Characterizing the Psychophysiological Signature of Boredom

by

Colleen Merrifield

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Arts

in

Psychology

Waterloo, Ontario, Canada, 2010

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Colleen Merrifield

Abstract

Recent research has suggested that boredom is a construct that can be distinguished from similar affective states including apathy, anhedonia, and depression, using self-reports. The current study investigated whether boredom and sadness (an analogue for depression) are distinct in terms of their physiological signatures. State boredom and sadness were induced in a group of healthy participants while their physiological parameters of heart rate (HR), skin conductance (SCL), and cortisol levels were monitored. Results indicated that the autonomic nervous system response for both states can be characterized by directional fractionation, with boredom resulting in increased HR but decreased SCL relative to sadness. Cortisol levels were higher after the boring induction than the sad induction, indicating increased hypothalamic-pituitary-adrenal axis activation for boredom. Overall, boredom appears to have a physiological signature that is distinguishable from a primary symptom of depression.

Acknowledgements

I would like to acknowledge and thank my supervisor, James Danckert, for his guidance and assistance with this project. I am fortunate to receive his continuous support and encouragement in pursuing all of my research interests. I am also very grateful to David Moscovitch, not only for his valuable contributions to this project, but also for his enthusiasm and support in helping me to achieve my research goals. I would like to thank both David Moscovitch and Dan Smilek, whose attention to detail in reviewing this project greatly improved the quality of this work. I am also very grateful for the support of my family and for their keen interest in all of my projects. Finally, I would like to thank Erin Fallis, Dee Gavric, Tracy Mewhort-Buist, and Vanessa Huyder for their research help and unwavering moral support.

Table of Contents

List of Tables

List of Figures

Boredom is a state that is experienced by everyone from time to time. Given the universality of its experience, it is not surprising that boredom has been examined across a wide range of contexts including education, leisure, risk management, health and safety, medicine and rehabilitation, crime and criminology, consumer behaviours, efficiency, absenteeism, job satisfaction, and tenure in the workplace (Abrams, 2003; Bracke, Bruynooghe, & Verhaeghe, 2006; Baker, D'Mello, Rodrigo, & Graesser, 2010; Charlton & Hertz, 1989; Dahlen, Martin, Ragan, & Kuhlman, 2005; Ferrell, 2004; Fisher, 1993; Game, 2007; Grose, 1989; Iso-Ahola & Weissinger, 1987; Kass, Vodanovich, & Callender, 2001; Passik, 2003; Porcherot & Issanchou, 1998; Randerson, 2003; Robinson, 1975; Shaw, 2003; Watt & Hargis, 2010; Workman & Studak, 2007). In psychology, boredom has been investigated in relation to temperament and personality factors, addiction, as well as the function it plays in truancy, psychopathology, and other human factors. Research has also indicated that boredom is positively correlated with lapses in attention, an inability to sustain attention over time, and the subjective overestimation of the passage of time (Blaszczynski, McConaghy, & Frankova, 1990; Carriere, Cheyne, & Smilek, 2007; Cheyne, Carriere, & Smilek, 2006; Culp, 2006; Damrad-Frye & Liard, 1989; Danckert & Allman, 2005; Farmer & Sundberg, 1986; Gordon, Wilkinson, McGowan, & Jovanoska, 1997; Hamilton, 1981; Hamilton, Haier, & Buchsbaum, 1984; Leong & Schneller, 1993; McGiboney & Carter, 1988; Orcutt, 1984; Pettiford, Kozink, Lutz, Kollins, Rose, & McClernon, 2007; Vodanovich, 2003; Vodanovich & Rupp, 1999; Wallace, Vodanovich, & Restino, 2003; Watt, 1991; Watt & Vodanovich, 1992; Wegner & Flisher, 2009). It is clear then, that boredom represents a common phenomenon that impacts a broad and heterogeneous range of human activities. Despite the breadth of research related to boredom, very few researchers have agreed on a definition of what, exactly, boredom is. That is, while boredom has been researched broadly, it is surprising how little research has been devoted to *defining* the distinct psychological or physiological underpinnings of the construct itself. Moreover, it is unlikely that any field of inquiry can progress in a useful way without such a definition. In the absence of a unified definition, it is difficult to establish criteria to identify and measure the experience. Thus, a definition of what boredom is, and what constitutes normal and atypical levels of boredom would go a long way toward advancing both research and treatment. For instance, it is known that the phenomenon of boredom is associated with depression and that often both co-occur in conditions such as traumatic brain injury (TBI) and cancer, and in patients who are hospitalized for other psychiatric and physical disorders (Binnema, 2004; Hamilton et al. 1984; Seel & Kreutzer, 2003; Theobald, Kirsch, Holtsclaw, Donaghy, & Passik, 2003; Passik, Inman, Kirsh, Thwobald, & Dickerson, 2003; Vodanovich, Verner, & Gillbride, 1991; Vodanovich, 2003). However, attempts to alleviate patients' emotional distress often focus on and target depression alone (Passik, 2003; Passik et al., 2003; Theobald et al. 2003), when boredom, in and of itself, may represent a major impediment to recovery. For example, in an eight-week-long open label trial of citalopram [a selective serotonin reuptake inhibitor (SSRI) antidepressant drug] in patients who reported high levels of both boredom and depression, Theobald and colleagues (2003) observed early improvements in depression but no significant improvements in boredom until week six. Thus, knowing the unique features and symptoms of boredom, may allow for better assessment and treatment of it outside of the context of depression. In other words, a greater understanding of boredom would help us understand its role in such disorders, and aid in the design and implementation of effective treatments.

There are two major points of disagreement in terms of defining what constitutes the experience of boredom. The first is whether boredom represents an aroused, agitated state, in which individuals feel motivated to engage in an appealing activity but are unable to do so, or whether it represents a state of ennui, in which one experiences an aversive emotional state, yet feels neither agitated nor motivated to engage in another activity. The second concerns whether boredom is a distinct emotional construct in and of itself, or whether it is better characterized (and treated) as a symptom of related syndromes, particularly depression. Up to this point, attempts to clarify these issues have been unsuccessful.

Apathetic Versus Agitated Boredom

Many definitions of boredom focus on arousal as a key factor in the experience. While there is general agreement that the state of boredom is unpleasant (i.e., it is experienced as affectively negative), and usually results because a situation is construed to be monotonous or dull (Barmack, 1939; Geiwitz, 1966; Hill & Perkins, 1985; Martin, Sadlo, & Stew, 2006; Mikulas & Vodanovich, 1993), there is less agreement as to whether boredom can be characterized by a decrease or increase in arousal levels. As mentioned, boredom can be characterized in two broad ways; first, a state of apathy or ennui in which one experiences a disconnection from the world around them and second, an agitated or restless state in which one desires to engage in meaningful activity, but is unable to do so (Fenichel, 1951; Goldberg, 2008). The apathetic and agitated bored states are thought to be associated with decreased and increased physiological arousal levels respectively. So, on one hand, research posits that boredom is associated with a state of low arousal (Barmack, 1939; Geiwitz, 1966; Hebb, 1955). Such research describes boredom as an unpleasant state of low arousal attributed to a situation that offers inadequate stimulation (Mikulas & Vodanovich, 1993). Barmack (1939) even suggests that inadequate motivation associated with boredom results in a physiological state that approaches that of sleep. In contrast, those who characterize boredom as an agitated state suggest that the experience is associated with a state of high physiological arousal (Berlyne, 1960; London, Schubert, & Washburn, 1972).

Up to this point, the vast majority of research has utilized psychometric self-report measures to establish links between the tendency to experience boredom (trait-like boredom proneness) and other measurable factors, rather than examining state boredom directly (Martin, Sadlo, & Stew, 2006). Some research, however, has suggested that increased physiological reactivity is correlated with state boredom; nevertheless, studies investigating physiological changes during boring tasks have reported mixed results. For example, Pattyn and colleagues (2008), investigated vigilance while participants completed an understimulating computer task that lasted for 90 minutes. While this task was not intended to induce boredom per se, participants reported experiencing the task as boring. Results demonstrated decreases in heart rate (HR) over time, suggesting that boredom may be associated with decreased autonomic arousal. In contrast, Ohsuga and colleagues (2001), also investigated vigilance while participants completed a stressful computer task that lasted for 40 minutes and a monotonous computer task that lasted for 60 minutes, while monitoring physiological parameters, including HR. Again, although the tasks were not intended to induce boredom, participants nevertheless reported experiencing boredom with results demonstrating an increase in HR during both tasks. This finding suggests that boredom can also be associated with increased arousal levels (Ohsuga, Shimono & Genno, 2001).

Experimental tasks designed to measure boredom per se seem to suggest that state boredom may be associated with increases in arousal; but again, results are somewhat equivocal. For example, London and colleagues (1972) had four different groups of participants complete one of two boring tasks or one of two interesting tasks, while measuring HR and skin conductance levels (SCL). They reported an increase in SCL during one boring task, relative to an interesting task. During the other boring task, they reported an increase in HR but no difference in SCL, relative to an interesting task. Again, these results suggest that boredom may be associated with an increase in arousal; however, the results are equivocal and methodological concerns prevent any firm conclusions from being drawn from this study (e.g. the tasks were not equated across a number of important characteristics, making meaningful comparisons between them difficult). More conclusive results were found by Lundberg and colleagues (1993), who had participants complete a boring, monotonous computer task and a stimulating, interesting computer task. Psychophysiological parameters including HR and cortisol levels were monitored throughout each of the 90 minute tasks. Results revealed that participants demonstrated an increase in both HR and cortisol levels during the boring task relative to the interesting task. The purpose of that study, however, was to determine whether computers in the workplace contribute to occupational stress and thus the focus was not on inducing boredom per se. Although levels of self-reported boredom were assessed, measures consisted of a single item, making them somewhat unreliable. Moreover, during the boring condition (a data entry task) there was a time constraint and participants reported having felt tense and irritated, in addition to being bored. As such, it is not possible to determine whether the observed increase in physiological parameters during the 'boring' condition were due to the fact that participants were bored or whether they resulted from participants feeling pressured by the time constraint. Thus, although limited by the small number of studies, research suggests that state boredom may be characterized by an increase in arousal; however, further inquiry involving carefully controlled psychophysiological monitoring under conditions in which participants are explicitly induced into a state of boredom is needed to clarify this question. Furthermore, none of the previous studies have addressed the question of whether boredom is distinct from *similar* affective states, such as depression.

Boredom and Depression

As mentioned, boredom is an important feature a number of psychological disorders. Particularly noteworthy is that boredom is often associated with depression. That is, the experience of boredom has repeatedly been shown to be highly correlated with depression (Farmer & Sundberg, 1986; Theobald, et al., 2003; Passik, 2003; Passik et al., 2003; Vodanovich, 2003). Consequently, the experience of boredom has not been clearly differentiated from other, similarly experienced, affective states or syndromes. This is not surprising given that some of the symptoms that must be present for a diagnosis of Major Depressive Disorder include: 1) a sad, depressed mood; 2) a loss of interest and pleasure in usual activities; and 3) a shift in activity level, showing either psychomotoric agitation or retardation (APA, 1994). Although little research has focused on differentiating the two constructs, Farmer & Sundberg (1986) have posited that, even though boredom and depression overlap somewhat in terms of their symptoms and features, they can be distinguished from each other in terms of mood quality and intensity. For example, depression is posited to be characterized by a greater intensity of symptoms when compared to boredom. Also, boredom would not be expected to be associated with feelings of hopelessness and guilt, which are characteristic symptoms of depression (Turner, 1984).

Recent work in our laboratory demonstrated that, although boredom is closely related to depression, the constructs are qualitatively and empirically distinct (Goldberg, 2008). We used structural equation modeling (SEM), to compare participants' experiences of apathy, anhedonia (an inability to experience pleasure), depression, and boredom, as measured by self-report questionnaires. Only small to moderate correlations were reported between participants' reports of boredom and apathy (r=.27) and boredom and anhedonia (r=.38). This suggests that, although related, the construct of boredom is distinct from both apathy and anhedonia. A larger correlation was observed between participants' reports of boredom and depression (r=.72), suggesting that these constructs are closely related and replicating findings that boredom and depression are highly correlated. However, a model in which boredom and depression were equated (i.e., they were treated as equivalent constructs) did not fit the data well, suggesting that boredom and depression are, in fact, distinct constructs.

Despite the fact that our previous research demonstrated that boredom and depression are, in fact, distinct affective constructs (Goldberg, 2008), the two constructs remain highly correlated both at a behavioural level and at the level of symptomatology. One potential way of further differentiating the two constructs would be to contrast measures of physiological activation. In other words, are boredom and symptoms of depression *physiologically* distinct? While previous research investigating the physiology of boredom has contrasted the state of boredom with interest, a more useful comparison would be to contrast boredom with depression, or symptoms of depression such as sadness. Examining the psychophysiology of boredom in such a manner could also help clarify whether boredom is characterized by an increase or a decrease in physiological arousal. Research has indicated that resting heart rates are elevated in individuals with depression as are cortisol levels (Kamphuis et al., 2007; Nemeroff & Evans, 1984; Sachar et al., 1985; Taylor, 2010; Varghese & Brown, 2001; Whooley et al., 2008). It seems then that both boredom and symptoms of depression may be associated with increased physiological arousal. What is unclear is whether these constructs are distinct from each other. Thus, the present study explored the psychophysiological properties of state measures of boredom and sadness to determine whether distinct signatures exist between the two closely related states and to examine whether boredom is characterized by increases or decreases in physiological arousal. Depression is a heterogeneous syndrome characterized by a number of features and symptoms, making it impossible to 'induce' in the laboratory in the same way that a state of boredom can be induced. Because of this, the present study used the state of sadness as an analogue for depression. The main reasons for this decision were: 1) sadness is a hallmark of depression and is one of the defining symptoms of the syndrome and 2) sadness is a state that can be reliably and validly elicited in the laboratory, where psychophysiological monitoring can be carried out (Ekman, Friesen, & Ancoli, 1980; Gross & Levenson, 1995; Philippot, 1993). Therefore, the present study used video clips to induce the states of boredom and sadness in participants while psychophysiological parameters of heart rate, skin conductance, and cortisol levels were monitored. Given that boredom and depression have been shown to be distinct constructs, it was hypothesized that boredom would also be distinguishable from sadness in terms of both psychophysiology and self-reports of affect. It was further hypothesized that boredom would be characterized by an increase in arousal; however, any hypotheses regarding differences between boredom and sadness were necessarily speculative at this stage.

