 2006; Thayer & Lane 2007).

This study is a pilot exploration of both the impact of baseline HRV measures on individual experiences of CFI, and the acute effects of CFI on HRV and cortisol. Imagery conditions were designed to stimulate two *different* types of positive affect. One type focused on being the *recipient* of compassion, while the control imagery focused on anticipation of reward (making one's ideal sandwich). Having two types of imagery targeted to stimulate the two different positive affects enables exploration of the specificity effects of positive affect on HRV.

We also explored the influence of self-reported self-criticism, self-compassion, attachment style, ease of feeling socially safe and stress, anxiety and depression on HRV responses to the CFI. We hypethesised whether self-criticism was associated with people finding CFI difficult and if this would be reflected in HRV and cortisol measures.

## Method

### *Participants*

Participants were recruited from the University of Derby (n =184) and completed a self-report screening questionnaire. Inclusion criteria were: aged between 18 and 35 years; BMI between 19 and 28; non-smoker; not-currently using medication (except contraception) or illicit drugs; consuming under 30 units alcohol per week; not working night shifts; no history of cardiovascular problems; and no major mental health problems (47 met these criteria). The final analyses consisted of 22 participants, exclusions included: A heart arrhythmia, being unable to sit still and concentrate, falling asleep, and imagining pity rather than compassion.

### *Procedures*

All experimental sessions commenced at 14:00 (to allow consistent recording of cortisol levels) in the psychology department at the University of Derby. Participants were welcomed by the researcher and seated in a relaxed but upright position with arm and head supports for the duration of the study. Figure 1 outlines the procedure.

### *Imagery*

Imagery was verbally guided by the researcher. Each condition (relaxation/baseline, compassion and control) lasted five and a half minutes. This was to ensure that 300 seconds of artefact-free ECG data was available for calculation of HRV metrics (Task Force 1996). During 'relaxation' participants were asked to 'allow the tension to drain from each of their muscles in turn'. Previous studies have used a variety of different instructions for obtaining baseline measures, including continuous counting, instructions to 'relax' (Osumi et al. 2006) and no baseline but inclusion of a control condition (Takahashi et al. 2005).

### *CFI*

The CFI imagery asked participants to imagine compassion for them coming from an external source. The researcher suggested that some people find it

Figure 1. *Procedure*

Continuous ECG recorded
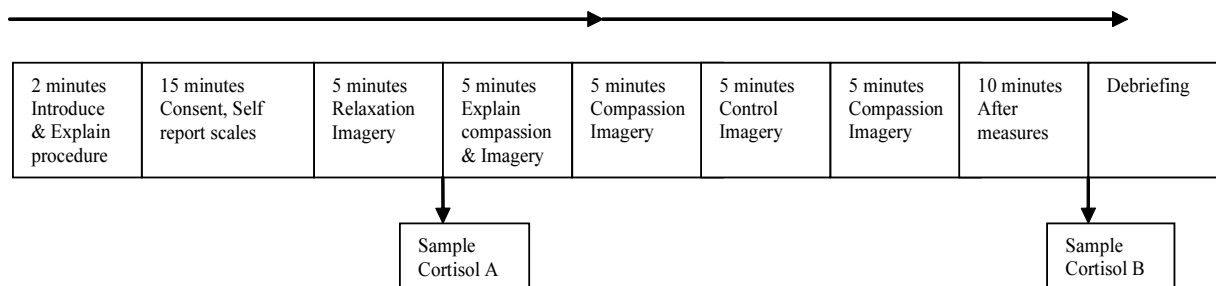
helpful to create a mental picture of this compassionate other (human or non-human). It was stressed that the image was to help them *feel* they were the recipient of compassion, and it was *feeling* that compassion that the research was exploring.

Participants were verbally prompted every 60 seconds by the researcher with various statements such as: "Allow yourself to feel that you are the recipient of great compassion; allow yourself to feel the loving-kindness that is there for you".

## Control Imagery

As noted, the positive affect system underpinning appetitive and resource acquiring activity is different to the soothing/contentment system (Depue & Morrone-Strupinsky 2005). Therefore to compare different types of positive affect inducing imagery, our control imagery focused on preparing one's favourite sandwich. Participants were prompted every 60 seconds with statements like 'Imagine entering the shop of your choice and taking some time to browse and look around at the selection of food before you' and 'Imagine preparing your bread and beginning to build your sand-wich.' The full script is available on request.

