

**Think about your heart: The Effects of Cognitive Dissonance on cardiovascular
functioning**

A Senior Research Thesis

Presented in partial fulfillment of the requirements for graduation with research
distinction in Psychology in the undergraduate colleges of The Ohio State University.

By

Claudia S.E. Cash

The Ohio State University

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Project Advisor: Dr. Julian F. Thayer, Department of Psychology

Abstract

Cognitive dissonance (CD) occurs when an individual's attitudes are inconsistent with his/her behavior, and can result in emotional distress. Individuals may regulate and reduce this emotional distress by changing their attitudes to match behaviors. Individuals with higher resting heart rate variability (HRV), a marker of overall health, have been shown to better regulate and control negative emotions. Thus, the following investigation sought to examine the relationship between cognitive dissonance, emotional distress, HRV, and other physiological indicators of health. HRV data were collected using an electrocardiogram (EKG) from 81 participants during a baseline evaluation, randomized CD induction of high or low choice, and recovery. In the low choice group, individuals were *instructed* to write a counter-attitudinal essay and therefore, attribute feelings of dissonance to experimenter demands. In the high choice condition, while urging them to comply, individuals were told that it is *optional* to write the counter-attitudinal essay; here, participants are motivated to change their attitudes to match behavior due to their compliance. I hypothesized that (1) The high choice group would be more likely to change their attitudes following the essay in comparison to the low choice group; (2) baseline HRV would predict attitude change following dissonance, especially in the high choice condition; (3) measures of arousal (e.g. self-reported mood, blood pressure) would be elevated in the high choice group in comparison to the low choice group. Results partially supported these hypotheses, showing that resting HRV does predict attitude change in both experimental conditions. Implication and future directions are discussed.

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Introduction

Cognitive Dissonance (CD) occurs when an individual holds cognitions, attitudes, and/or behaviors are inconsistent with one another, often resulting in a psychologically aversive state (Festinger, 1957). The individual then becomes motivated to reduce the uncomfortable psychological state, doing so by altering one of the inconsistencies in an attempt to make them more consistent (Losch & Cacioppo, 1990). Frequently, individuals undergo a phenomenon widely known as attitude change – that is, individuals change their attitudes to become consistent with behaviors and/or cognitions. Research suggests that it is easier for one to change their attitudes in comparison to their environment (especially in an experimental setting).

Cognitive Dissonance

CD research provides insight on the relationship between cognition, perception, emotion and motivation (Harmon-Jones, Amodio and Harmon-Jones 2009). Since CD's original publication (Festinger, 1957), the 'action-based model' has been developed to better understand the dissonance process (Harmon-Jones, Amodio & Harmon-Jones, 2009). The action-based model suggests that the cognitions that initiate action may have no conscious consideration. These cognitions, that are inconsistent with behavior, result in a negative emotional state referred to as 'dissonance'. In order to reduce the negative arousal, individuals are motivated to reduce this cognitive-behavior inconsistency via attitude change (Harmon-Jones, Amodio & Harmon-Jones, 2009, Losch & Cacciopo, 1990). That is, people change their attitudes in order to match their behavior and reduce the arousal and/or the unpleasant emotional state induced by the dissonance. Evidence documents the prevalence of this phenomenon when in a dissonant state (Zanna &

Cooper; 1974, Elliot & Devine; 1994; Cooper, 2007). Investigators have also tested the notion that the nonspecific physiological “arousal” component of the dissonant state also increases dissonance reduction via attitude change (Losch & Cacioppo, 1990). To provide evidence of this phenomenon, subjects in one study wrote counter-attitudinal essays under conditions of high or low choice, accompanied by a measure of skin conductance (Losch & Cacioppo, 1990). When subjects had *low choice* (no choice) in writing a counter-attitudinal essay, they attributed the experience of CD to the experiment and did not experience an increase in psychological or physiological arousal (and showed no attitude change). However, when participants had the choice to write the counter-attitudinal essay (i.e. *high choice*, writing the counter-attitudinal essay was encouraged, not required) but still complied with the experimenter, they experienced CD and an increase in psychological and physiological arousal, resulting in an attitude change in favor of the essay (attitudes now match the behavior exhibited) reducing arousal. Overall, high choice subjects experienced CD and had an increase in sympathetic nervous system arousal, but low choice subjects, who attributed dissonance to the experiment, did not have physical or psychological arousal. Losch and Cacioppo (1990) concluded that the need to reduce dissonance is a result of the psychological uncomfortable state.

For years, research has investigated the link between mental well-being and physical health. Considering psychological distress created by dissonance, research suggests that acute and chronic psychological distress, when not properly regulated, can have deleterious effects on health (Krantz & McCeney, 2002). Two recent meta-analyses including more than 300,000 participants have confirmed that individuals who have high daily stress are more likely to develop heart disease, serving as one of the largest causes

for death world-wide (Lancet, 2012; American Heart Association, 2012). Research has begun to propose a connection between CD effects on biomarkers of health. Some research has identified caregiver professions as chronically dissonant careers that have a high burnout rate. Caregivers often are put in situations where they may feel sadness but need to portray happiness (Kovacs, Kovacs & Hegedus, 2009). Studies have shown that nearly half of all caregivers are clinically depressed, female caregivers have an increased risk in developing coronary heart disease (Robinson & Demaree, 2007). Naturally occurring chronic dissonance may have the potential to negatively affect cardiovascular functioning, subsequently leading to a higher risk for hypertension, stroke, and other cardiovascular diseases.