Study 1 – Validation of Video Clips

Study 1, a pilot study, was conducted to select and validate the video stimuli for use in the psychophysiological monitoring study (Study 2). Videos were chosen as the mood induction method because they offer a number of advantages for psychophysiological monitoring. First, by having participants simply sit in a comfortable chair while watching video clips, most movement artefacts would be eliminated. Second, the use of videos to induce mood states in experimental protocols has been shown to be a reliable, valid, and effective way to induce a number of different emotional states (Ekman et al., 1980; Gross & Levenson, 1995; Philippot, 1993). Finally, videos can be equated across a number of important characteristics (e.g. length, presence or absence of faces, presence or absence of dialogue, etc.) to ensure that the stimuli are as similar as possible across affective states. The purpose of Study 1 was to select a set of three videos to be used in Study 2; one intended to induce boredom, one intended to induce sadness, and a third video intended to return participants' affective state to baseline levels between the affectively-valenced videos.

Method

Participants. Participants were 48 undergraduate students (33 female; mean age 21.5 years, ±4.96; range 17 - 45 years) from the University of Waterloo who participated in exchange for course credit. All participants reported having normal or corrected to normal hearing and vision. Participants' eligibility to participate in the current study was determined based on their scores on two measures: the Boredom Proneness Scale (BPS; Farmer & Sundberg, 1986; described below) and the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996; described below). These measures were administered online as part of a larger battery given to all potential research participants in the department of psychology. For the current study, participants were eligible to participate if their total score on the BPS fell within one standard deviation of the sample mean and their total score on the BDI-II was less than 19. In the current sample, the mean score on the BPS was 99.12 (*SD*=15.31) and the mean score on the BDI was 8.98 (*SD*=9.05). As we are interested in how boredom is manifested in healthy individuals, this selection procedure ensured that any participants who had a high propensity to experience boredom or were experiencing significant symptoms of depression were not included in the study (Beck et al., 1996). All procedures were reviewed by and received approval from the Office of Research Ethics at the University of Waterloo.

Measures. ***Trait boredom.*** The Boredom Proneness Scale, developed by Farmer and Sundberg (1986) assesses an individual's general propensity to experience boredom. Items on the 28-item scale reflect situations in which one is likely to become bored and personal characteristics related to boredom. The scale was originally developed in a true/false format, however, for the current study, participants rated how much they agreed with each statement on a Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Sample items included "In situations where I have to wait, such as a line or queue, I get very restless" (situation) and "I find it easy to entertain myself" (personal characteristic). Responses on each item were summed to obtain a total score ranging from 28-196, with higher scores reflecting greater proneness to experiencing boredom (Sommers & Vodanovich, 2000; Vodanovich et al., 1991; Watt & Vodanovich, 1999). The original true/false version of the scale demonstrates adequate internal consistency (α = .79), and test-retest reliability over a duration of one week (r = .83; Farmer & Sundberg, 1986). Similar values for internal consistency and reliability have been reported by other researchers (Vodanovich, 2003, for review).

Current depression. The Beck Depression Inventory II, developed by Beck and colleagues (1996), assesses the presence and severity of depressive symptoms as outlined in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* Fourth Edition (DSM-IV; 1994). The 21-item inventory includes two subscales, measuring symptoms of depression across somatic-affective and cognitive domains. Scores in the range from 0-13 indicate minimal clinical depression, 14–19 indicate mild clinical depression, 20-28 indicated moderate clinical depression, and 29-63 indicate severe clinical depression (Beck et al. 1996).

State affect. *General state affect*. The State Affect (SA) questionnaire was used to assess participants' state affect. This scale was developed for this study based on similar procedures used by others (Ekman, et al., 1980; Gross & Levenson. 1995; Philippot, 1993). The 26-item questionnaire consisted of 24 emotion terms. To assess intensity, participants indicated the greatest amount of each emotion they felt at the beginning of the study (baseline) and while watching each film (post-film) on a Likert scale ranging from 0 (*none/not at all*) to 8 (*a great deal/extremely*). One free-form item asked participants to list any other emotion(s) they experienced and to rate that emotion on the same Likert scale. To assess the valence of participants' state affect, individuals rated the pleasantness of their emotional state on a Likert scale ranging from 0 (*unpleasant*) to 8 (*pleasant*). On the post-film version of the questionnaire, participants were also asked whether or not they had seen the film previously (Appendix A).

State sadness and state interest. The sadness subscale and the interest subscale of the Differential Emotions Scale (DES; Izard, Libero, Putnam, & Haynes, 1993) were each administered to assess participants' state sadness and state interest. These subscales are each composed of three items taken from the larger, 36-item instrument, which assesses 12 different basic emotions. In the original version, participants rate how often they feel different emotional states on a Likert scale ranging from 1 (*rarely or never*) to 5 (*very often*). Items included, "In your daily life, how often do you feel unhappy, blue, downhearted" (sadness), "In your daily life, how often do you feel like what you're doing or watching is interesting" (interest). Both subscales in the original version of the scale demonstrated adequate internal consistency (α = .85 for the sadness subscale, α = .75 for the interest subscale; Izard et al., 1993). Since sadness and boredom were hypothesized to be very closely related states, and because each subscale in the current study only consisted of a small number of items, the range of the response scale was increased. To do this, participants rated the statements on a Likert scale ranging from 0 (*not at all*) to 8 (*extremely/a great deal*). In addition, for each item, the phrase "In your daily life, how often do you feel…" was replaced with the phrase, "Right now, at this moment, do you feel…" (baseline) or "While watching the previous film clip, did you feel…" (post-film). For each subscale, responses on each item were summed to obtain an overall score, ranging from 0 to 24, with higher scores indicating greater amounts of sadness or interest.

State boredom. Items from the Multidimensional State Boredom Scale (MSBS; Fahlman, Mercer, Flora, & Eastwood, 2008) were used to assess state boredom. The original version of this scale included 28 items that measure current feelings of boredom on a 7-point Likert scale ranging from 1(*strongly disagree*) to 7 (*strongly agree*). In the full-length scale, boredom is measured across the five domains of inattention, disengagement, agitation, dysphoria and time. For the current study, in the interest of time (this scale was re-administered a number of times throughout the session), five items from the MSBS were administered to participants. One item was selected from each domain (except the domain of dysphoria, from which no item was selected in order to avoid confounding dysphoria with sadness). Items administered were: "Right now, at this moment, do you feel that it is difficult to focus your attention" (inattention), "Right now, at this moment, do you feel like time is passing by slower than usual" (time), "Right now, at this moment, do you feel like your mind is wandering" (disengagement), "Right now, at this moment, do you feel like you want to do something fun, but nothing appeals to you" (disengagement), and "Right now, at this moment, do you feel agitated" (agitation). In order to maintain consistency among the self-report scales, the current study utilized a Likert scale ranging from 0 (*not at all*) to 8 (*extremely/a great deal*). In addition, the phrase "Right now, at this moment...", used to assess baseline state boredom, was substituted for the phrase "While watching the previous film...” in the post-film version of the questionnaire. Responses on each item were summed to obtain an overall score, ranging from 0 to 40, with higher scores indicating greater amounts of boredom.

Apparatus. ***Mood induction videos.*** Three video clips were shown to each participant. Two of these videos were intended to induce specific emotional states (sadness and boredom) while the third was intended to be of neutral valence. All videos were shown on a standard colour television with a 35-inch screen, while participants were seated in a comfortable chair approximately 2 metres from the television.

Boredom. To elicit boredom, we created a novel video clip for this investigation that portrayed two men hanging laundry to dry, while occasionally asking each other for a clothes pin. Lengths of the film clips were 171, 233, and 341 seconds (s) which was manipulated as a between-subjects factor. That is, a participant who watched a 171 s sad clip also watched a 171 s boring clip.

Sadness. Based on Gross and Levenson's (1995) work, we used a clip from the movie *The Champ,* portraying a young boy grieving over the death of his father, to induce sadness (Lovell & Zeffirelli, 1979). From the full length film we created clips of three different lengths. The first clip was 171 s in length (identical to the clip used by Gross & Levenson, 1995) and was selected based on its ability to reliably and validly elicit sadness in that study. We also created clips that were 233 s and 341s in length to match the lengths of the boring video clips. All three sad clips were created from the same scene used in the original study by Gross & Levenson (1995).

Neutral affect. A clip, posited to be of neutral valence, was included to return participants' affect to baseline levels between the emotionally-valenced video clips. This clip was an excerpt from the British Broadcasting Company's (BBC) documentary film, *Planet Earth* (Fothergill, Berlowitz, Malone, & Lemire, 2007) and depicted exotic animals, landscapes, and vegetation, with voice commentary and background music. The clip was 233 s in length.

Procedure

Participants were seated in a comfortable armchair approximately 2 metres from the television. After obtaining informed consent, participants were told that they would be viewing three video clips of varying lengths. They then filled out the SA questionnaire, the sadness and interest subscales from the DES, and the five items from the MSBS to establish their emotional baseline. Following this, the experimenter presented the first video clip, which was either boring or sad (counterbalanced) and was either 171 s, 233 s, or 341 s in length (counterbalanced). Immediately after viewing the video, participants again filled out each of the four self-report affect questionnaires to assess what their emotional state had been while watching the preceding video. Next, participants watched the neutral video, which was 233 s in length, following which, they again filled out each of the four self-report affect questionnaires. Following this, participants watched a third video. This video was either boring or sad depending on which video had been viewed first. The third video was either 171 s, 233 s, or 341 s in length and matched the length of the first video so that time was constant within subjects (i.e., if the first video was 171 s in length, so too was the third video). Finally, participants filled out each of the four self-report questionnaires to assess what their state affect had been while they watched the preceding video clip. Each participant watched three video clips during a single laboratory session ranging from 20 – 60 minutes. The order in which the emotion-eliciting videos (the sad and boring videos) were presented was counterbalanced while the neutral video was always shown in between the emotionally arousing videos. Each participant watched only one length of sad/boring video clip. In other words, the length of the video clip was administered as a between-subjects variable.

Data Analytic Approach

For each epoch separately (i.e., baseline, boring, neutral, sad), a repeated measures ANOVA was conducted to compare the three highest-rated emotion terms endorsed by participants during each epoch on the State Affect (SA) questionnaire. Pearson correlations were then calculated between the top-rated emotion in each epoch and totals on the MSBS and DES subscales. To determine whether the number of different emotion terms endorsed on the SA questionnaire differed across each set of videos, one-way ANOVAs were conducted separately for the three boring and three sad films, with video length as the between-subjects factor and number of emotion terms endorsed as the dependent variable. Additional one-way ANOVAs were conducted to determine whether the target emotions (boredom and sadness) were elicited more intensely by a specific video clip within the boring or sad video sets. Finally, one-way ANOVAs were conducted on the pleasantness ratings from the SA questionnaires to determine whether differences existed in the valence of the target emotions elicited by the boring and sad video sets. Bonferroni corrections were used, where appropriate, to adjust for multiple comparisons.

Results

Baseline. On the SA questionnaire during the baseline epoch, participants endorsed having felt interested (M=4.57, SD=1.57), happy (M=4.11, SD=2.26), and alert (M=3.79, SD=2.26) most strongly. A repeated measures ANOVA indicated that there were no differences in the intensity with which participants felt these states [$F(2, 92)=2.97$, $p=.07$; Table 1]. Correlations between the highest rated terms on the SA questionnaire and the MSBS, and DES subscales are listed in Table 2.

Boring videos. For all lengths of video the two highest rated emotions were boredom and confusion (Table 1). In all three conditions boredom was felt more intensely than confusion (all F's>7.04, p's<.001, all η^2's>.34; all t's>3.29, all p's<.01). Importantly, ratings of intensity for confusion did not differ from the third highest ranked emotions (alertness, anger, and happiness in the 171, 233, and 341 s videos respectively). This indicates that boredom was most highly endorsed for all lengths of video while all other emotions were minimally endorsed. Further analyses revealed that there were no differences in the number of emotion terms endorsed on the SA questionnaire for each of the boring videos [$F(2,44)=.08$, $p>.90$]. Similarly, there were no differences in the intensity of boredom ratings from the SA questionnaires [$F(2,43)=1.34$, $p=.27$] and there were no differences in total scores on the MSBS items [$F(2,27)=.22$, $p=.80$] across the boring films. This indicated that there were no differences in how intensely each of the boring videos elicited boredom in participants. In addition, there were no differences in the pleasantness ratings from the SA questionnaires during each boring film [$F(2,41)=2.94$, $p=.07$], indicating that the valence of participants' affect during each boring film was equally negative (Table 1).