## Measures

### Laboratory Measures

A three lead ECG was recorded using Ag-AgCl disposable electrodes with Biopac PRO Lab software version 3.6.7 and MP30 Hardware (Linton Instrumentation). Data was sampled at 1Khz to ensure millisecond accuracy of the Inter-Beat Intervals (IBIs). IBIs were determined off line using the Biopac R-wave detection algorithm for 3 x 300 second periods corresponding to baseline and each imagery condition. All IBIs were manually checked by a researcher to ensure their accuracy, and to correct missed and ectopic beats due to the reported effects from such errors (Berntson et al. 2005). Artefacts were corrected according to the Task Force (1996) recommendations.

### Heart Rate Variability Metrics

Using the artefact corrected ECG data, inter-beat intervals were measured and from these heart rate was calculated. CMetx software (Allen et al. 2007) was used to calculate the SDNN, the standard deviation of inter-beat intervals, a measure recommended by the Task Force (1996). This is a global measure of HRV, reflecting the sum of all of cyclic components contributing to the variation of inter-beat intervals. This was chosen as an appropriate measure for pilot work, which would give good indication as to the likely merit of further exploration using other measures of HRV.

To obtain measures of HRV reactivity to CFI the raw HRV metrics corresponding to each condition (baseline, compassion and control) were used to calculate participants' *change* in HRV values. These change values were calculated by subtracting each

participant's control imagery HRV value from their CFI HRV value. (The control imagery HRV value was used as it attempts to keep constant the possible effects of mental effort and visualisation on HRV). Since HRV shows less acute reactivity in individuals with low HRV (Porges 2007), we adjusted the raw HRV change values in proportion to the participants baseline value by expressing HRV *change* values as a percentage of the baseline HRV value. These variables, which we will refer to as *HRV change,* make the magnitude of HRV response to imagery comparable between individuals.

## Cortisol

Saliva samples were collected using salivettes (Sarstedt Ltd). The final cortisol sample was optimally timed to allow for a delay in possible HPA axis response to CFI (Dickerson & Kemeny 2004). All samples were frozen before being assayed for cortisol by Obsidian Research Ltd (Port Talbot, UK) using an Enzyme-Linked ImmunoSorbent Assay (ELISA).

## Self-Report Measures

Participants completed a demographics form, the following self-report scales and additional questions.

## Forms of Self-Criticism/Self-Reassuring Scale (FSCRS) (Gilbert et al. 2004).

This 22-item scale assesses participant's thoughts and feelings about themselves during a perceived failure. Two subscales measure forms of self-criticising, *(inadequate self* and *hated self)* and one subscale measures tendencies to be reassuring to the self *(reassured Self*). Participants respond on a Likert scale 0 – 4. The scale has good reliability with Cronbach's alphas of .90 for inadequate self, .86 for hated self, and .86 for reassured self (Gilbert et al. 2004).

## Self-Compassion Scale (SCS) (Neff 2003)

This 26-item scale assesses levels of self-compassion. There are three factors of *positive* self-compassion: *self-kindness, common humanity* and *mindfulness,* and three factors that focused on a *lack* of self-compassion: *self-judgement, isolation* and *over-identification.* Participants indicate how often they engage in these ways of self-relating on a Likert scale 1 – 5. The scale has good reliability (Cronbach's alphas ranging from .75 to .81).

## Adult Attachment Scale (Collins & Read 1990)

This 18-item scale measures three attachment dimensions. *Depend* measures abilities to depend on others, *anxious* measures degree of worry about abandonment and *close* measures ease of getting close to others. Respondents are asked to rate on a Likert scale 1 – 5 how characteristic each statement is of them.

The Cronbach's alphas were 0.75 for depend, 0.72 for anxiety and 0.69 for close.

## Social Safeness Scale (Gilbert et al. submitted)

This 11-item scale was developed to measure the extent to which people experience their social world as safe, warm and soothing, and their ability to enjoy feelings of closeness with others. Each item is scored on a Likert scale 0 – 4. This scale had a Cronbach's alpha of .82.