Despite previous research, there is little evidence directly connecting CD and biomarkers of health to emotion regulation. Emotion regulation is important when regulating distress created by negative emotions. CD, like other psychological stressors, can create negative emotions and lead to distress. In contrast, the link between emotion regulation and health is not a new one. Thayer and Lane (2000) proposed a model of emotion dysregulation and health, the Neurovisceral Integration Model (NIM), to help explain the relationship between emotional control and health. Specifically, these researchers posit that heart rate variability (HRV), defined as the beat-to-beat fluctuations between heartbeats, is a reliable and valid measure of emotion regulation and overall physical health.

Neurovisceral Integration Model (NIM)

Cortical brain areas, such as the anterior cingulate cortex and prefrontal cortices, and subcortical brain areas, such as the amygdala and insular cortex, are functionally,

structurally, and chemically connected with the autonomic nervous system (for a thorough review, see Thayer et al., 2012). The Autonomic Nervous System (ANS), comprised of the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS), along with the heart's pacemaker, regulates heart rate. The SNS is referred to as the 'fight or flight' system [e.g. increases heart rate (HR), pupil dilatation] and is mostly associated with subcortical brain areas and thus, mostly related to threat and other emotions. In contrast, the PNS is referred to as the 'rest or digest' system (e.g. decreases in HR, pupil constriction), and is thought to be controlled by cortical brain areas. These same brain areas are though not only to regulate the periphery (e.g. heart, lungs) but also emotions, thoughts, and behaviors (Thayer et al., 2012). Overall, it is suggested that cortical and subcortical brain areas are responsible for regulating the ANS and thus, regulating the periphery (i.e the heart). The heart is under tonic inhibitory control via the vagus nerve, such that the PNS dominates the SNS at rest, keeping the body in a healthy state (i.e. autonomic balance); (Thayer & Lane, 2000). At rest, vagally-mediated HRV serves as an index of emotion regulation capabilities – that is, greater resting HRV reflects greater activity of the self-regulation pathway (vagus nerve) and thus, greater activity of cortical brain areas responsible for the regulation of emotions (Thayer et. al, 2012).

Moreover, the ANS can contribute to many adverse physical health states. In particular, a hyperactive SNS and a hypoactive PNS is characteristic of autonomic imbalance. Autonomic imbalance (or low PNS activity) has been shown to be a marker for not only CVD, but also all-cause mortality (Thayer & Lane, 2007). Taken together, HRV is a marker of vagus nerve, or PNS activity, such that an individual with higher

HRV reflects a healthy and adaptive organism (Thayer & Lane, 2000), suggesting that HRV is a measure of overall adaptability, stress, and health. Individuals who are unable to regulate emotions in an adaptive manner often show lower HRV and lower cortical brain activity.

The Present Study

The limited number of studies that have evaluated CD and physiological health outcomes have focused on measuring SNS activity (Losch & Cacioppo, 1990). While research has shown that increased sympathetic reactivity to cognitive and emotional stressors predicts thromboses, arterial lipid deposition (a hallmark of coronary artery disease [CAD]), coronary artery vasoconstriction, and cardiac electrical instability (Robinson & Demaree, 2007), these studies have failed to examine the PNS, which may also have negative consequences of similar physiological reactivity and influence immune function, and other somatic and mental disease. The present study follows the Losch and Cacioppo (1990) experimental paradigm where CD is viewed as a possible stressor of health. The following study evaluates CD effects on the PNS, as measured by heart rate variability (HRV), and the SNS, as measured by Blood Pressure (BP) and systole time intervals (i.e. impedance Cardiography (ICG)). ICG obtains both left ventricular ejection times (LVET) and pre-ejection periods (PEP). LVET is defined as the time interval of the opening and closing of the aortic valve (period of time blood is being pumped through the left ventricle). PEP is defined as the time interval of the beginning of electrical stimulation of the ventricles to the opening of the aortic valve (period prior to left ventricular ejection). Both PEP and LVET are systolic time intervals and thus, mainly reflects SNS influence over the heart (Sherwood et al., 1990).

It was hypothesized that my data would reflect a classical dissonance effect such that those in the high choice group would be more likely to change their attitudes than those in the low choice group. Subjects in the low choice group should have had higher HRV, lower BP, and lower attitude change in comparison to the high choice group *following* the dissonance manipulation. However, it was hypothesized that the urge to reduce dissonance is not only due to the psychological uncomfortable state, but the primitive need to have autonomic balance. Further, it was hypothesized that HRV would be predictive of attitude change such that those with higher HRV (effective emotion regulators) would be more likely to change their attitudes as an emotion regulation technique. Overall, the following study investigated the relationship between cognitive dissonance, emotion regulation, and vagal tone as indexed by HRV.

Method

Participants

Eighty-one undergraduate students (39 women, 16 minorities) were recruited via the ‘Research Experience Program’ (REP) that is part of the Psychology 1100 course at The Ohio State University (table 1). Participants’ ages ranged from 18-24, with an average age of 19. Participants were awarded one hour of research credit for completing the study. Participants were required to not have had any physical activity or smoking four hours prior to the study. Participants were removed if they did not comply, were outliers on physiological measures, or if they did not understand the instructions. The final N after removing outliers is 70. This number decreases when reporting physiological results due to technical difficulties as well as gender due to individuals who chose to not identify their gender.

Physiological Data

Participants were connected to a 7-lead electrocardiogram (EKG) that collects continuous heart rate (HR) and ICG data. ICG is a non-invasive technique that measures systolic time intervals. ICG provides systolic time intervals such as the pre-ejection period and left ventricular ejection time (Sherwood et. al, 1990). Participants were also connected to a Finometer blood pressure (BP) monitor, collecting beat-to-beat BP by wrapping around the individual's middle finger and wrist.