Neutral video. During the neutral video, on the SA questionnaire, participants endorsed having felt interest (M=5.17, SD=2.17), amusement (M=4.81, SD=2.13), and happiness (M=4.17, *SD*=2.51) most strongly [F(1.7,77.2)=5.44, p=.01, η^2=.11]. Unlike boredom in which the boring term was endorsed significantly higher than all other emotion terms, a number of emotion terms were endorsed equally strongly during this epoch (Table 1).

Sad videos. For all lengths of video the three highest rated emotions were sadness, upset, and interest [F(1.8,27.7)=4.48, p=.02, η^2=.23; all t's>2.22, all p's<.04; Table 1]. In all three conditions sadness was the highest rated emotion term. Importantly, ratings of intensity for the second and third highest terms did not differ from each other. This indicates that sadness was the most highly endorsed emotion for all lengths of video with other emotions being endorsed only minimally. Furthermore, there were no differences in the number of emotion terms endorsed on the SA questionnaire for each of the sad videos [F(2,43)=.77, p=.47, η^2=.01]. Similarly, there were no differences in the intensity of the sadness ratings from the SA questionnaires [F(2,43)=1.48, p=.24], and there were no differences in total scores on the DES sadness subscale across the sad films [F(2,27)=1.89, p=.17]. This indicated that there were no differences in how intensely each of the sad videos elicited sadness in participants. In addition, as with the boring videos, there were no differences in the pleasantness ratings from the SA questionnaires during each sad film [F(2,37)=.23, p=.70], indicating that the valence of participants' affect during each sad film was equally negative (Table 1).

Table 1. Study 1 – Means (SD) of video ratings.

	Epoch							
	Baseline	Boring			Neutral	Sad		
	180s	171s	233s	341s	233s	171s	233s	341s
	Interest[a]	Boring[a]	Boring[a]	Boring[a]	Interest[a]	Sadness[a]	Sadness[a]	Sadness[a]
	4.57(1.57)	5.40(2.61)	6.81(2.11)	6.27(2.52)	5.17(2.17)	4.25(2.54)	5.34(2.34)	5.63(2.60)
	Happiness[a]	Confusion[b]	Confusion[b]	Confusion[b]	Amusement[a]	Alertness[b]	Upset[b]	Upset[b]
	4.11(2.26)	3.00(2.75)	1.88(2.13)	2.07(2.19)	4.81(2.13)	2.88(2.45)	3.79(3.17)	3.94(2.67)
	Alertness[a]	Alertness[b]	Anger[b]	Happiness[b]	Happiness[a]	Upset[b]	Interest[b]	Interest[b]
	3.79(2.26)	2.20(2.01)	1.31(2.55)	1.27(1.98)	4.17(2.51)	2.69(2.39)	2.64(2.62)	3.69(2.60)
MSBS Total	7.67(5.66)	20.78(8.29)[a]	21.30(7.54)[a]	19.11(6.29)[a]	5.52(4.89)	6.60(4.48)	9.00(5.05)	5.33(2.74)
DES Interest	9.96(4.80)	2.80(2.94)[a]	1.30(2.26)[a]	2.67(2.35)[a]	14.27(5.91)	8.50(5.99)	8.00(6.04)	10.78(5.72)
DES Sadness	2.74(2.82)	2.20(1.69)	1.80(3.58)	2.78(1.72)	1.30(1.84)	5.50(3.98)[a]	9.56(6.88)[a]	9.78(5.22)[a]
Pleasantness Ratings	5.25(1.58)[a]	4.33(2.13)[b]	2.69(.95)[b]	3.43(1.99)[b]	5.50(1.77)[a]	5.52(1.74)[b]	2.73(1.83)[b]	2.33(1.61)[b]

In the upper section of the table, [a] is significantly different from [b] in each *column*. In the lower section of the table, for each *row*, [a's] are not significantly different from each other. Similarly, [b's] are not significantly different from each other. Also, [a] is significantly different from [b] in each *row*.

Table 2. Study 1 – Correlations between SA questionnaire, MSBS, and DES.

Ratings on SA Questionnaire	MSBS Total	DES Interest	DES Sadness
Interest rating (baseline epoch)	.25	.41***	-.05
Boredom rating (171 s boring epoch)	-.05	-.80*	-.44
Boredom rating (233 s boring epoch)	.82***	-.56*	.44
Boredom rating (341 s boring epoch)	.56*	-.57*	0
Interest rating (neutral epoch)	-.46**	.52***	-.05
Amusement rating (neutral epoch)	-.38**	.66***	-.10
Happiness rating (neutral epoch)	-.39**	.46**	.12
Sadness rating (171 s sad epoch)	-.21	.38	.80***
Sadness rating (233 s sad epoch)	-.07	.38	.77**
Sadness rating (341 s sad epoch)	-.07	.39	.75**

*** p<.01, ** p<.05, * p<.15

Discussion

The purpose of this study was to develop video clips that would reliably induce the mood states of boredom and sadness that would serve as mood induction stimuli for Study 2, in which participants' psychophysiological responses to each state were monitored. With respect to the 'neutral' film clip, results showed that while participants felt somewhat more interested after watching this video when compared with baseline, there was no difference in the *valence* of participants' affective states. In other words, participants' experienced a state of interest while watching the so-called neutral video, but this state was very similar to their baseline state. With respect to boredom, each of the boring video clips was equally successful at eliciting boredom in terms of intensity and valence. Furthermore, while the relationships between boredom ratings on the SA questionnaire and total MSBS scores were only significant for the 233 s clip, they approached significance for the 341 s clip. That is, high boredom ratings on the SA questionnaire were associated with high scores on the MSBS - measures of state boredom - for the 233 s and 341 s boring clips. In terms of mood induction, it appears as though all three boring clips elicited boredom well, although the 233 s may have been slightly more reliable in doing so. All three sad videos elicited sadness equally well in terms of valence and intensity. Significant positive correlations were observed between participants' sadness ratings on the SA questionnaire and their total scores on the DES sadness subscale for all three sad clips. Thus, in terms of mood elicitation, any of the sad videos were suitable for use in Study 2. In terms of length, we chose the 233 s sad video in order to keep an equivalent length relative to the boredom inducing clip.

Study 2 – Psychophysiological Monitoring

The boring and sad videos developed above (i.e., 233 s versions) were used to induce the states of boredom and sadness in participants while psychophysiological parameters of heart rate, skin conductance, and cortisol levels were monitored. The ‘neutral’ video from Study 1 (also 233 s in length) was shown between the boring and sad videos to induce a state of interest, similar to participants’ baseline affective state. Because this interesting/'neutral' video clip induced interest, it offered the further opportunity to compare autonomic arousal during a state of boredom and during a state of interest.

Method

Participants

Participants were 72 undergraduate students from the University of Waterloo (44 women, mean age 18.93, ± 1.35; range 17 – 23 years) who participated in exchange for course credit. Individuals who participated in Study 1 were not eligible to participate in Study 2. All participants reported having normal or corrected to normal hearing and vision. None of the participants had a history of cardiac abnormalities nor were any taking medications that altered their heart rate and/or rhythm. Participants' eligibility criteria were the same as for Study 1. Participants' mean score on the BPS in the current sample was 96.24 (*SD*=10.67) and their mean BDI score was 6.00 (*SD*=4.20). This ensured that any participants who had a high propensity to experience boredom or were experiencing anything more than mild symptoms of depression were not included in the study (Beck et al., 1996). All procedures were reviewed by and received approval from the Office of Research Ethics at the University of Waterloo.

Measures

As in Study 1, the Boredom Proneness Scale (BPS), Beck Depression Inventory II (BDI-II), and the State Affect (SA) questionnaires were all utilized in Study 2. The sadness and interest subscales of the the Differential Emotions Scale (DES) and the same five items from the Multidimensional State Boredom Scale (MSBS) that were used in Study 1 were also used in Study 2.

Apparatus

Mood induction videos. Based on the results of Study 1, the 233 s boring video was shown to participants to elicit boredom, and the 233 s sad video was shown to induce sadness. The 233 s interesting/neutral video was identical to the 'neutral' video shown in Study 1 (Fothergill et al.; Gross & Levenson, 1995; Lovell & Zeffirelli, 1979).

Psychophysiological equipment. Monitoring of HR and SCL was carried out using equipment and software designed by the James Long Company (JLC; Caroga Lake, NY), and with the data-acquisition program Snap-Master™ for Windows.

Heart rate (HR). Heart rate was used as a measure of emotional activity. Past research has used this parameter to differentiate between positive and negative emotions and arousal (Winton, Putnam, & Krauss, 1984; Papillo & Shapiro, 1990). Heart rate (HR; in beats per minute) was recorded via two resting, conductive adhesive electrodes (CDI UMP3-P). The two electrodes were placed, laterally, on participants' torso, one on the left side and one on the right side at approximately the same level as the fifth rib (active sites). A third reference electrode was placed on the midline of participants' torso at the mid-sternum level. Before the electrodes were attached, participants' skin in these areas were cleansed with alcohol wipes and allowed to dry. ECG signals were amplified using a JLC Bioamplifier Output Box and SA Instrumentation Bioamplifiers (James Long Company). HR data were analyzed using a computer program (ECGRWAVE program by JLC) that utilized an algorithm to detect R-waves and artefacts. Artefacts (e.g., a body movement incorrectly coded as an R-wave) were corrected manually off line. R-waves that were missed by automated detection were also inserted manually by the experimenter, off line. HR values (number of R-waves per minute) were calculated on a second-by-second basis.

Skin conductance levels (SCL) Skin conductance levels measure the conductivity of the skin. Changes in the activity of endocrine sweat glands in the skin cause the conductivity to change, resulting in SCL fluctuations. Since endocrine sweat glands respond to psychological stimulation, rather than simply to physical or environmental changes, measures of SCL typically demonstrate a linear relation with both emotional arousal and cognitive activity (Boucsein, 1992; Lang, 1995; Stern et al., 2001). Skin conductance levels in the current study were measured by two silver/silver chloride (Ag-AgCl) electrodes (UFI 1081FG), placed on the palmar side of the medial phalanges of the third and fourth fingers of individuals' non-dominant hand with Velcro strips. Each electrode was filled with electroconductive gel (Electro-Gel) and the skin in these areas was cleansed with alcohol wipes prior to attachment. SCL were averaged over one second intervals and are reported in microsiemens (μS).

Electrocardiogram (HR) and SCL were measured continuously throughout the experiment. Epochs of interest were defined using a manual event marker, which was engaged by the experimenter to mark the beginning and end of each epoch. These measures were digitized at 512 samples per second with a 31-channel A/D converter operating at a resolution of 12 bits, with an input range of -2.5 volts to +2.5 volts. Amplification rates, high-pass filter (HPF), and low-pass filter (LPF) settings were as follows: ECG (Gain = 500 volt per microsiemens, HPF = 0.1 Hz, LPF = 1000 Hz) and SCL (Gain = 0.1 volt per microsiemens, HPF = none/DC, LPF = 10 Hz, 6 dB/octave, single pole RC; see Cacioppo, Tassinary, and Berntson, 2000 for review).

Cortisol. Activation of the hypothalamic-pituitary-adrenal (HPA) axis was measured by salivary cortisol levels. Salivary cortisol levels show a close linear relationship with plasma cortisol levels (Ansseau, 1984; Cook et al., 1986; Greenwood & Shutt, 2004; Harris et al., 1990).

Collection of salivary data involves a simple non-invasive procedure (Sanchez-Martin, Cardas, Ahedo, Fano, Echebarria, & Azpiroz, 2001). Four saliva samples were collected from each participant throughout the laboratory session, as described below, using the ‘Salivette’ device (Sarstedt, Montreal, Canada), which consists of a cotton swab in a capped plastic tube. Subjects were instructed to chew the cotton swab for approximately one minute, then place the saturated swab into the plastic tube. Tubes were stored at -20 °C. Once all data had been collected, the samples were sent off-site for biochemical analysis. After thawing, samples were centrifuged at 2700 rpm for 5 min. Free salivary cortisol levels were measured by a radioimmunoassay (RIA) with a scintillation proximity assay (SPA; Amersham Biosciences Europe, Freiburg, Germany). The lower detection limit of the assay is 150 pg/ml. Inter-assay and intra-assay coefficients of variance were 0.5. Test–retest reliability of the assay was assessed on 25 randomly selected saliva samples, using Pearson correlation coefficients ($r = 0.98$, $p < .001$). Results are reported in nanomols per litre (nmol/L).

Procedure

Upon arrival at the laboratory participants were asked to wash their hands using soap and water. The experimental protocol was explained to participants and written informed consent was obtained. Next, the HR and SCL electrodes were attached to participants by the experimenter and participants were asked to sit in a comfortable chair, with their eyes closed for a period of three minutes to become accustomed to the equipment and to establish their baseline physiological response. At the end of this baseline period, a cortisol sample was obtained, following which participants filled out all four of the self-report state affect measures (SA, MSBS items, DES sadness subscale, DES interest subscale). Next, participants watched either the 233 s boring video or the 233 s sad video (video order was counterbalanced). Immediately after watching the first video, another cortisol sample was collected and participants filled out the four self-report state affect measures. Participants next watched the interesting video. This video was always shown second and immediately after participants viewed it, another cortisol sample was collected by the experimenter and they filled out the four self-report state affect measures. Next, participants watched the third video, which was either the boring or the sad video. After the final video, a final cortisol sample was collected and participants filled out the four self-report affect measures one last time (Figure 1). As in Study 1, each participant watched three video clips (one boring, one interesting, one sad) during a single laboratory session lasting approximately 45 minutes. As video lengths were constant in Study 2, lab sessions were of equal length for all participants.