## Depression, Anxiety and Stress Scale (DASS-21) (Lovibond & Lovibond 1995)

This 21-item shortened version of the DASS-42 consists of three subscales measuring *depression*, *anxiety* and *stress*. Participants are asked to rate how much each statement applied to them over the past week, on a Likert scale 0 – 4. The DASS-21 subscales have Cronbach's alphas of .94 for Depression, .87 for Anxiety and .91 for Stress (Antony et al. 1998).

## Results

Analysis was conducted using SPSS version 14. The data were screened for normality of distribution and for outliers.

Table 1. *Means and standard deviations of SDNN across conditions for both groups*

| Condition | SDNN | |
|---|---|---|
| | Group1M(SD) | Group2M(SD) |
| Baseline (Relaxation) | 55.28 (17.74) | 64.06 (23.35) |
| Compassion imagery | 44.61 (17.09) | 60.05 (16.44) |
| Control imagery | 53.85 (15.25) | 51.51 (18.87) |

Participants' reported 'boredom' and fatigue during the second CFI (C2) and therefore we removed this data as it was unreliable.

Heart *rate* changes and HRV changes are related but distinctly different measures. We therefore performed an ANOVA to determine whether there were any differences in heart rate between the three experimental conditions, or between groups. There were no significant differences, indicating that any changes in HRV found were not merely a product of changes in heart rate. Physical demands were kept constant throughout the study to ensure that any changes in the measures taken could be attributed to thought induced alterations of metabolic demand.

## Heart Rate Variability

The HRV data showed two opposing responses to CFI. Some people showed a reduction in HRV (measured by SDNN) in response to compassion, while others showed an increase. We felt these were important differences and therefore split participants into two groups. Group 1 contains 11 individuals who showed a reduction in SDNN value from control to CFI (called 'Group 1[SDNNdowns]'), while Group 2 contains 11 individuals who showed an increase in SDNN value during the CFI (called 'Group 2[SDNNups]'). This equal number arose by chance.

Means and standard deviations for each condition and group are reported in Table 1. In addition, the mean SDNN for each group during each condition are depicted in Diagram 1.

The SDNN was analysed using repeated measures ANOVAs to explore the effects of imagery condition (relaxation, control and compassion) and group (i.e. whether participants decreased or increased in SDNN in response to CFI). The SDNN value calculated for each imagery condition was used as within-subjects variable, and group was used as a between-subjects variable. Post hoc t-tests were performed to explore where any significant differences lay between different imagery tasks.

The ANOVA showed both a significant main effect of imagery condition ($F$(1.15, 23.00) =4.41, $p$=.042) and interaction effects with group ($F$(1.15, 23.00) =5.18, $p$=.028). The difference in mean SDNN value between Group 1[SDNNdowns] and Group 2[SDNNups] is apparent at relaxation and is accentuated during the CFI. However, the groups are very similar in SDNN during the control imagery. The implications of this are that for some positive imagery tasks (e.g. making a sandwich), there are no discriminatory effects on HRV. However, for positive imagery associated with affiliative interpersonal affects (warmth, kindness and social connectedness) certain individuals responded with a decrease in HRV whilst others had an increase in HRV. The post hoc t-test revealed a significant difference between groups during the CFI ($t(20)$=-2.20 $p$=.043). This is visually represented in Diagram 1.