To measure HRV, inter-beat-intervals (IBIs), or the time in milliseconds (ms) between R spikes, were extracted from heart rate using HRV 2.51 computer software (HRV 2.51, 2007). Kubios HRV Analysis Software (<http://kubios.uku.fi/>) was used to provide time and frequency domain indices of HRV (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2008). The root mean square of successive differences (RMSSD; time-domain) and High Frequency (HF; frequency-domain) were used as indices of HRV (Task Force, 1996). There was a high correlation between RMSSD and HF ($r=0.825$, $p<.001$) thus, the main measure of HRV is considered to be RMSSD; higher values reflecting higher HRV. The natural log (ln) of RMSSD was taken to fit assumptions of linear analyses. It is important to note that results are in the same direction when using HF. BP data were extracted via BeatScope computer program (BeatScope 1.1a, 2005), obtaining systolic, diastolic and mean arterial pressure. Impedance data was extracted via IMP 3.0.25 software, obtaining the left ventricular ejection times (LVET) and the pre-ejection periods (PEP).

Possible covariates of HR and HRV are: respiration, BMI, ethnicity and gender. Previous research has shown that respiration is a modulator of HRV such that slower

controlled breathing is associated with high HRV (Bernardi, Porta, Gabutti, Spicuzza & Sleight, 2001). Gender and ethnicity have also been shown to reflect significant differences in HRV (Antelmi et. al, 2004 and Choi et al, 2006). Further, weight has been associated with HRV such that those that are severely overweight have lower HRV and are able to increase their HRV with weight-loss (Karason, Molgaard, Wikstrand, & Sjostrom, 1999). These were considered covariates when analyzing resting HRV.

Questionnaires

During the questionnaire period, participants answered a number of scales related to emotional control. The Difficulty in Emotion Regulation Scale (DERS) is a 36-item scale that has participants respond to how often they experience the statement from 1 (almost never) to 5 (almost always). It also has 6 subscales: Non-acceptance of emotional responses, difficulties engaging in goal directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. A higher score on the DERS suggests greater issues in emotion regulation. This scale is used to assess the frequency of emotion dysregulation participants' experience (Gratz & Roemer, 2004). The Distress Tolerance Scale (DTS) is a 14-item scale that instructs participants to indicate how much they agree with the item from 5 (strongly disagree) to 1 (strongly agree). A higher score on the DTS suggests more tolerance of distress. The scale includes items that relate to the appraisal of distress, absorption of negative emotions and regulation to reduce distress (Simons & Gaher, 2005). The mood questionnaire accesses the participants' current mood (Pietri, Fazio, & Shook, 2012). This questionnaire uses mood descriptives on a continuum from 1-5, to assess mood. One is "very sad" and five is "very happy." Lower scores reflect moods that

are more negative. This was used twice, once before the counter-attitudinal essay (mood-1) and once immediately afterwards (mood-2). Following the second administration, participants responded to the 'attitude change' question "How do you feel about tuition increase" from 1 (very negatively) to 7 (very positively). It is assumed that all participants are against tuition increase.

Procedure

The experimenter met participants in the designated waiting area and brought them into the laboratory. Participants were given informed consent without revealing the hypothesis. Once informed consent was obtained, participants were attached to the EKG and BP machine. The experimenter then entered a control room and instructed the participant to begin the study over a two-way microphone. Participants experienced (1) a five-minute baseline period, (2) Self-report scales (3) completion of a mood questionnaire (4) composition of a counter-attitudinal essay (3) completion of a follow up mood questionnaire and finally (4) ten-minute recovery period. The baseline period was five minutes long and participants were instructed to: "try to be still, sit in silence and try not to move". Participants then completed self-report questionnaires including: Difficulty in Emotion Regulation (DERS), Distress Tolerance Scale (DTS), and a mood questionnaire. Following this, participants were randomized into conditions A or B. In condition A (high choice), the experimenter entered the room and delivered the memorized script: "The Board of Trustees at Ohio State are considering increasing student fees now that Ohio State is under a tuition freeze. These student fees are mandatory, and will raise the amount you pay each semester. Before making this decision they have asked for students to provide arguments both for and against this decision. They will take these arguments

in consideration when making their decision. As one can imagine, most students have opted to write against the student fee increase. Since this is an experimental setting, I cannot tell you to write arguments for the fee increase. We would however appreciate if you did.” Here, participants were urged to write an essay in favor of fee increase (which is counter attitudinal, assuming no student wants increases in fees); however, they were not *required* to do so. In condition B (low choice) the experimenter entered the room and delivered the memorized script: “The Board of Trustees at Ohio State is considering increasing student fees now that Ohio State is under a tuition freeze. These student fees are mandatory, and will raise the amount you pay each semester. Before making this decision they have asked for student’s to provide arguments both for and against this decision. They will take these arguments in consideration when making their decision. As you can imagine, most students have opted to write against the student fee increase. Because of this, you have been assigned to write arguments for student fee increase.” Here, participants were required to write the counter-attitudinal essay. Participants who did not comply to or understand instructions were removed from the dataset.

Immediately following the counter-attitudinal essay participants responded to the mood questionnaire again. Following the mood questionnaire, participants were asked to indicate how they felt about tuition increase on a scale of 1-7. It was assumed that college students were opposed to tuition increase, thus this question represented attitude change. They then sat through a recovery period for ten minutes. The recovery period consisted of the same procedure and instructions as the original baseline.

Results

An independent-samples t-test was conducted to compare attitude change following dissonance induction in high and low choice conditions. There was not a significant difference in attitude change between high choice and low choice conditions; $t(58)=-.113, p=0.910$ (figure 1).