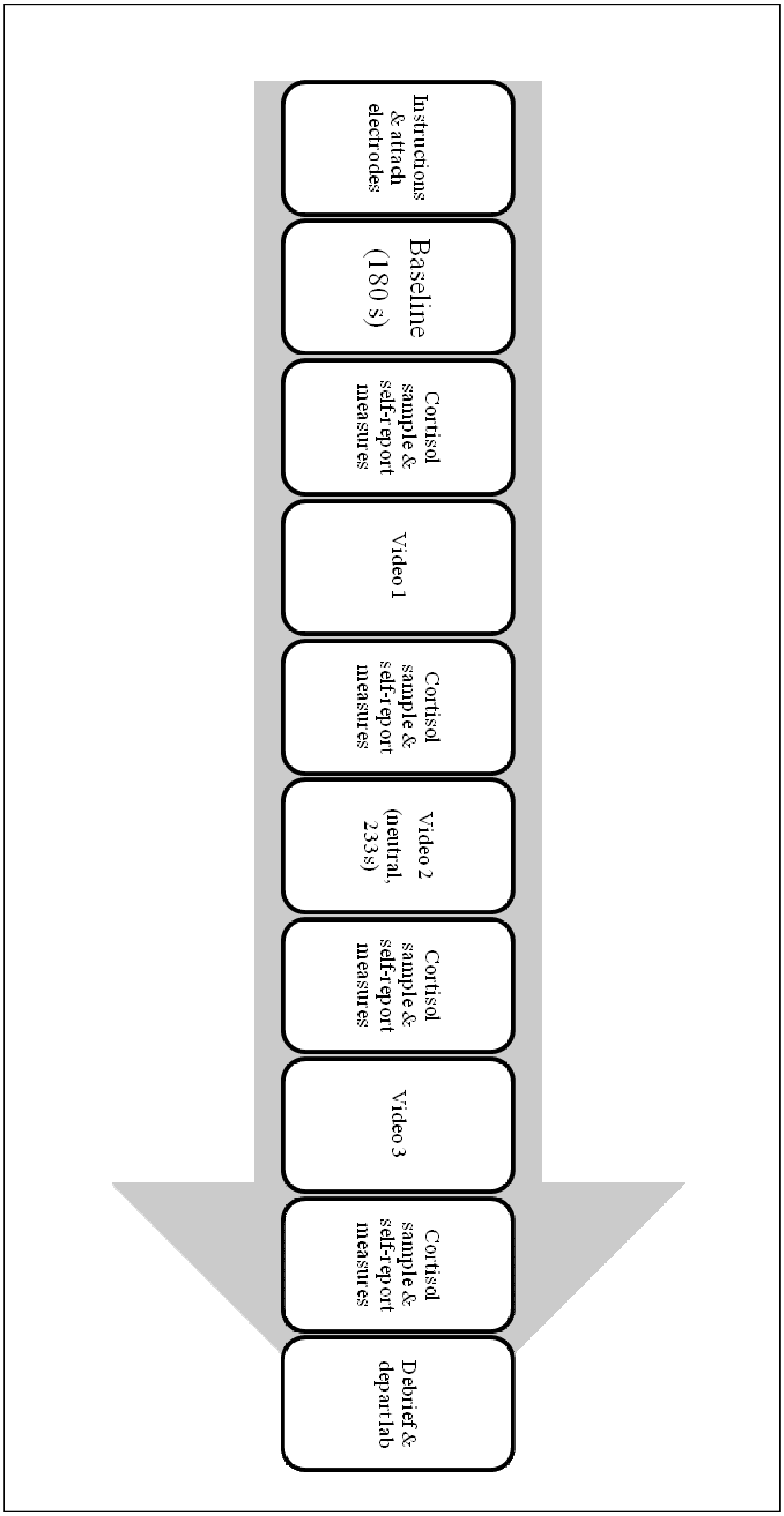

Figure 1. The laboratory protocol for Study 2.

Results

Mood Induction

Using the same procedure as in Study 1, a manipulation check was performed, as a first step, to ensure that each target emotion was elicited by the videos in the current sample and to determine which emotion(s) participants felt most strongly during the baseline period. Results were very close to those obtained in Study 1 such that boredom was strongly endorsed for the boring clip and sadness for the sad clip. Details of these analyses are presented in Appendix B. In other words, the video clips reliably induced their relevant target emotions (Tables 3 & 4, Appendix B).

Table 3. Study 2 – Means (SD) of video ratings.

	Epoch			
	Baseline	Boring	Neutral/Interesting	Sad
	Interest[a]	Boredom[a]	Interest[a]	Sadness[a]
	5.60(1.65)	5.54(2.37)	5.93(1.50)	5.10(1.85)
	Happiness[b]	Confusion[b]	Amusement[b]	Upset[b]
	4.53(2.09)	2.68(2.48)	5.44(1.85)	4.12(2.19)
	Excitement[b]	Amusement[b]	Happiness[c]	Interest[b]
	3.75(1.97)	2.53(2.56)	4.72(2.03)	3.84(1.98)
MSBS Total	7.76(6.18)[a]	18.66(8.56)[b]	5.09(6.76)[c]	5.52(6.20)[c]
DES Interest	10.68(5.34)[a]	2.98(3.89)[b]	14.15(5.38)[c]	9.56(5.28)[a]
DES Sadness	1.93(3.51)[a]	1.22(2.91)[a]	.74(1.83)[a]	8.72(4.62)[b]
Pleasantness	5.87(1.19)[a]	3.24(1.87)[b]	6.18(1.51)[a]	2.63(1.51)[b]

In the upper section of the table, [a] is significantly different from [b] in each *column*. In the lower section of the table, [a], [b], & [c] are all significantly different from each other in each *row*.

Table 4. Study 2 – Correlations between SA questionnaire, MSBS, and DES.

	MSBS Total	DES Interest	DES Sadness
Interest rating (baseline epoch)	.21	.41***	-.03
Boredom rating (boring epoch)	.82***	-.56***	.18
Interest rating (neutral epoch)	-.46**	.52***	-.28*
Amusement rating (neutral epoch)	-.38*	.66**	-.11
Happiness rating (neutral epoch)	-.39*	.46*	-.14
Sadness rating (sad epoch)	-.01	.26	.77*

*** p<.001, ** p<.01, * p<.05

Psychophysiological Measures

Data Analyses. Due to technical difficulties with the psychophysiological monitoring equipment, ECG and SCL data were only collected for 47 participants (21 males, 26 females). No differences related to gender or culture were observed across any of the psychophysiological data. As such, all of the analyses that follow are based on the entire sample of 47 participants who completed the physiological monitoring. Overall epoch means were calculated based on the mean raw estimates for each participant, during each epoch (Table 5 & Figure 2). Data were then subjected to within-subjects repeated measures ANOVAs with epoch (baseline, boredom, neutral, sadness) as the within-subjects factor and mean psychophysiological parameter (HR, SCL, cortisol level) as the dependent variables. Multiple comparisons of each epoch were made using paired-samples *t*-tests. Next, the raw HR and SCL data, for each epoch, were binned into 30-second intervals and means of each 30 s interval were calculated for each participant (Table 6). Within-subjects repeated measures ANOVAs were carried out with epoch (baseline, boredom, neutral, sadness) and interval (30 s, 60 s, 90 s, 120 s, 150 s, 180 s, 210 s, 230 s) as within-subjects factors. Multiple comparisons were conducted using paired-samples *t*-tests. In addition, least squares regression analyses were conducted for each epoch to determine r^2 and slope values (Table 7 & Figure 3). Bonferroni corrections were employed for all multiple comparisons to control for Type 1 (alpha) errors.

Results. ***Heart rate.*** Relative to baseline, decreases in HR were observed across the boring, interesting, and sad epochs. A repeated measures ANOVA, with a Greenhouse-Geisser correction, indicated that the differences in participants' HR across epochs were significant [$F(2.3,100.5)=17.53$, $p<.001$, $\eta^2=.29$]. Multiple comparisons revealed that HR during baseline was significantly higher than all other epochs (all t's>2.84, all p's<.001). Mean HR during the boring epoch trended towards being significantly higher than during the neutral/interesting epoch [$t(45)=1.53$, $p=.13$] and the sad epoch [$t(45)=1.50$, $p=.14$]. Mean HR during the sad epoch and the neutral/interesting epoch did not differ [$t(44)=.24$, $p=.81$; Table 5, Figure 2]. Next, means of each 30 s interval were compared between all four epochs. As expected, there was a significant effect of epoch [$F(2.5,102.6)=25.36$, $p<.001$, $\eta^2=.38$], such that HR during the baseline epoch was significantly higher than during any other epoch. There was also a significant effect of interval [$F(3.7,151.7)=3.89$, $p<.001$, $\eta^2=.09$], that was subsumed by a significant interaction of epoch by interval [$F(8.5,349.6)=3.85$, $p<.001$, $\eta^2=.09$; Table 6].

Table 5. Epoch means for HR, SCL, and cortisol.

	Epoch			
	Baseline	Boredom	Neutral/Interesting	Sadness
mean HR	75.20(10.87)^a	72.73(9.82)^b	71.74(9.52)^e	71.84(9.77)^e
mean SCL	6.30(2.75)^a	8.57(3.45)^b	9.21(8.32)^c	9.66(4.44)^d
mean cortisol	14.25(12.36)^a	13.39(8.90)^a	-	11.04(8.02)^b

For each row, ^{a}, ^{b}, ^{c}, and ^{d} are all significantly different from each other. In addition, ^{b} and ^{e} trend toward being significantly different from each other at $p<.15$.

Table 6. HR and SCL means of 30 s intervals for each epoch.

Time Interval (s)	Baseline	Boredom	Neutral/Interesting	Sadness
		HR		
30	74.38 (10.93)	72.55 (10.56)	72.97(9.91)	71.51(10.64)
60	74.81 (10.64)	74.80 (10.86)	71.44(10.45)	71.13(10.79)
90	75.47(11.91)	72.07 (10.64)	70.22(10.38)	70.52(9.87)
120	75.59 (10.61)	71.95 (9.87)	70.04(10.32)	71.95(10.35)
150	75.63 (10.63)	72.94 (9.94)	71.90(9.51)	71.28(9.42)
180	76.04 (10.78)	72.92 (9.78)	72.00(9.54)	71.15(9.76)
210	-	72.32 (10.14)	71.89(9.80)	71.00(9.97)
233	-	73.04 (10.38)	70.98(10.15)	72.57(10.57)
		SCL		
30	6.36(2.58)	9.20(3.69)	10.17(4.21)	10.20(4.53)
60	6.31(2.73)	8.81(3.37)	9.75(4.11)	9.81(4.43)
90	6.32(2.81)	8.57(3.31)	9.38(4.06)	9.54(4.37)
120	6.26(2.88)	8.34(3.26)	9.00(3.99)	9.31(4.39)
150	6.30(2.96)	8.12(3.28)	8.70(3.97)	9.19(4.38)
180	6.30(3.12)	7.94(3.33)	8.52(3.95)	9.12(4.45)
210	-	7.95(3.57)	8.38(3.99)	9.31(4.61)
233	-	8.37(3.88)	8.67(4.15)	9.57(4.66)

To further explore the epoch by interval interaction, linear regression equations were calculated for the group data and were found to be significant for the baseline and boring epochs only (Table 7 & Figure 3). For the baseline epoch, there was a significant increase in HR over time [r^2= .31, $F(1,177) = 79.46$, $p<.001$; β=.56, t=8.91, $p<.001$]. The same pattern was found during the boring epoch; that is, HR increased significantly over time [r^2= .05, $F(1,231) = 12.25$, $p<.001$; β=.22, t=3.50, $p<.01$]. Regression equations for the sad epoch and the neutral epoch were not significant, indicating that HR during those epochs did not change significantly (Table 7, Figure 3).

Table 7. Curve measures for HR and SCL during each epoch.

	Baseline		Boredom		Neutral/Interesting		Sadness	
	r^2	Slope	r^2	Slope	r^2	Slope	r^2	Slope
HR	.31*	.56*	.05*	.22*	.01	-.07	.01	.08
SCL	.70*	-.83*	.95*	-.98*	.97*	-.99*	.85*	-.92*

* $p<.05$

Finally, scores on the BPS were found to be significantly correlated with mean HR during both the baseline (r=.31, p=.03) and the boring epoch (r=.33, p=.03), indicating that participants who scored higher on the measure of trait boredom also had higher HRs during baseline and the boring video, while those who scored lower in trait boredom tended to have lower HRs during the same epochs. No other correlations between the self-report and physiological measures were significant.