## Cortisol

Cortisol values after relaxation and before CFI (Cortisol A), and after CFI (Cortisol B) were analysed using a repeated measures ANOVA, with group as a between-subjects variable. There was a significant main effect of imagery on cortisol value ($F$ = 4.54, ($df$ =1, 19) $p$ = .046) but no significant interaction of group. Post-hoc t-tests revealed a non-significant difference between the two groups cortisol A values (Group 1[SDNNdowns] = 5.80ng/ml, Group 2[SDNNups] = 5.40ng/ml). Both groups showed a mean cortisol value decrease after CFI (Group 1[SDNNdowns] = 5.70ng/ml; Group 2[SDNNups] = 4.92ng/ml). However, for Group 2[SDNNups] this decrease in cortisol was significant, while for Group 1[SDNNdowns] the decrease was non-significant. This greater decrease in Group 2[SDNNups] resulted in a significant difference between the group means for cortisol B ($t$=2.50, $p$= .022) and can be seen clearly in Diagram 2. Cortisol A correlated negatively with change in cortisol meaning that the lower a participant's initial cortisol value was,
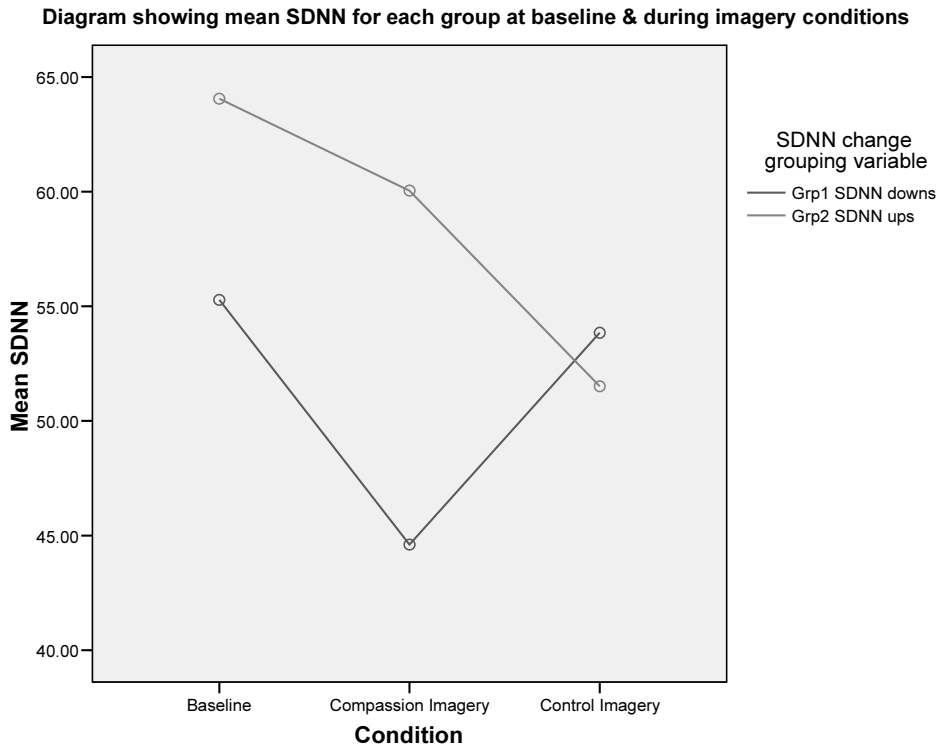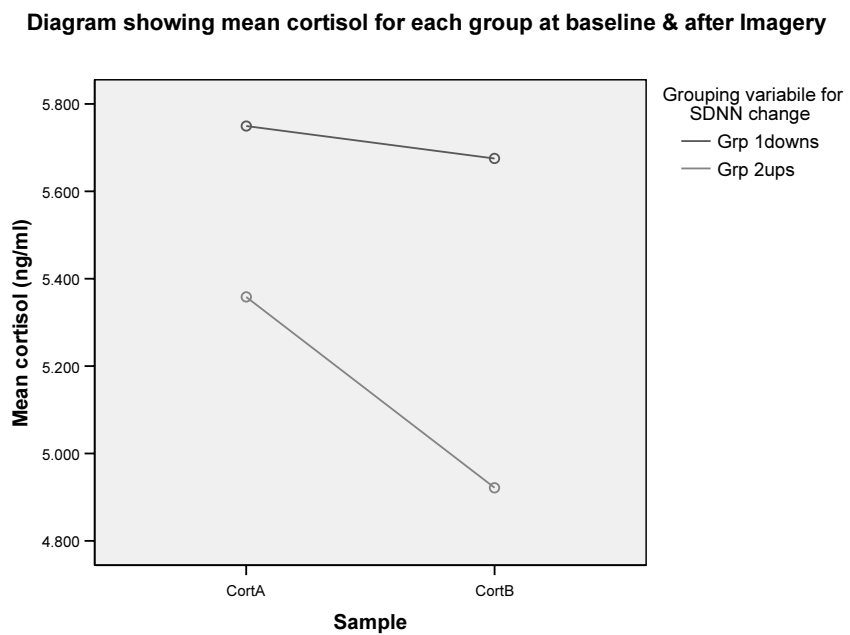
Diagram 1