Next an ANOVA was used to test if self-reported mood was lower in those more likely to experience CD (high choice). Controlling for mood at time 1, an analysis of variance (ANOVA) yielded no significant differences in mood at time two between the high and low choice groups ($F(1,49)= 0.289 p=0.593$) (figure 2). To assess changes in SNS and PNS activity throughout the experiment as a function of experimental manipulation, a series of repeated measures ANOVAs were conducted [within factors: mean physiological values for 3 periods (baseline, essay (task), recovery), and between factor was condition]. Results showed no differences in changes in SNS activity mean arterial pressure (MAP), systolic and diastolic pressure (figure 3), LVETs (figure 4), or PEPs (figure 5)) between the groups (all p 's for interaction $> .36$). Similar results were obtained when examining HRV (PNS) activity throughout the experiment $F(2, 50)= .0210 p=.811$ (figure 6).

To examine individual differences in attitude change following dissonance, we tested if resting HRV predicted attitude change within the sample. A linear regression analysis ($\beta =.306 p<.05$) confirmed that HRV was predictive of attitude change even when controlling for: respiration, BMI, ethnicity, condition and gender.

There was a marginal correlation between distress tolerance scores and attitude change in the high choice condition, $r=-0.384, p<.1$. In other words, those in the high

choice condition who do not tolerate distress, tended to change their attitude after a dissonance induction. See table 2 for correlations of trait measures and attitude change between groups.

Discussion

Results partially confirmed the hypotheses; baseline HRV does predict attitude change, but in both experimental conditions. Results did not replicate the traditional dissonance effect (significant difference in attitude change by condition). Results also did not show that measures of arousal (self-reported mood, BP, ICG) increased in the high choice condition compared to low choice condition.

One possible explanation for the null finding of attitude change between groups is that when examining baseline HRV, the two conditions differ as a failure of random assignment (trending for RMSSD and significant for HF) (table 3). Considering the correlation between HRV and attitude change, high HRV individuals in the low choice condition were changing their attitudes when they should have been attributing dissonance to the experiment. When controlling for baseline HRV, the dissonance effect is not significant, but begins to trend in the hypothesized direction (figure 8). This suggests that individual differences in resting HRV and attitude change following dissonance may confound the original dissonance phenomenon in this present investigation. I propose that more participants are needed to overcome the individual differences present here, and show a traditional dissonance effect. Moreover, these individual differences may have contributed to the null findings in arousal (both self-report and physiological differences) such that the experience of dissonance may have been altered as a function of emotion regulation capabilities.

Nevertheless, results from the present study suggest that baseline HRV is predictive of attitude change. This finding supports previous research that HRV is an index for emotion regulation (Thayer et. al, 2012). Particularly, high HRV individuals that have *any* cognitive-behavior inconsistency may show greater attitude change to help alleviate the inconsistency. It is then possible that high HRV individuals may be internalizing attributions of dissonance; that is, even in the low choice where they may attribute dissonance to the experiment, they remain more likely to change their attitudes and thus, must be making their attributions inward rather than externally towards the experiment. Of course, this rests on the assumption that these individuals did experience dissonance. The present investigation does not present strong evidence that arousal was experienced; nevertheless, when considering previous research, it is a possibility that even minor inconsistencies may warrant attitude change from those higher in resting HRV. Moreover, DTS correlations show that in the high choice condition, those who do not tolerate distress were most motivated to change their attitudes, suggesting that people in the high choice condition may have experienced dissonance. This suggests that individuals in the high choice condition who are particularly intolerant to distress are more sensitive to dissonance induction and thus are more likely to reduce the negative arousal via attitude change. Overall, subjects with high HRV seem to be regulating their dissonance via attitude change regardless of condition. Previous research has suggested that HRV is an individual difference measure of emotion regulation (Thayer & Lane, 2000), and this evidence may suggest it also serves as an individual difference measure for CD. Individuals with higher HRV being more adept at emotion regulation are also more likely to utilize a coping mechanism (i.e. attitude change) when faced with a

negative arousal, but more research is needed, particularly, replicating these results while obtaining the original dissonance effect.

Limitations and Future Directions

In the present study there was a failure in random assignment. Individuals in the high choice condition had lower resting baseline HRV (inefficient emotion regulators) in comparison to the low choice, who had higher resting HRV (adaptive emotion regulators). Thus, the low baseline HRV subjects in the high choice condition may not have changed their attitude as hypothesized because they lack efficient emotion regulation abilities. This is a possible explanation for why our results did not show significant differences in attitude change by condition. Future studies examining the connection between HRV and CD should be especially conscious of how many high/low HRV individuals are in each condition. To overcome the effects of individual differences, more participants are needed to achieve the power necessary to detect an effect.

Another limitation of the present study was the counter-attitudinal essay topic. The present study was based upon Losch and Caccioppo (1990). The present study assumed that fee increase was a topic relevant to all students. Students who use financial means to pay for college other than compensation from a job (e.g. loans, scholarships, college funds, etc), may confound the experimental manipulations; that is, these subjects may not have strong attitudes against fee increases. Overall, future CD studies should include a pre-screening so that researchers can recruit subjects with strong attitudes on the chosen counter-attitudinal topic.

This research has real life and clinical applications. CD may be experienced frequently in some individuals' lives due to work environment. If an individual works at

an organization that holds opposing beliefs to his or her own beliefs, CD may become chronic and unavoidable. As mentioned earlier, caregiver professions has been identified as an especially cognitively dissonant career that is also associated with CVD (Robinson & Demaree, 2007). If research is able to consistently confirm that HRV is predictive of emotion regulation following dissonance, it may become possible to pinpoint individuals 'at risk' for chronic dissonance.