Skin conductance. In contrast to the HR findings, increases in SCL were observed across the boring, interesting, and sad epochs, relative to baseline. A repeated measures ANOVA, with a Greenhouse-Geisser correction, indicated that the differences in participants' SCL across epochs were significant [$F(1.7,75.4)=64.64$, $p<.001$, η^2=.59]. Multiple comparisons revealed that

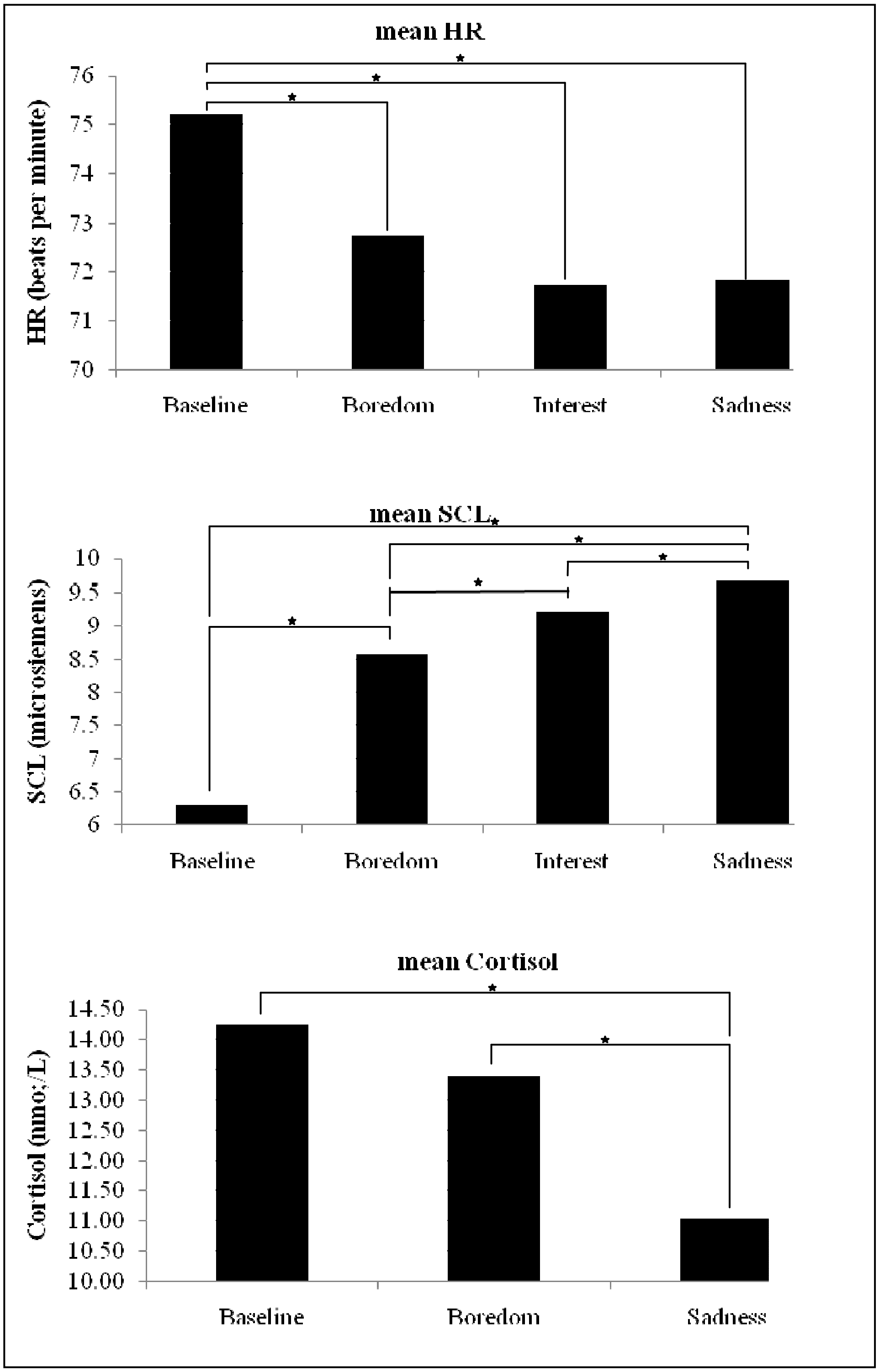

Figure 2. Mean HR, SCL, and cortisol values for each epoch. Significant differences are indicated

SCL during baseline was significantly lower than all other epochs (all t's>8.48, all p's<.001).

Mean SCL during the boring epoch was significantly lower than during the neutral [$t(46)=2.11$, $p=.04$] and sad epochs [$t(45)=4.08$, $p<.001$]. Finally, mean SCL during the sad epoch was significantly higher than during the neutral epoch [$t(45)=2.82$, $p=.01$; Table 5, Figure 2]. As was done for HR, means of each 30 s interval were compared between all four epochs (Table 6). Results indicated there was a significant effect of epoch [$F(1.6,68)=66.64$, $p<.001$, $\eta^2=.61$]. There was significant effect of interval [$F(1.5,62.5)=70.67$, $p<.001$, $\eta^2=.62$], that was subsumed by a significant interaction of epoch by interval [$F(2.9,126.2)=15.97$, $p<.001$, $\eta^2=.27$], such that SCL during the neutral epoch decreased over time more so than for any other epoch. Linear regression equations were found to be significant for the mean SCL values during each epoch. That is, for each epoch, participants' mean SCL decreased systematically over time (Table 7, Figure 3).

Cortisol. Relative to baseline, decreases in salivary cortisol were observed across the boring, neutral, and sad epochs. First, a repeated measures ANOVA was conducted with epoch (baseline, boredom, neutral, sadness) as the within-subjects factor and mean cortisol level during each epoch as the dependent variable. Results indicated that there were differences in mean cortisol levels across epochs [$F(1.8,116.5)=5.50$, $p=.01$, $\eta^2=.08$]. Multiple comparisons (with Bonferroni corrections) revealed that cortisol levels during baseline were significantly higher than during the boring, neutral, and sad epochs (all t's>2.28, all p's<.05). No other differences were observed in cortisol levels across epochs. Due to the time required for changes in cortisol levels to become detectable in the saliva (de Weerth, Graat, Buitelaar, & Thijssen, 2003), any changes in cortisol levels for the boring or sad epochs likely would not be measureable until the end of the subsequent neutral epoch. That is, the effects of boredom or sadness on cortisol levels would take approximately 20 minutes to accrue (de Weerth, Graat, Buitelaar, & Thijssen, 2003). The measures taken directly after watching each video were taken after only approximately 4 minutes. To account for this, a second repeated measures ANOVA was carried out with different epochs as the within-subjects factor. Changes in cortisol levels that occurred during the boring epoch were measured by analyzing mean cortisol values from the end of the subsequent neutral epoch (i.e., approximately 10 minutes after commencing the boring video), for trials when the boring video was shown first (boring + neutral; n=34). Similarly, changes in cortisol levels that occurred during the sad epoch were measured by analyzing the mean cortisol values from the end of the neutral epoch that followed the sad video, for participants who viewed the sad video first (sad + neutral; n=34). Thus, the between-subjects factor for this ANOVA was epoch (baseline, boring+neutral, sad+neutral) with mean cortisol level as the dependent variable. Results indicated that there were significant differences in cortisol levels across epochs [$F(1.7,55.8)=5.50$, $p=.01$, $\eta^2=.08$]. Multiple comparisons revealed that cortisol levels were highest during baseline. Mean cortisol levels during baseline were not significantly different than after the boring induction [$t(33)=.66$, $p=.51$]; however, they were significantly higher than after the sad induction [$t(33)=3.06$, $p=.01$]. Mean cortisol levels after the boring induction were significantly higher than after the sad induction [$t(33)=2.28$, $p=.03$; Table 5, Figure 3].

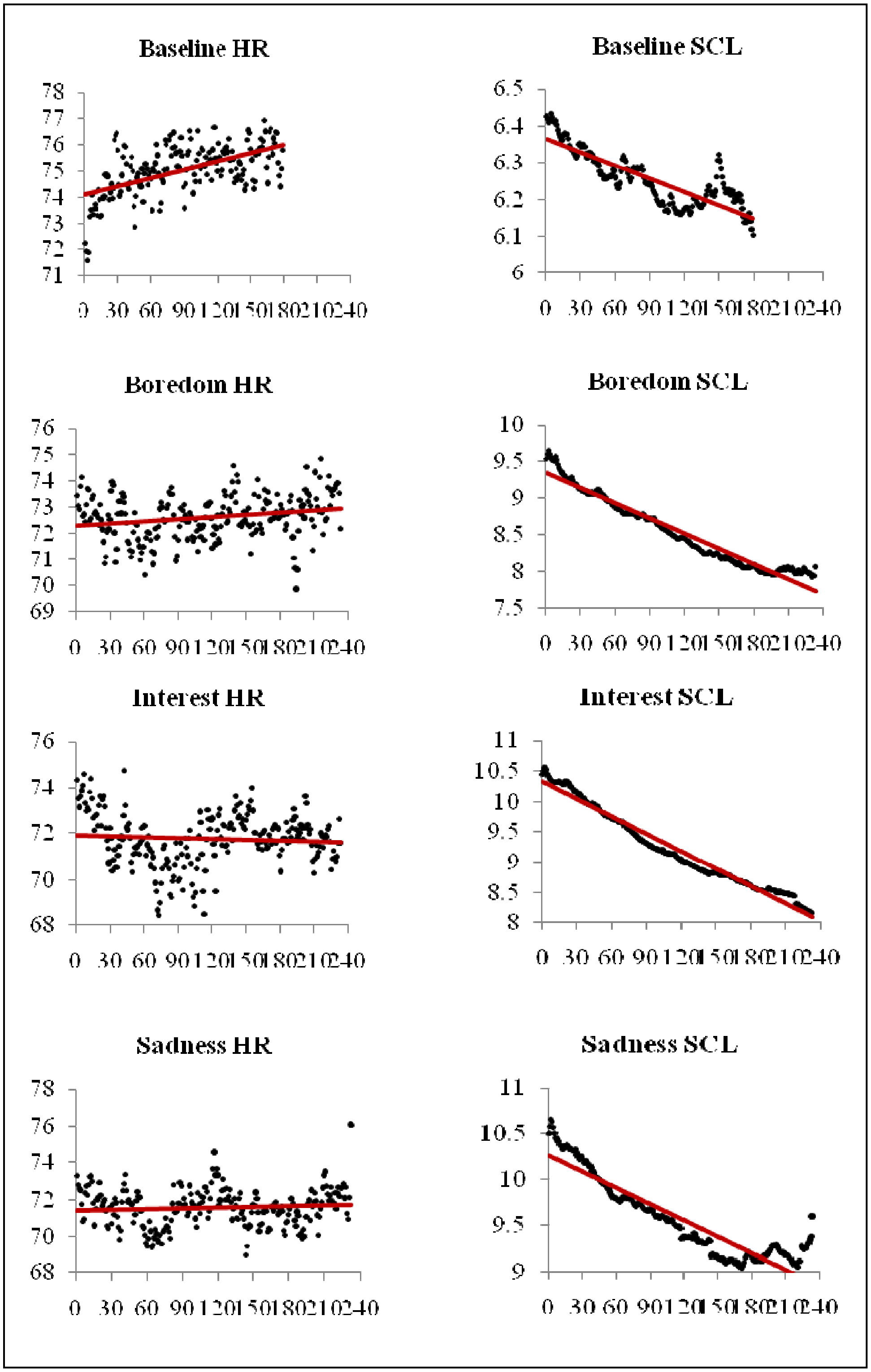

Figure 3. Second-by-second HR and SCL means for each epoch with linear regression line.

Discussion

Despite the breadth of research investigating various facets of boredom, it has remained unclear whether boredom is a distinct affective construct, or whether it is a symptom of other syndromes, such as depression. Although self-reported boredom has been distinguished from self-reported symptoms of depression (Goldberg, 2008), the constructs have not been compared at a behavioural or physiological level. The primary aim of the present study, therefore, was to distinguish the physiological signatures of boredom and sadness (i.e., as an analogue of depression). By examining their physiology, and circumventing the inherent limitations of psychometric instruments, it may be possible to more clearly distinguish these closely related constructs. In addition, research has been divided as to whether boredom can be characterized as an agitated state of increased physiological arousal, or as an apathetic state, characterized by inertia, and decreased physiological arousal. A secondary aim of this research, therefore, was to investigate whether the state of boredom is characterized by an increase or a decrease in arousal. More specifically, we investigated whether boredom was psychophysiologically distinct from the related state of sadness (a primary symptom of depression) and a neutral/interested state by monitoring changes in HR, SCL, and salivary cortisol concentration.

Results indicated that boredom, sadness, and the neutral/interested state were all associated with lower mean HRs, lower cortisol levels, and higher SCL relative to participants' baseline affective state. Thus, results suggest that the baseline state may have been the most physiologically arousing. The baseline state may well reflect a relatively high level of state anxiety given that participants are placed in a foreign circumstance and were asked to expose their chest to allow a stranger to attach electrodes. Also, given the relatively short duration of the baseline period (180 s), participants may not have had time to habituate to the laboratory environment. As such, higher arousal during this period is not unexpected. Furthermore, because all hypotheses concerning the present study involved differences between boredom and sadness, all future discussion will concern the direct comparisons of boredom and sadness only. Where relevant, differences involving the neutral/interested state will be considered.

With respect to HR, mean HR during the boring epoch trended towards being higher than during the sad epoch. In addition, when comparing the time course of HR changes during these periods, boredom was associated with a linear increase in HR over time whereas the slope of the regression line for HR during the sad epoch was not significant. This indicated that HR increased over the duration of the boring video, whereas it did not change significantly over time during the sad epoch. With respect to SCL, directly comparing boredom and sadness revealed that boredom resulted in a significantly lower mean SCL than did sadness. Considering changes in SCL over time, significant linear decreases in SCL were observed over each epoch.

Results of the HR and SCL monitoring were divergent, with boredom resulting in an increasing HR and lower SCL compared to both sadness and the neutral/interested state. On one hand, increasing HR would indicate increasing autonomic arousal; whereas lower SCL typically indicate lower autonomic arousal. Heart rate and SCL are both modulated by the ANS and within this system the sympathetic and parasympathetic branches are responsible for arousal (increased HR and SCL) and relaxation (decreased HR and SCL), respectively. However, changes in ANS function as measured by HR/SCL may be related to a number of processes including effort and attention (Öhman, Hamm, & Hugdahl, 2000), such that the changes seen here may not be exclusively related to emotional responding (Berntson & Cacioppo, 2000; Obrist, Webb, Sutterer, & Howard, 1970; Stemmler, 2004).