**Diagram showing mean SDNN for each group at baseline & during imagery conditions**



Diagram 2

**Diagram showing mean cortisol for each group at baseline & after Imagery**

Table 2. *Correlations between change in HRV measures and self-report scales*

| Self report measure | Inadequate self | Reassured self | Self Compassion | Self Coldness | Depend Attachment | Anxious Attachment | Close Attachment | Social Safeness | Depression DASS | Anxiety DASS | Stress DASS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SDNN $r$ | -.54* | .36 | .33 | -.30 | .52* | -.48* | .18 | .57** | -.22 | -.37 | -.19 |
| (% Change) $(p)$ | (.010) | (.098) | (.130) | (.169) | (.014) | (.025) | (.424) | (.006) | (.328) | (.088) | (.403) |

\* $p < .05$
\*\* $p < .01$

Note for readers interested in the results of other HRV metrics: 'RMSSD change' also showed a correlation with the 'Depend' attachment subscale ($r = .44$, $p =.043$), 'Toichi's Cardiac Vagal Index change' also showed positive correlations with the 'Depend' attachment subscale ($r = .45$, $p =.034$), Toichi's Cardiac Sympathetic Index also showed a significant correlation with the social safeness and pleasure scale ($r = .45$, $p =.035$)

the bigger their decrease in cortisol during compassion also was. These results show that for people who had an increase in HRV during CFI there was a significant decrease in cortisol. While for those who had a decrease in HRV during CFI, there was a minimal non-significant decrease, as would be expected from diurnal rhythm alone.

Mauchly's test indicated that the assumption of sphericity was violated for SDNN. Therefore, Greenhouse-Geisser estimates of sphericity were used to correct the degrees of freedom. Calculations of effect size (indicated by partial eta squared) revealed that effect sizes associated with cortisol measures were higher (i.e. $\omega^2 > .08$). than for SDNN ($\omega^2 = <.08$).

## Self-Report Scales

Data were screened for normality of distributions, skewness values ranged from 0.09 to 1.43 and Kurtosis values from -0.23 to 1.42. The 'hated self' subscale derived from the forms of self-criticism and reassurance scale was skewed and kurtotic. This is not surprising to find in a non-clinical population due to a floor effect, and we chose to remove this subscale from further analyses. T-tests were conducted to examine differences in self-report scores between groups 1[SDNNdowns] and 2[SDNNups]. A significant difference was found between social safeness scores ($t$=0.03), with Group 1[SDNNdowns] having a lower mean score (38.00) than Group 2[SDNNups] (44.64). We also noted that the group differences on the other self-report variables are all in the predicted directions, however statistical significance was not reached, possibly a limitation of the small numbers.

## Correlation Analysis

Pearson's correlation coefficients for self-report scales, cortisol measures, baseline HRV and HRV change data are given in Table 2.

*Change* in SDNN was positively correlated with ability to depend on others (adult attachment scale), and with the social safeness and pleasure scale ($r = .52, .014$ and $r = .57, p = .006$ respectively). In other words, HRV response to CFI is linked to people's current experiences of themselves in social relationships. This is further indicated with the contrasting result that anxious attachment was negatively correlated with *change* in SDNN ($r = -.48$, $p = .025$). We also found self-criticism that focuses on feelings of self-inadequacy was negatively associated with reduced HRV when trying to engage in CFI ($r$=-.54). In addition, although not significant, the ability to be self-reassuring ($r$=.36) and self-compassionate ($r$=.33) were positively correlated with SDNN change.

## Discussion

This study aimed to explore the impact of CFI on two different physiological measures (HRV and cortisol) we also explored individual differences informed by clinical observations that some people find CFI difficult or threatening (Gilbert 2007). Our data indicates two key processes. First, CFI does impact on HRV. Some people show a clear increase in HRV, whereas others show a more threat-like response with a reduction in HRV. We also found that those individuals who showed elevated HRV to compassionate imagery experienced a drop in cortisol, indicative of a soothing effect on the HPA axis. In contrast, those who showed a reduction in HRV experienced a non-significant cortisol change. There is research suggesting that some individuals with secure attachments, typically engage in soothing images and memories of feeling cared for and these can aid emotional regulation (Baldwin 2005, Mikulincer & Shaver 2007). Buddhism also specifically focuses on training people in CFI (Leighton 2003).