Conclusion

Overall, the purpose of this study was to investigate the relationship between dissonance induction, physiological biomarkers of health, and attitude change. Results revealed that HRV is predictive of attitude change even when controlling for: respiration, BMI, ethnicity, condition, gender and compliance. However, the results must be interpreted with caution as this study did not show psychological nor physiological arousal following the dissonance induced manipulations. Thus, these results support previous research suggesting that HRV serves as an index of emotion regulation but extends it to a cognitive dissonance situation research should pay close attention to resting vagally-mediated HRV, as it may serve as an individual difference measure to many dissonance paradigms, and provide a useful tool in predicting individuals who will better regulate cognitive-behavioral inconsistencies.

References

- Antelmi, I., Paula, R. S., Shinzato, A. R., Peres, C. A., Mansur, A. J., & Grupi, C. J. (2004). Influence of age, gender, body mass index, and functional capacity on heart rate variability in a cohort of subjects without heart disease. *The American Journal of Cardiology*, *93*(3), 381-385.
- Bernardi, L., Porta, C., Gabutti, A., Spicuzza, L., & Sleight, P. (2001). Modulatory effects of respiration. *Autonomic Neuroscience*, *90*(1-2), 47-56.
- Choi, J. (2006). Age and ethnicity differences in short-Term heart-rate variability. *Psychosomatic Medicine*, *68*(3), 421-426.
- Cooper, J. (2007). *Cognitive dissonance: 50 years of a classic theory*. London: SAGE.
- Elliot, A. J., & Devine, P. G. (1994). On the motivational nature of cognitive dissonance: Dissonance as psychological discomfort. *Journal of Personality and Social Psychology*, *67*(3), 382-394.
- Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, Calif.: Stanford University Press.
- Gratz, K., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, Factor Structure, and Initial Validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41-54.
- Harmon-Jones, E., Amodio, D. M., & Harmon-Jones, C. (2009). Action-based model of Dissonance: a review, integration, and expansion of conceptions of cognitive Conflict. *Advances in experimental social psychology* (pp. 120-160).

Amsterdam: Elsevier ;.

- Karason, K., Molgaard, H., Wikstrand, J., & Sjostrom, L. (1999). Heart rate variability in obesity and the effect of weight loss. *The American Journal of Cardiology*, 83(8), 1242-1247.
- Kovacs, M., Kovacs, E., & Hegedus, K. (2010). Is emotional dissonance more prevalent in oncology care? Emotion work, burnout and coping. *Psycho-Oncology*, 19(8), 855-862.
- Krantz, D., & McCeney, M. (2002). Effects of psychological and social factors on organic disease: A critical assessment of research on coronary heart disease. *Annual Review of Psychology*, 53, 341-369.
- Losch, M. E., & Cacioppo, J. T. (1990). Cognitive dissonance may enhance sympathetic tonus, but attitudes are changed to reduce negative affect rather than arousal. *Journal of Experimental Social Psychology*, 26(4), 289-304.
- Pietri, E. S., Fazio, R. H., & Shook, N. J. (2012). Valence weighting as a predictor of emotional reactivity to a stressful situation. *Journal of Social and Clinical Psychology*, 31(7), 746-777.
- Robinson, J. L., & Demaree, H. A. (2007). Physiological and cognitive effects of expressive dissonance. *Brain and Cognition*, 63(1), 70-78.
- Roger, V. L., Makuc, D. M., Marcus, G. M., Marelli, A., & Matchar, D. B. (2012). Heart disease and stroke statistics--2012 update: A report from the American Heart Association. *Circulation*, 125(1), e2-e220.
- Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & Doornen, L. J. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology*, 27(1), 1-23.

- Simons, J. S., & Gaher, R. M. (2005). The Distress Tolerance Scale: development and validation of a self-report measure. *Motivation and Emotion, 29*(2), 83-102.
- Tarviainen, M.P., Niskanen, J.P., Lipponen, J.A., Ranta-aho, P.O., & Karjalainen, P.A. (2008). Kubios HRV- A Software for Advanced Heart Rate Variability Analysis. In J. Vander Sloten, P. Verdonck, M. Nyssen, J. Haueisen (Eds.), Proceedings of the 4th European Conference of the International Federation for Medical and Biological Engineering: Vol. 22. (pp.1022–1025), Springer Berlin Heidelberg.
- Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. (1996). Heart rate variability: Standards of measurement, physiology interpretation, and clinical use. *Circulation, 93*, 1043-1065.
- Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders, 61*(3), 201-216.
- Thayer, J. F., & Lane, R. D. (2007). The role of vagal function in the risk for cardiovascular disease and mortality. *Biological Psychology, 74*(2), 224-242.
- Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart Rate variability, prefrontal neural function, and cognitive performance: The Neurovisceral Integration Perspective on Self-regulation, Adaptation, and Health. *Annals of Behavioral Medicine, 37*(2), 141-153.
- Thayer, J. F., Ahs, F., Fredrikson, M., Sollers, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews, 36*(2), 747-756.

Zanna, M. P., & Cooper, J. (1974). Dissonance and the pill: An attribution approach to studying the arousal properties of dissonance.. *Journal of Personality and Social Psychology*, 29(5), 703-709.