With respect to boredom, it may be especially important to consider the role of attention in modulating ANS reactivity. Research has suggested that the physiological signature of an emotional state can often be characterized by a pattern termed 'directional fractionation', in which HR and SCL are altered in opposing ways (Lacey, 1959). Considering the physiological patterns associated with attention, research suggests that SCL reflects the general engagement of attention during performance of a task, with lower SCL related to decreased attention (Frith & Allen, 1983). Indeed, a study by O'Connell and colleagues (2008) reported increased skin conductance and improved accuracy on the Sustained Attention to Response Task (SART) after an attention training paradigm. In contrast, vigilance decrements, or reductions in the ability to sustain attention over time, were observed in the control condition and were associated with reduced skin conductance levels (O'Connell, Bellgrove, Dockree, Lau, Fitzgerald, & Robertson, 2008). Research has also demonstrated a close relationship between attention and heart rate such that heart rate slows while attending (Coles, 1972; Lacey & Lacey, 1970; Papillo & Shapiro, 1990; Porges & Raskin, 1969; Ravaja, 2004; Turpin, 1986). Interestingly, the pattern of directional fractionation observed here for boredom (i.e., increased HR with decreased SCL) has also been observed in individuals with Attention Deficit Hyperactivity Disorder (ADHD; Hermens, Williams, Lazzaro, Whitmont, Melkonian, & Gordon, 2004; Losoya, 1995; Snoek, Van Goozen, Matthys, Buitelaar, & Van Engeland, 2004). Furthermore, in related research, we recently found a strong positive correlation between high levels of boredom proneness (as measured by the BPS) and adult symptoms of ADHD (r=0.59, p<.001; Merrifield & Danckert, in preparation). This association was even more robust than the correlation between boredom proneness (as measured by the BPS) and symptoms of depression measured by the BDI-II. In the current study, participants reported that their minds wandered (a measure of inattention) significantly more during the boring video than during either the sad or interesting/neutral videos (Appendix B), further evidence that the state of boredom was associated with decreased attention. Thus, the current results would suggest that boredom can be described as a negative affective state associated with increased arousal (i.e., increasing HR; higher cortisol levels), and decreased attention (lower SCL). Not only does this account fit the directional fractionation of the HR and SCL responses, it also fits with the divergent subjective descriptions of the experience of boredom, in which individuals report being agitated yet unable to engage in meaningful activities.

With respect to the cortisol findings, the boring induction resulted in significantly higher salivary cortisol levels than did the sad induction. Thus, the cortisol results support the notion that boredom is associated with overall increased physiological arousal. This finding is also consistent with other research indicating that activation of the HPA axis often co-occurs with sympathetic activation and that negative emotional states can activate both systems (LeDoux, 1996; Southwick et al., 1993). That is, when the sympathetic nervous system (SNS) is activated in response to negative emotions (among other things), sympathetic nerves that innervate the adrenal glands directly enhance the HPA axis response. Thus, concurrent activation of the HPA axis and the SNS in response to negative emotional states such as boredom would be expected.

Although boredom seems to be associated with an overall increase in physiological arousal compared to sadness and interest, it is worth noting that this response is small in comparison to other, more objectively arousing events. For example, research suggests that HR and skin conductance values associated with objectively arousing events such as the anticipation of giving a speech, being judged, or intense navy training, tend to be higher than reported here (e.g., de Rooij, Schene, Phillips, & Roseboom, 2010; Hofmann, Moscovitch, & Kim, 2005;

Lackschewitz, Huther, Kroner-Herwig, 2008; Strahler, Mueller, Rosenloecher, Kirschbaum, & Rohleder, 2010). In this context, boredom may be considered to be less stressful or anxiety provoking than the kinds of behaviours mentioned above. Alternatively, the changes observed here may be reflective not of stress or anxiety per se but rather may reflect the agitation experienced during an episode of boredom. Further research would be necessary to disentangle these two possibilities.

Given that boredom seems to result in slight increases in autonomic and HPA axis arousal, an important next step in this line of research would be to examine the effects of chronic boredom on physical and mental health. It was recently suggested that the cumulative effects of boredom may be associated with cardiovascular disease and early death (Britton & Shipley, 2010). Undoubtedly, there are other variables that may have contributed to this finding, including associations between boredom proneness and potentially harmful characteristics such as sensation-seeking, impulsivity, and addiction (Sommers & Vodanovich, 2000). Or, perhaps because activity is less appealing to those who are prone to experiencing boredom, they are more likely to lead a sedentary lifestyle, resulting in increased incidence of cardiovascular disease. Given the well-established links between stress, cortisol, and cardiovascular disease (for example, Hiromichi, 2010; Looser, Metzenthin, Helfricht, Kudielka, Loerbroks, Thayer, & Fischer, 2010), it may be worthwhile to examine whether those who are boredom-prone experience chronic, low-level increases in sympathetic and HPA axis activation and whether such increases have long-term health consequences. Furthermore, the effects of chronic boredom could be further examined with respect to depression. One of the most highly replicated findings in biological psychiatry is the association of prolonged hypersecretion of HPA axis hormones, including cortisol, and depression (Nemeroff & Evans, 1984; Sachar et al., 1985; Varghese &

Brown, 2001). Examination of the relationships between boredom, depression, and chronic but low levels of cortisol may further illuminate the links between these highly related emotional states.

Finally, another important avenue of future inquiry would be to further examine the links between boredom and attention. Results of this study converge with other research suggesting that boredom may be associated with inattention (Carriere, Cheyne, & Smilek, 2007; Cheyne, Carriere, & Smilek, 2006; Ohsuga et al., 2001; Pattyn et al., 2008). Examining boredom with respect to both transient and sustained measures of attention would shed further light on the nature of the experience. As boredom is associated with such adverse conditions as depression, ADHD, and TBI, investigating boredom in individuals with attention deficits, such as in ADHD, may help us to better understand how the cognitive profile of boredom is different from these related syndromes. A more thorough understanding of these constructs, in turn, is an integral step in designing and implementing effective treatments.

References

Abrams, S. E. (2003). Chronic illness: “Chronic” boredom. *Public Health Nursing, 20*, 250-251.

American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders. Fourth Edition (DSM-IV). Washington, DC: Author.

Ansseau, M. (1984). Use of saliva cortisol in the dexamethasone suppression test. *Psychiatry Research, 13*, 203-211.

Baker, R., D'Mello, S., Rodrigo, M., & Graesser, A. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive affective states during interactions with three different computer-based learning environments. *International Journal of Human-Computer Studies, 68*, 223-241.

Barmack, J. E. (1939). A definition of boredom: A reply to Mr. Berman. *The American Journal of Psychology, 52*, 467-471.

Beck, A.T., Steer, R.A., & Brown, G.K. (1996). *Manual for the Beck Depression Inventory-II.* San Antonio, TX: Psychological Corporation.

Berlyne, D. E. (1960). *Conflict, Arousal, and Curiosity*. McGraw-Hill, New York, NY.

Berntson, G. G. & Cacioppo, J. T. (2000). Psychobiology and social psychology: Past, present, and future. *Personality and Social Psychology Review, 4*, 3-15.

Blaszczynski, A., McConaghy, N., & Frankova, A. (1990). Boredom proneness in pathological gambling. *Psychological Reports, 67*, 35-42.

Binnema, D. (2004). Interrelations of psychiatric patient experiences of boredom and mental health. *Issues in Mental Health Nursing, 25*:8, 833-842.

Boucsein, W. (1992). *Electrodermal Activity*. New York, Ny, USA: Plenum Press.

Bracke, P., Bruynooghe, K., & Verhaeghe, M. (2006). Boredom during day activity programs in rehabilitation centers. *Sociological Perspectives, 49*, 191-215.

Britton, A. & Shipley, M. J. (2010). Bored to death? *International Journal of Epidemiology, 39*, 370-371.

Cacioppo, J. T., Tassinary, L. G., Berntson, G. G. (2000). Psychophysiological Science. In J. T. Cacioppo, L. G. Tassinary, G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 3-23). Cambridge, UK: Cambridge University Press.

Carriere, J.S.A., Cheyne, J. A., & Smilek, D. (2007). Everyday attention lapses and memory failures: The affective consequences of mindlessness. *Consciousness and Cognition, 17*, 835-847.

Cheyne, J.A., Carriere, J.S.A., & Smilek, D. (2006). Absent-mindedness: Lapses of conscious awareness and everyday cognitive failures. *Consciousness and Cognition, 15*, 578-592.

Charlton, J., & Hertz, R. (1989). Guarding against boredom: Security specialists in the U.S. air force. *Journal of Contemporary Ethnography, 18*, 299-326.

Coles, M.G.H. (1972). Cardiac and respiratory activity during visual search. *Journal of Experimental Psychology, 96,* 371-379.

Cook, N., Harris, B., Walker, R., & Hailwood, R. (1986). Clinical utility of the dexamethasone suppression test assessed by plasma and salivary cortisol determinations. *Psychiatry Research, 18*, 143-150.

Culp, N. A. (2006). The relations of two facets of boredom proneness with the major dimensions of personality. *Personality and Individual Differences, 41*, 999-1007.

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. *Accident Analysis and Prevention, 37*, 341-348.

Damrad-Frye, R. & Liard, J. D. (1989). The experience of boredom: The role of the self perception of attention. *Journal of Personality and Social Psychology, 57*, 315-320.

Danckert, J. A. & Allman, A. A. (2005). Time flies when you're having fun: Temporal estimation and the experience of boredom. *Brain and Cognition, 59*, 236-245.

de Rooij, S. R., Schene, A. H., Phillips, D. I., & Roseboom, T. J. (2010). Depression and anxiety: Associations with biological and perceived stress reactivity to a psychological stress protocol in a middle-aged population. *Psychoneuroendocrinology, 35,* 866-877.

de Weerth, C., Graat, G., Buitelaar, J. K., & Thijssen, J. H. H. (2003). Measurement of cortisol in small quantities of saliva. *Clinical Chemistry, 49*, 658-660.

Ekman, P., Friesen, W. V., & Ancoli (1980). Relative importance of face, body, and speech judgements of personality and affect. *Journal of Personality and Social Psychology, 38*, 270-277.

Fahlman, S.A., Mercer, K.B., Flora, D.B., & Eastwood, J.D. (2008). Development and validation of the Multidimensional State Boredom Scale (MSBS). Manuscript submitted for publication.

Farmer, R. & Sundberg, N. D. (1986). Boredom proneness – The development and correlates of a new scale. *Journal of Personality Assessment, 50*, 4-17.

Fenichel, H. (1951). Review of the literature on boredom. The Psychoanalytic Quarterly, 20, 345-346.

Ferrell, J. (2004). Boredom, crime and criminology. *Theoretical Criminology, 8*, 287-302.

Fothergill, A, (director), Berlowitz, V., Malone, S., & Lemire, M. (producers). (2007). Planet Earth [film]. Warner Home Video, Burbank, CA, USA.

Frith, C. D. & Allen, H. A. (1983).The skin conductance orienting response as an index of attention. *Biological Psychology, 17*, 27-39.

Game, A. M. (2007). Workplace boredom coping: Health, safety, and HR implications. *Personnel Review, 36*(5), 701-721.

Giewitz, P. J. (1966). Structure of boredom. *Journal of Personality and Social Psychology, 3*, 592-600.

Goldberg, Y. K. (2008). Establishing the construct of boredom as distinct from apathy, anhedonia, and depression. Unpublished masters thesis, University of Waterloo, Waterloo, ON.

Gordon, A., Wilkinson, R., McGowan, A., & Jovanoska, S. (1997). The psychometric properties of the boredom proneness scale: An examination of its validity. *Psychological Studies, 42*, 85-97.

Greenwood, P. & Shutt, D. (2004). Salivary and plasma cortisol as an index of stress in goats. *Australian Veterinary, 69*, 161-163.

Grose, V. L. (1989). Coping with boredom in the cockpit before it's too late. *Professional Safety, 34*, 24-26.

Gross J. J. & Levenson, R. W. (1995). Emotion elicitation using films. *Cognition & Emotion, 9*, 87-108.

Hamilton, J. A. (1981). Attention, personality and the self-regulation of moos: Absorbing interest and boredom. *Progress in Experimental Personality Research, 10*, 281-315.

Hamilton, J. A., Haier, R. J., & Buchsbaum, M. S. (1984). Intrinsic enjoyment and boredom coping scales: Validation with personality, evoked potential and attention measures. *Personality and Individual Differences, 5*, 183-193.

Harris, B., Watkins, S., Cook, N., & Walker, R. F. (1990). Comparisons of plasma and salivary cortisol determinations for the diagnostic efficacy of the dexamethasone suppression test. *Biological Psychiatry, 27*, 897-904.

Hebb, D. O. (1955). Drives and the CNS (conceptual nervous system). *Psychological Review, 62*, 243-254.

Hermens, D. F., Williams, L. M., Lazzaro, I., Whitmont, S., Melkonian, D., & Gordon, E. (2004). Sex differences in adult ADHD: A double dissociation in brain activity and autonomic arousal. *Biological Psychology, 66*, 221-233.

Hill, A. B. & Perkins, R. E. (1985). Towards a model of boredom. *British Journal of Psychology, 76*, 235-240.