It appears that different people have different physiological responses to CFI. So the question is to try to identify the sources of these differences. Why do some people benefit from CFI and experience it as soothing while others appear threatened? We explored this with self-report measures. The self-report data suggests that people's experiences of CFI are related to current experiences of social safeness; Group 2[SDNNups] had higher mean scores of social safeness. Although other self-report measures did not show significant differences between the two groups, all differences showed trends in the expected directions (e.g. Group 1[SDNNdowns] had higher mean scores of self-criticism, self-coldness, anxious attachment and psychopathologies; whilst Group 2[SDNNups] had higher mean scores of self-compassion, self-reassurance and ability to depend on

others and experience close relationships). This would fit with Gilbert's (1989) concepts of a safeness system and Porges' (2003, 2007) view that higher HRV is linked to interpersonal approach and socially adaptive behaviours.

Further evidence for this link was revealed in the pattern of correlations. A significant positive correlation was found between change in SDNN during CFI and social safeness and ability to depend on others. In contrast, anxious attachment was negatively associated with SDNN change; in other words, anxious attachers may find CFI more threatening. The data raises important implications for psychotherapy (Gilbert & Irons 2005; Gilbert & Procter 2006). The differences in HRV response seen between participants reflect clinical observations; that for some people (particularly self-critics and those scoring low in social safeness), focusing on compassion can at first be unfamiliar, threatening and feel unsafe (Gilbert 2007; Gilbert & Irons 2005; Gilbert et al. 2006). Self-critics often report feeling reluctant to 'let go' of their self-criticism for fear of their 'standards slipping'; that they might become selfish or arrogant, or that it constitutes a change to self-identity. They can also 'fear' compassion because they feel they do not deserve compassion or because it is unfamiliar, triggers sadness, or it is frightening to let others (even imagined ones) get close (Gilbert & Procter 2006).

It is unclear which aspects of compassion are particularly threatening because our CFI involved experiencing acceptance, loving kindness, warmth, and compassion. Clinically, people often experience sadness and grief when their attachment systems are activated (Bowlby 1969, 1980). Compassionate imagery involves activating these systems and drawing on emotional memories of attachment (Gilbert 2007). The finding that self-criticism was linked to an SDNN decrease when engaging in CFI provides further support that self-critics may find CFI difficult at first, this could also be related to a lack of compassionate memories on which to draw. This difficulty, and/or negative response to feeling compassion for the self, can be a barrier to the development of self-compassion, and could also be a cause of the HRV decrease seen in Group 1[SDNNdowns]. This suggestion fits with data by Segerstrom and Solberg Nes (2007) who found HRV decreases to be associated with self-regulatory processes, such as inhibition of emotion.

A number of authors have noted that self-criticism is a major vulnerability factor for low mood and psychopathologies (Whelton & Greenburg 2005). Both criticism from others (Dickerson & Kemeny 2004) and self-criticism is linked to HPA axis arousal and cortisol release (Mason et al. 2001). Gilbert (2007) suggests that chronic self-criticism continually stimulates the threat system thus having a detrimental impact on positive affect.

We concentrated on reporting the SDNN as recommended by the global HRV metric Task Force, (1996). However, there are other methods for exploring the periodic processes involved in HRV, which may shed more light on the relationships indicated by this study. Second, we did not measure respiration or muscle tension, and consequently the HRV changes could be attributable to changes in breathing rate/depth, or muscle tension. However, physical demands were kept constant throughout the study making this unlikely.

Yet to be explored is whether training and working through the fears and blocks to self-compassion, will impact on HRV and other neurophysiological processes linked to social soothing, and if this methodology could be adapted for evaluating psychotherapies. Given the increasing interest in compassion as a therapeutic aid, further research into the neurophysiological mediators and effects of compassion, may indicate ways of developing psychotherapeutic techniques (Gilbert & Irons 2005).

## Acknowledgments

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