Appendix

Figures

Figure 1: Attitude change by condition

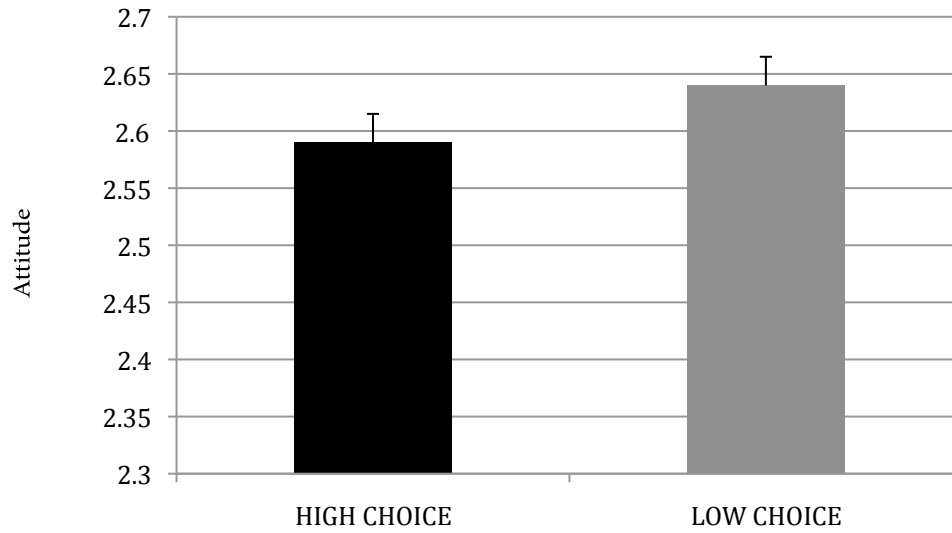


Figure 2: Self-reported mood at time 2 by condition

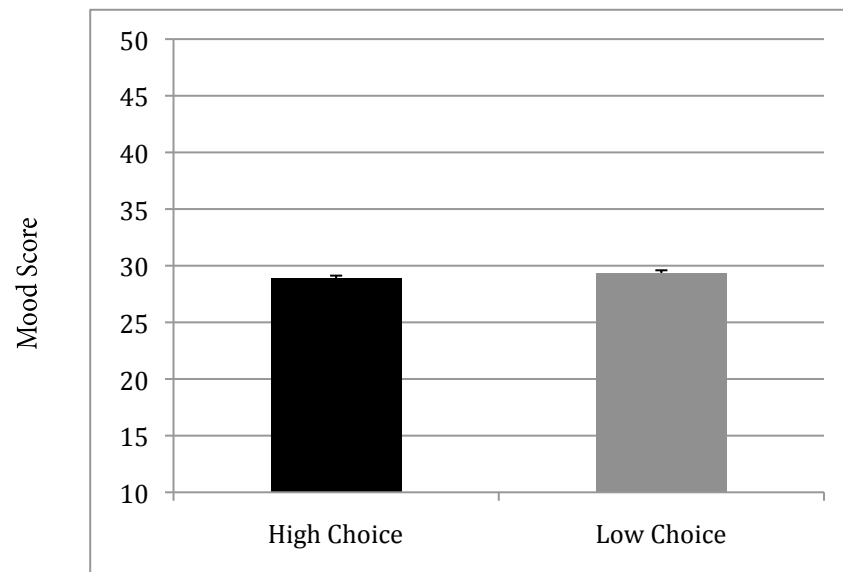


Figure 3: Measures of Blood Pressure by Condition

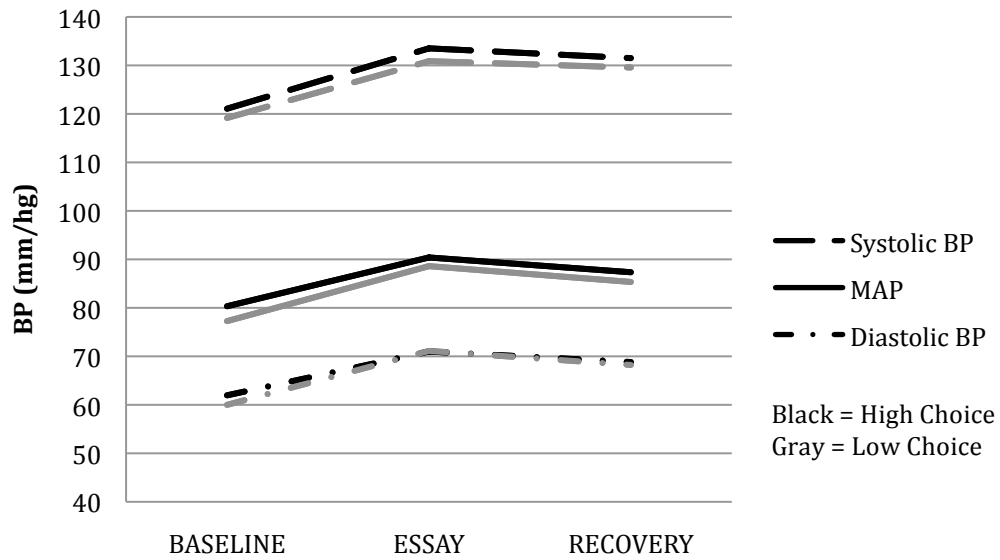


Figure 4: LVET by condition

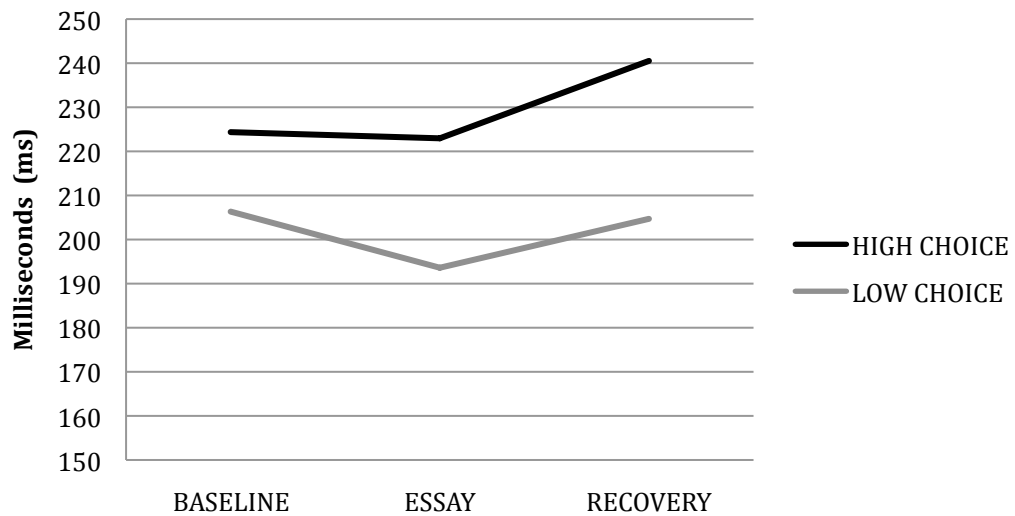