Hiromichi, W. (2010). Salivary cortisol is related to coronary heart disease risk [abstract]. 74th Annual Scientific Meeting of the Japanese Circulation Society (JCS 2010), International Conference Center and Grand Prince Hotel, Kyoto, 5-7 Mar 2010.

Hofmann, S. G., Moscovitch, D. A., & Kim, H.-J. (2005). Autonomic correlates of social anxiety and embarrassment in shy and non-shy individuals. *International Journal of Psychophyiology, 61*, 143-142.

Iso-Ahola, S. E., & Weissinger, E. (1987). Leisure and boredom. *Journal of Social and Clinical Psychology, 5*(3), 356-364.

Izard, C. E., Libero, D. Z., Putnam, P., & Haynes, O. M. (1993). Stability of emotion experience and their relations to traits of personality. *Journal of Personality and Social Psychology, 64*, 847-860.

Kamphuis, M.D., Geerlings, M.I., Dekker, J.M., Giampaoli, S., Nissinen, A., Grobbee, D.E., & Kromhout, D. (2007). Autonomic dysfunction: a link between depression and cardiovascular mortality? The FINE Study. *European Journal Cardiovascular Prevention & Rehabilitaion. 14*, 796–802.

Kass, S. J., Vodanovich, S. J., & Callender, A. (2001). State-Trait boredom: Relationship to absenteeism, tenure, and job satisfaction. *Journal of Business and Psychology, 16*, 317-327.

Lacey, J. I. (1959). Psychophysiological approaches to the evaluation of psychotherapeutic process and outcome. In E. A. Rubinstein & M. B. Parloff (Eds.). *Research in Psychotherapy*, Washington, DC, USA: American Psychological Association.

Lacey, J. I. & Lacey, B. C. (1970). Some autonomic-central nervous system interrelationships. In P. Black (Ed.), *Physiological Correlates of Emotion* (pp. 205-228). New York, NY, USA: Academic Press.

Lackschewitz, H., Huther, G., & Kroner-Herwig, B. (2008). Physiological and psychological stress responses in adults with attention-deficit/hyperactivity disorder (ADHD). *Psychoneuroendocrinology, 33*, 612-624.

Lang, P. J. (1995). The emotion probe. Studies of motivation and attention. *American Psychologist, 50*, 372-385.

LeDoux, I. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. New York, NY, USA: Simon & Schuster.

Leong, F. T. L. & Schneller, G. R. (1993). Boredom proneness: Temperamental and cognitive components. *Personality and Individual Differences, 14*, 233-239.

London, H., Schubert, D. S., & Washburn, D. (1972). Increase of autonomic arousal by boredom. *Journal of Abnormal Psychology, 80*, 29-36.

Looser, R. R., Metzenthin, P., Helfricht, S., Kudielka, B. M., Loerbroks, A., Thayer, J. F., & Fischer, J. E. (2010). Cortisol is significantly correlated with cardiovascular responses during high levels of stress in critical care personnel. *Psychosomatic Medicine, 72,* 281-289.

Losoya, S. H. (1995). Patterns of emotional responding in children with and without attention-deficit hyperactivity disorder. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 55*, 5097.

Lovell, D. (producer) & Zeffirelli, F. (director). (1979). *The Champ* [film]. MGM/Pathe Home Video, Culver City, CA, USA.

Lundberg, U., Melin, B., Gary, W. E., & Holmberg, L. (1993). Physiological deactivation after two contrasting tasks at a video display terminal: Learning versus repetitive data entry. *Ergonomics, 36*, 601-611.

Martin, M., Sadlo, G., & Stew, G. (2006). The phenomenon of boredom. *Qualitative Research in Psychology, 3*, 193-211.

McGiboney, G. W. & Carter, C. (1988). Boredom proneness and adolescents' personalities. *Psychological Reports, 63*, 741-742.

Mikulas, W. L. & Vodanovich, S. J. (1993). The essence of boredom. *The Psychological Record, 43*, 3-12

Nemeroff, C. B. & Evans, D. L. (1984). Correlation between the dexamethasone suppression test in depressed patients and clinical response. *American Journal of Psychiatry, 141*, 247-249.

Obrist, P. A., Webb, R. A., Sutterer, J. R., & Howard, J. L. (1970). Cardiac deceleration and reaction time: An evaluation of two hypotheses. *Psychophysiology, 6,* 695-706.

O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., Lau, A., Fitzgerald, M, & Robertson, I. H. (2008). Self-alert training: Volitional modulation of autonomic arousal improves sustained attention. *Neuropsychologia, 46*, 1379-1390.

Öhman, A., Hamm, A., & Hugdahl, K. (2000). Cognition and the autonomic nervous system: Orienting anticipation, and conditioning. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of Psychophysiology* (2nd ed.). New York, NY, USA: Cambridge University Press.

Orcutt, J. D. (1984). Contrasting effects of two kinds of boredom on alcohol use. *Journal of Drug Issues, 14*, 161-173.

Ohsuga, M., Shimono, F., & Genno, H. (2001). Assessment of phasic work stress using autonomic indices. *International Journal of Psychophysiology, 40*, 211-220.

Papillo, J. F. & Shapiro, D. (1990). The cardiovascular system. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Principles of Psychophysiology: Physical, Social, and Inferential Elements* (pp. 456-512). New York, NY, USA: Cambridge University Press.

Passik, S. D, Inman, A., Kirsh, K. Theobald, D. E., & Dickerson, P. (2003). Initial validation of a scale to measure purposelessness, understimulation, and boredom in cancer patients: Toward a redefinition of depression in advanced disease. *Palliative and Supportive Care, 1*, 41-50.

Passik, S. D. (2003). Boredom as a component of distress in advanced cancer patients. *Psycho-Oncology, 12*, 227.

Pattyn, N., Neyt, X., Henderickx, D., and Soetens, E. (2008). Psychophysiological investigation of the vigilance decrement: Boredom or cognitive fatigue? *Physiology and Behavior, 93*, 369-378.

Pettiford, J., Kozink, R. V., Lutz, A. M., Kollins, S. H., Rose, J. E., & McClernon, F. J. (2007). Increases in impulsivity following smoking abstinence are related to baseline nicotine intake and boredom susceptibility. *Addictive Behaviors, 32*, 2351-2357.

Philippot, P. (1993). Inducing and assessing differentiated emotion-feeling states in the laboratory. *Cognition & Emotion, 7*, 171-193.

Porcherot, C., & Issanchou, S. (1998). Dynamics of liking for flavoured crackers: Test of predictive value of a boredom test. *Food Quality and Preference, 9*, 21-29.

Porges, S.W., & Raskin, D.C. (1969). Respiratory and heart rate components of attention. *Journal of Experimental Psychology, 81,* 497-503.

Randerson, J. (2003). Physiotherapy - virtual workout beats the boredom for stroke patients. *New Scientist, 177*, 20.

Ravaja, N. (2004). Effects of a small talking facial image on autonomic activity: The moderating influence of dispositional BIS and BAS sensitivities and emotions. *Biological Psychology, 65,* 163-183.

Sachar, E. J., Puig-Antich, J., Ryan, N. D., Asnis, G. M., Rabinovich, H., ... Davies, M. (1985). Three tests of cortisol secretion in adult endogenous depressives. *Acta Psychiatric Scandinavica, 71*, 1-8.

Sanchez-Martin, J. R., Cardas, J., Ahedo, L., Fano, E., Echebarria, E., & Azpiroz, A. (2001). Social behaviour, cortisol, and sIgA levels in preschool children. *Journal of Psychosomatic Research, 50*, 221-227.

Seel, R. T. & Kreutzer, J. S. (2003). Depression assessment after traumatic brain injury: An empirically based classification method. Archives of Physical Medicine and Rehabilitation, 84, 1621-1628.

Shaw, A. (2003). Time to put BORED on the run. *The Safety & Health Practitioner, 21*, 28-30.

Snoek, H., Van Goozen, S. H. M., Matthys, W, Buitelaar, J. K., & Van Engeland, H. (2004). Stress responsivity in children with externalizing behavior disorders. *Development and Psychopathology, 16*, 389-406.

Southwick, S., Krystal, J., Morgan, A., Johnson, D., Nagy, L., Nicolaou, A., … Charney, D. (1993). Abnormal noradrenergic function in post-traumatic stress disorder. *Archives of General Psychiatry, 50*, 266-274.

Sommers, J. & Vodanovich, S. J. (2000). Boredom proneness: Its relationship to psychological- and physical-health symptoms. *Journal of Clinical Psychology, 56*, 149-155.

Stern, R. M., Ray, W. J., & Quigley, K. S. (2001). *Psychophysiological recording* (2nd ed.). Oxford, UK: Oxford University Press.

Stemmler, G. (2004). Physiological processes during emotion. In P. Philippot & R. S. Feldman (Eds.), *The Regulation of Emotion* (pp. 33-70). Mahwah, NJ, USA, Lawrence Erlbaum Associates Publishers.

Strahler, J., Mueller, A., Rosenloecher, F., Kirschbaum, C., & Rohleder, N. (2010). Salivary α-amylase stress reactivity across different age groups. *Psychophysiology, 47*, 587-595.

Taylor, C. B. (2010). Depression, heart rate related variables and cardiovascular disease. *International Journal of Psychophysiology, 77*, np.

Theobald, D. E., Kirsh, K. L., Holtsclaw, E., Donaghy, K, Passik. S. D. (2003) An open label pilot study of citalopram for depression and boredom in ambulatory cancer patients. *Palliative and Support Care, 1*, 71-77.

Turner, M. A. (1984). Chronic boredom: Characteristics and relationship to depression and temporal experience. Unpublished dissertaion, University of Missouri, St. Louis, MO, USA.

Turpin, G. (1986). Psychophysiology, psychopathology and the social environment. In A. Gale & J. A. Edwards (Eds.), *Physiological Correlates of Human Behaviour, Vol. 3: Individual Differences and Psychopathology* (pp. 265-280). San Diego, CA, USA, Academic Press.

Varghese, F. P. & Brown, E. S. (2001). The hypothalamic-pituitary-adrenal axis in major depressive disorder: A brief primer of primary care physicians. *Primary Care Companion to the Journal of Clinical Endocrinology and Metabolism, 90*, 3279-3286.

Vodanovich, S. J. (2003). Psychometric measures of boredom: A review of the literature. *Journal of Psychology: Interdisciplinary and Applied, 137*, 569-595.

Vodanovich, S. J., & Rupp, D. E. (1999). Are procrastinators prone to boredom? *Social Behavior and Personality, 27*, 11-16.

Vodanovich, S. J., Verner, K. M., & Gilbride, T. V. (1991). Boredom proneness: Its relationship to positive and negative affect. *Psychological Reports, 69*, 1139-1146.

Wallace, J. C., Vodanovich, S. J., & Restino, B. M. (2003). Predicting cognitive failures from boredom proneness and daytime sleepiness scores: An investigation within military and undergraduate samples. *Personality and Individual Differences, 34*, 635-644.

Watt, J. D. (1991). Effect of boredom proneness on time perception. *Psychological Reports, 69*, 323-327.

Watt, J. D., & Hargis, M. B. (2010). Boredom proneness: Its relationship with subjective underemployment, perceived organizational support, and job performance. *Journal of Business and Psychology, 25*, 163-174.

Watt, J. D., & Vodanovich, S. J. (1992). Relationship between boredom proneness and impulsivity. *Psychological Reports, 70*, 688-690.

Wegner, L., & Flisher, A. J. (2009). Leisure boredom and adolescent risk behaviour: A systematic literature review. *Journal of Child and Adolescent Mental Health, 21*, 1-28.

Whooley, M.A., de Jonge, P., Vittinghoff, E., Otte, C., Moos, R., Carney, R.M., ... Browner, W.S. (2008). Depressive symptoms, health behaviors, and risk of cardiovascular events in patients with coronary heart disease. *Journal of the American Medical Association, 300*, 2379–2388.

Winton, W. M., Putnam, L. E., & Krauss, R. M. (1984). Facial and autonomic manifestations of the dimensional structure of emotion. *Journal of Experimental Social Psychology, 20*, 195-216.

Workman, J. E., & Studak, C. M. (2007). Relationships among fashion consumer groups, locus of control, boredom proneness, boredom coping and intrinsic enjoyment. *International Journal of Consumer Studies, 31*, 66-75.

Appendix A

State Affect Questionnaire [Post-Film version]

0	1	2	3	4	5	6	7	8
none/ not at all				some/ somewhat				a great deal / extremely

Using the scale above, please indicate the greatest amount of each emotion you are currently experiencing, at this moment [experienced while watching the previous film].

___ amusement	___ embarrassment	___ neutral
___ anger	___ fear	___ pride
___ nervous	___ guilt	___ sadness
___ confusion	___ happiness	___ shame
___ contempt	___ interest	___ surprise
___ disgust	___ joy	___ distress
___ boredom	___ alert	___ upset
___ excitement	___ hostility	___ love

Please use the following pleasantness scale to rate the feelings you are experiencing right now [had during the film]. Circle your answer:

0	1	2	3	4	5	6	7	8
unpleasant								pleasant

[Had you seen this film before? ___ yes ___ no]

[Did you close your eyes or look away during any scenes? ___yes ___ no]

Appendix B

Mood Induction Analyses– Study 2

Differences within each epoch. A manipulation check was performed, as a first step, to ensure that each target emotion was elicited by the videos in the current sample and to determine which emotion(s) participants felt most strongly during the baseline period. For each epoch separately (i.e., baseline, boredom, interest, sadness), a repeated measures ANOVA was conducted to compare the top three emotion terms endorsed by participants during each epoch on the State Affect (SA) questionnaire. Pearson correlations were then calculated between the top-rated emotion in each epoch and totals on the MSBS and DES subscales.