Figure 5: PEP by condition

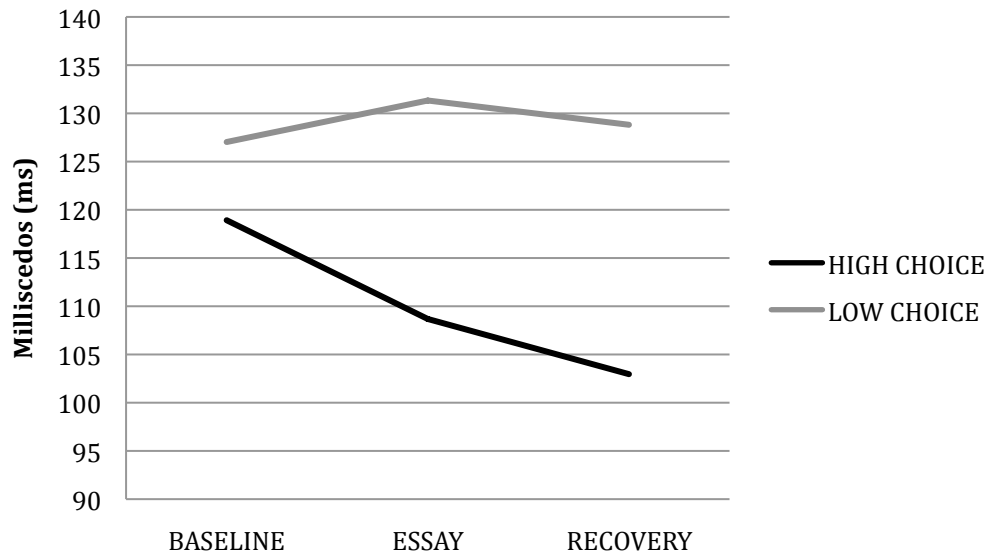


Figure 6: HRV by condition

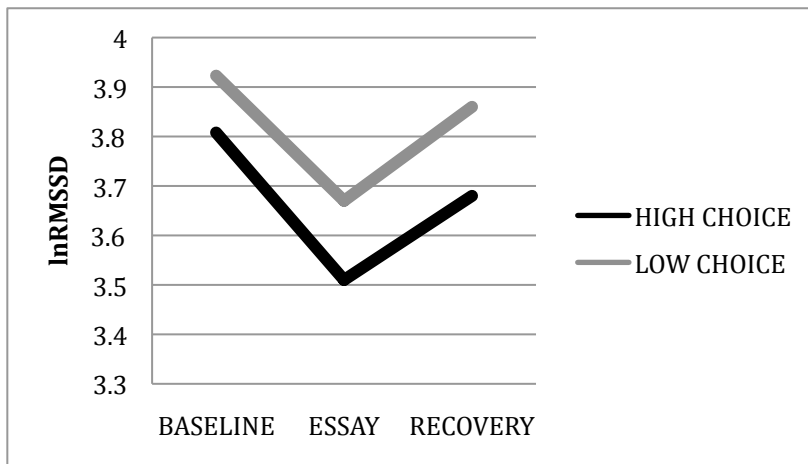


Figure 8: Attitude Change Controlling for Baseline HRV

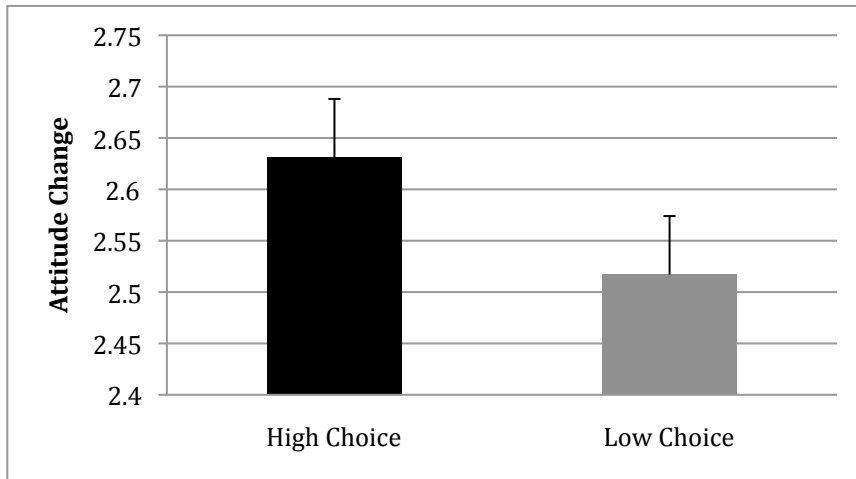


Table 1: Participant descriptives by condition

Condition	N	Male	Female	Caucasian	African American	Asian
High	32	14	16	25	3	2
Low	38	15	23	27	3	8

Table 3: Systematic differences at baseline

Condition	HR	RR	PNN50	lnRMSSD	lnHF*	Mood 1
HIGH	74.79	833.15	24.04	3.81	6.49	28.26
LOW	73.09	854.99	29.52	2.92	7.05	29.86

*p<.05

Table 2: Pearson r Correlation Coefficients

Table 1A: Total N	HRV	Attitude Change	Mood 1	Mood 2	DTS
HRV	--				
Attitude Change	.324*	--			
Mood 1	.099	.035	--		
Mood 2	.078	-.036	.921**	--	
DTS	.200	.019	.458**	.417**	--
DERS	-.099	-.106	.053	-.010	-.068

Table 1B: High Choice	HRV	Attitude Change	Mood 1	Mood 2	DTS
HRV	--				
Attitude Change	.291	--			
Mood 1	.110	.300	--		
Mood 2	-.053	.182	.928**	--	
DTS	.231	-.384 †	.518*	.488*	--
DERS	.162	.211	.319	.319	.423*

Table 1C: Low Choice	HRV	Attitude Change	Mood 1	Mood 2	DTS
HRV	--				
Attitude Change	.303	--			
Mood 1	.159	-.137	--		
Mood 2	.235	-.172	.914**	--	
DTS	.263	.356 †	.335	.302	--
DERS	-.464*	-.365 †	-.326*	-.337 †	-.745**

Correlation coefficients between the Attitude change (score), Mood 1 (total score), Mood 2 (total score), the Distress Tolerance Scale (DTS) (total score), the Difficulty in Emotion Regulation scale (DERS), and RMSSD heart rate variability (HRV). *p<.05 ** p<.01 † p < .1

Self-Report Measures

Difficulty in Emotion Regulation (DERS)

Instructions: Please indicate how often the following 36 statements apply to you by selecting the appropriate number from the scale (1-5).

Response categories:

1. Almost never (0-10%)
2. Sometimes (11-35%)
3. About half the time (36-65%)
4. Most of the time (66-90%)
5. Almost always (91-100%)

1. I am clear about my feelings.
2. I pay attention to how I feel.
3. I experience my emotions as overwhelming and out of control.
4. I have no idea how I am feeling.
5. I have difficulty making sense out of my feelings.
6. I am attentive to my feelings.
7. I know exactly how I am feeling.
8. I care about what I am feeling.
9. I am confused about how I feel.
10. When I'm upset, I acknowledge my emotions.
11. When I'm upset, I become angry with myself for feeling that way.
12. When I'm upset, I become embarrassed for feeling that way.
13. When I'm upset, I have difficulty getting work done.
14. When I'm upset, I become out of control.
15. When I'm upset, I believe that I will remain that way for a long time.
16. When I'm upset, I believe that I'll end up feeling very depressed.
17. When I'm upset, I believe that my feelings are valid and important.
18. When I'm upset, I have difficulty focusing on other things.
19. When I'm upset, I feel out of control.
20. When I'm upset, I can still get things done.
21. When I'm upset, I feel ashamed with myself for feeling that way.
22. When I'm upset, I know that I can find a way to eventually feel better.
23. When I'm upset, I feel like I am weak.
24. When I'm upset, I feel like I can remain in control of my behaviors.
25. When I'm upset, I feel guilty for feeling that way.
26. When I'm upset, I have difficulty concentrating.
27. When I'm upset, I have difficulty controlling my behaviors.
28. When I'm upset, I believe there is nothing I can do to make myself feel better.
29. When I'm upset, I become irritated with myself for feeling that way.
30. When I'm upset, I start to feel very bad about myself.
31. When I'm upset, I believe that wallowing in it is all I can do.
32. When I'm upset, I lose control over my behaviors.
33. When I'm upset, I have difficulty thinking about anything else.
34. When I'm upset, I take time to figure out what I'm really feeling.
35. When I'm upset, it takes me a long time to feel better.
36. When I'm upset, my emotions feel overwhelming.

Distress Tolerance Scale (DTS)

Instructions: Think of times that you feel distressed or upset. Select the item from the menu that best describes your beliefs about feeling distressed or upset.

1. Strongly agree
2. Mildly agree
3. Agree and disagree equally
4. Mildly disagree
5. Strongly disagree

1. Feeling distressed or upset is unbearable
2. When I feel distressed or upset, all I can think about is how bad I feel.
3. I cant handle feeling distressed or upset.
4. My feelings of distress are so intense that they completely take over.
5. There's nothing worse than feeling distressed or upset.
6. My feelings of distress or being upset are just an acceptable part of life.
7. I can tolerate being distressed or upset as well as most people.
8. My feelings of distress or being upset are not acceptable.
9. I'll do anything to avoid feeling distressed or upset.
10. Other people seem to be able to tolerate feeling distressed or upset better than I can.
11. Being distressed or upset is always a major ordeal for me.
12. I am ashamed of myself when I feel distressed or upset.
13. My feelings of distress or being upset scares me.
14. I'll do anything to stop feeling distressed or upset.
15. When I feel distressed or upset I must do something about it immediately.
16. When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually feels.

Mood Scale

Instructions: Indicate how you feel currently.

1 (negative emotion) to 5 (positive emotion)

1. Very Depressed to Very Elated
2. Very Sad to Very Happy
3. Very bad to very good
4. Very tired to very energetic
5. Very dissatisfied to very satisfied
6. Very sedate to very aroused
7. Very anxious to very relaxed

Attitude Change

Ho do you feel about tuition increase?

1(very negatively) to 7(very positively)