Baseline. Participants endorsed having felt interest most strongly during baseline. Similar to Study 1, participants also endorsed having felt happy, and exited. On the SA questionnaire during the baseline epoch, participants endorsed having felt interested (M=5.60, SD=1.65), happy (M=4.53, SD=2.09), and excited (M=3.75, SD=2.20) most strongly (Table 3). A repeated measures ANOVA, with a Greenhouse-Geisser adjustment for lack of sphericity, indicated that there were differences in the intensity with which participants endorsed feeling these states [$F(1.6, 105.4)=13.23$, $p<.001$, $\eta^2=.17$]. Multiple comparisons revealed that participants felt more interested than either happy (*mean difference*=1.07, $p<.001$) or excited (*mean difference*=1.85, $p<.001$). Participants also felt more happy than excited (*mean difference*=.78, $p<.01$). Participants' interest ratings on the SA questionnaire were positively correlated with their total scores on the DES interest subscale (r=.41, $p<.001$) such that high interest ratings on the SA questionnaire were associated with high scores on the DES interest subscale. There was no relationship between interest ratings on the SA questionnaire and the totals of MSBS items or the DES sadness subscale (all p's>.05; Table 4).

Boredom. The highest rated emotion terms on the SA questionnaire during the boring video were boredom (*M*=5.54, *SD*=2.37), confusion (*M*=2.68, *SD*=2.48) and amusement (*M*=2.53, *SD*=2.56; Table 2). A repeated measures ANOVA, with a Greenhouse-Geisser adjustment for lack of sphericity, indicated that there were differences in how strongly participants felt each of these emotions [$F(1.7,111.8)=28.89$, $p<.001$, $\eta^2=.30$]. Multiple comparisons revealed that participants felt boredom more strongly than either confusion (*mean difference*=2.87, $p<.001$) or amusement (*mean difference*=3.02, $p<.001$). There was no difference between the intensity of participants confusion or amusement ratings (*mean difference*=.15, $p>.99$; Table 3). There was a strong positive correlation between boredom ratings on the SA questionnaire and total scores on the MSBS items ($r=.82$, $p<.001$), and a strong negative correlation between boredom ratings on the SA questionnaire and the interest subscale of the DES ($r=-.56$, $p<.001$; Table 4). These correlations indicate that high boredom ratings on the SA questionnaire were associated with higher scores on the total of the MSBS items and lower scores on the interest subscale of the DES. No relationship existed between boredom ratings on the SA questionnaire and the DES sadness subscale ($r=.18$, $p>.10$).

Neutral/interesting. During the neutral video, on the SA questionnaire, participants endorsed having felt interest (*M*=5.93, *SD*=1.50), amusement (*M*=5.44, *SD*=1.85), and happiness (*M*=4.72, *SD*=2.03) most strongly (Table 3). A repeated measures ANOVA, with a Greenhouse-Geisser adjustment for lack of sphericity, indicated that there were differences in the intensity with which participants felt these emotions during the neutral epoch [$F(1.7,113.7)=21.06$, $p<.001$, $\eta^2=.24$]. Multiple comparisons revealed that participants felt more interest than either amusement (*mean difference*=1.21, $p<.001$) or happiness (*mean difference*=.49, $p=.01$). Participants rated their experience of amusement as more intense than their experience of happiness (*mean difference*=.72, $p<.01$). Interest ratings on the SA questionnaire were positively correlated with scores on the DES interest subscale ($r=.52$, $p<.001$), and negatively correlated with total scores on the MSBS items ($r=-.46$, $p<.01$) and the sadness subscale of the DES ($r=-.28$, $p<.05$).

Sadness. The highest rated emotion terms on the SA questionnaire during sad video were sadness ($M=5.10$, $SD=1.85$), upset ($M=4.12$, $SD=2.19$) and interest ($M=3.84$, $SD=1.98$; Table 2). A repeated measures ANOVA indicated that there were differences in how strongly participants felt each of these states [$F(2,134)=9.92$, $p<.001$, $\eta^2=.13$]. Multiple comparisons revealed that participants felt more sadness than both upset (*mean difference*=.99, $p<.01$) and interest (*mean difference*=1.27, $p=.001$). There was no difference in the intensity with which participants felt either upset or interest (*mean difference*=.28, $p>.80$). A positive correlation was also observed between sadness ratings on the SA questionnaire and total scores on the DES sadness subscale ($r=.77$, $p<.05$).

Differences between epochs. One-way repeated measures ANOVAs, with epoch (i.e. baseline, boredom, interest, sadness) as the within subjects factor, were conducted to determine whether the target emotions differed in intensity and valence across each of the four epochs.

Intesity. *Interest.* There were significant differences in intensity of the SA questionnaire interest ratings across epochs [$F(3,201)=104.05$, $p<.001$, $\eta^2=.80$]. Multiple comparisons, revealed that interest ratings during the baseline epoch ($M=5.60$, $SD=1.65$) did not differ in intensity from interest ratings during the neutral/interesting epoch ($M=5.93$, $SD=1.50$; *mean difference*=.32, $p>.90$). Interest ratings during the sad epoch ($M=3.84$, $SD=1.98$) were less than during the baseline (*mean difference*=1.77, $p<.001$) and neutral/interesting (*mean difference*=2.09, $p<.001$) epochs and were greater than during boring epoch ($M=1.76$, $SD=1.99$;

mean difference=2.07, $p<.001$). The intensity of participants' interest ratings during the boring epoch was significantly less than all other epochs (all *mean differences*>2.07, all *p*'s <.001). Scores on the DES interest subscale also differed across epochs [$F(3,174)=72.17$, $p<.001$, $\eta^2=.55$]. Multiple comparisons revealed that scores on the DES interest subscale were higher during the neutral/interesting epoch (M=14.15, SD=5.38) than during the baseline epoch (M=10.68, SD=5.34; *mean difference*=3.48, p=.001), the sad epoch (M=9.56, SD=5.28; *mean difference*=4.59, $p<.001$), and the boring epoch (M=2.98, SD=3.89; *mean difference*=11.17, $p<.001$). There were no differences between scores on the DES interest subscale during the baseline and sad epochs (*mean difference*=1.12, $p>.80$). Scores on the DES interest subscale were significantly lower during the boring epoch than all other epochs (all *mean differences* >6.58, all *p*'s<.001). Given these findings with respect to the DES interest subscale, Pearson correlations were conducted to further explore participants' interest ratings across the baseline, neutral, and sad epochs. During the baseline epoch, interest ratings on the SA questionnaire were positively correlated with DES sadness subscale scores (r=.41, $p<.001$). Interest ratings on the SA questionnaire were also positively correlated with scores on the DES interest subscale (r=.52, $p<.001$) during the neutral/interesting epoch. Comparing these correlations directly revealed that the association between the interest ratings during the neutral/interesting epoch was stronger than the association between the interest ratings during the baseline epoch (z=1.94, p=.05). During the sad epoch, interest ratings on the SA questionnaire were positively correlated with scores on the DES interest subscale (r=.40, $p<.01$). The strength of this correlation was not significantly different than the strength of the correlation between interest ratings during the baseline epoch (z=.48, $p>.60$), suggesting that the intensity of participants interest was equal across the baseline and sad epochs. Results suggest that, although the intensity was not significantly different, the overall quality of participants' interest may have been somewhat different across the baseline, neutral/interesting, and sad epochs. As such, paired samples t-tests, adjusted for multiple comparisons with Bonferroni corrections, were conducted to compare other highly rated emotion terms during these epochs. Results indicated that the intensity of participants alertness did not differ across the baseline, neutral/interesting, and sad epochs [all *t*'s <.84, *p*>.40]; however, participants' excitement rating was higher during the neutral/interesting epoch (*M*=4.56, *SD*=2.04) than at baseline [*M*=3.75, *SD*=1.97, *t*(67)=2.88, *p*<.01]. Participants' also felt more upset during the sad epoch (*M=3.69, SD*=2.30) than during the baseline [*M=.44, SD*=1.07, *t*(67)=12.14, *p*<.001] or neutral [*M=.21, SD*=.51, *t*(67)=12.42, *p*<.001] epochs. There were no differences between upset ratings between the baseline and neutral/interesting epochs [*t*(67)=1.87, *p*>.05]. Taken together, these results suggest that participants felt equally interested during the baseline and neutral/interesting epochs, however the quality of their overall affect differed somewhat across these periods. At baseline, participants seemed to be more interested and alert but less excited than during the neutral epoch when they felt more interested and excited.

Boredom. There were significant differences in intensity of the boredom ratings on the SA questionnaire across epochs [$F(2.5,164.4)=125.32$, $p<.001$, $\eta^2=.65$; with Greenhouse-Geisser corrections]. Multiple comparisons, with Bonferroni corrections, revealed that boredom ratings during the boring epoch (*M*=5.54, *SD*=2.37) were significantly higher than during the baseline epoch (*M*=1.50, *SD*=1.75; *mean difference*=4.04, *p*<.001), the interesting epoch (*M*=1.03, *SD*=1.47; *mean difference*=4.52, *p*<.001), and the sad epoch (*M*=1.03, *SD*=1.47; *mean difference*=4.52, *p*<.001). There were no differences between the boredom ratings across the baseline, neutral, and sad epochs (all *mean differences*<.47, all *p*'s>.99). A repeated measures

ANOVA, with a Greenhouse-Geisser correction, indicated that total scores on the MSBS items differed across epochs [$F(2.3,130.1)=107.70$, $p<.001$, $\eta^2=.65$]. Multiple comparisons revealed that scores on the MSBS items were highest during the boring epoch (*M*=18.66, *SD*=8.56) than during the baseline epoch (*M*=7.76, *SD*=6.18; *mean difference*=10.90, *p*<.001), interesting epoch (*M*=5.09, *SD*=6.76; *mean difference*=13.57, *p*<.001), and sad epoch (*M*=5.52, *SD*=6.20; *mean difference*=13.14, *p*<.001). Totals on the MSBS items during baseline were slightly higher than during the neutral/interesting (*mean difference*=2.67, *p*<.01) and sad (*mean difference*=2.24, *p*<.01) epochs. There was no difference in the total MSBS scores across the neutral/interesting and sad epochs (*mean difference*=.43, *p*>.99). Together, these findings indicate that the boring video successfully elicited boredom and that the intensity of participants' boredom was much higher during the boring epoch than during any other period.

Sadness. There were also significant differences in intensity of the sadness ratings on the SA questionnaire across epochs [$F(1.5,49.9)=97.4$, $p<.001$, $\eta^2=.86$]. Multiple comparisons revealed that sadness ratings during the sad epoch (*M*=5.10, *SD*=1.85) were significantly higher than during the baseline epoch (*M*=.49, *SD*=1.03; *mean difference*=4.62, *p*<.001), the interesting epoch (*M*=.32, *SD*=.78; *mean difference*=4.78, *p*<.001), and the boring epoch (*M*=.40, *SD*=.98; *mean difference*=4.71, *p*<.001). There were no differences between the sadness ratings across the baseline, neutral, and sad epochs (all *mean differences*<.16, all p's>.60). A repeated measures ANOVA, with a Greenhouse-Geisser correction, indicated that total scores on the DES sadness subscale differed across epochs [$F(2,114)=103.78$, $p<.001$, $\eta^2=.65$]. Multiple comparisons revealed that scores on the DES sadness subscale were highest during the sad epoch (*M*=8.72, *SD*=4.62) than during the baseline epoch (*M*=1.93, *SD*=3.51; *mean difference*=6.79, *p*<.001), boring epoch (*M*=1.22, *SD*=2.91; *mean difference*=7.50, *p*<.001), and the neutral/interesting epoch (*M*=.74, *SD*=1.83; *mean difference*=7.98, $p<.001$). There were no other differences in DES sadness subscale scores across epochs (all *mean differences*<1.19, all *p*'s>.05). These findings indicate that the sad video elicited sadness and the intensity of this emotion was much higher during the sad epoch than during any other period.

Finally, to compare intensity of participants affect, regardless of which emotion was felt, across epochs, a repeated measures ANOVA, with epoch as the within-subjects factor, was carried out using the highest rated emotion term from each epoch. Comparing the interest rating during the baseline and interesting epochs, the boredom rating during the boring epoch, and the sadness rating during the sad epoch revealed that there were no differences in affect intensity across epochs [$F(2.5,169.3)=2.51$, $p>.05$, $\eta^2=.04$].

Valence. Results of a repeated measures ANOVA, with epoch as the within-subjects factor, indicated there were significant differences in the valence of participants' affect across epochs [$F(3,117)=64.78$, $p<.001$, $\eta^2=.66$; Table 3]. Multiple comparisons revealed that participants' pleasantness ratings on the SA questionnaire were highest during the baseline (*M*=5.87, *SD*=1.19) and interesting (*M*=6.18, *SD*=1.51) epochs and there was no difference in these ratings between the baseline and neutral/interesting epochs (*mean difference*=.31, $p>.99$). Participants pleasantness ratings on the SA questionnaire were lowest during the boring (*M*=3.24, *SD*=1.87), and sad (*M*=2.63, *SD*=1.51) epochs and, again, there was no difference in pleasantness between the boring and sad epochs (*mean difference*=.61, $p>.99$). Lastly, the pleasantness of participants' affect was significantly higher during the baseline and neutral/interesting epochs than during the boring and sad epochs (all *mean differences*<3.05, all *p*'s <.05).